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Food habits or preferences and protecting or encouraging of native ladybugs (Coleoptera: Coccinellidae)

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Abstract
Of all the predaceous beetle insects, feasibly the most familiar to non-specialists is the ladybug family Coccinellidae of order Coleoptera. Due to the familiarity and economic significance of Coccinellidae, this article deals with information concerning food habits or preferences and protecting or encouraging of native coccinellids. It is widely known fact that this charismatic group includes many beneficial species that are voracious predators of pestiferous aphids and scale insects which feed on plant juices so farmers like to ladybugs because they help the plant to stay alive. Ladybugs also known as ladybeetles or ladybird beetles are familiar insects that can be classified as an omnivore because they feed on leaves, fungus and insects. Ladybugs find their food by sensing it with their antennae that help them to find and sense their food. Ladybugs in their larval and adult stages eat aphids, mealy bugs, soft scales, psyllids (jumping plant lice), whiteflies, mites, and other pest insects. Findings suggest that one ladybug can eat nearly 1,000 aphids in its lifetime and several hundred lady beetles are sufficient to get rid of most soft-bodied insect pests in a modest garden. However, not all ladybug species are carnivores, though some of these also eat pollen, mildew or mushrooms, and a few eat plants and are pests themselves. But, most ladybugs are predators and a welcome sight to gardeners or farmers. Ladybug eggs are small and yellow and usually laid on the backside of a leaf, near aphid colonies. This ensures that young ladybug larvae can have a food source as soon as they hatch. Ladybugs also lay eggs that are infertile or would not hatch amongst the fertile eggs thus to serve as first meal for their offspring. Ladybugs larvae and adults may supplement their normal prey in times of scarcity with other types of food. However, when an artificial sugar solution is applied to plant foliage in an attempt to further supplement food, then ladybugs are attracted. Clearly our understanding of the trophic requirements of this group is not comprehensive and a more complete understanding would lend further insights into the transition from predatory to mycophagous habits within this clade.

Keywords: Coccinellidae, Generalist predation, Food preference, Prey, Trophic shift

1. Introduction
There are about 4,000 species of lady beetles worldwide, which act as an important biological control agent for gardens and orchards, and are commonly sold commercially to the growers. Most ladybugs are predators and they eat other insects, maximum of which are considered pests to humans who like to grow plants for food or beauty. They are often called a gardener's the best friend and the most common insects that ladybugs eat are aphids, which are serious pests of plants. They can control the pest insects in the garden without the gardener having to use chemical pesticides on plants. They also eat other insects that have soft bodies, like mites, white flies and scale insects all of which are pests of plants. However, the question of what do ladybugs eat is much more complex than this. There are exceptions to most every rule, for example sub family Epilachninae can actually be considered vegetarian ladybugs. Some of them eat fungus, like mushrooms and there are some that like to dine on mildew. Still others prefer to eat leaves and can even become pests of some plants. Still, most of ladybugs are not pests, and in fact, due to what they eat, most of them can almost be thought of as exterminators. After all, the majority of ladybugs are subscribed to a diet that allows them to eat other pests. Hence, as a group they are considered predators. At the very least, the fact that they can effectively keep a shrubbery and all the plants in it free of aphids or other tiny insects in certainly a beneficial way. It is great that what a ladybug eats these help to humans with the food production that persons eat [1, 2]. Most persons like to ladybugs because they are cute, but gardeners affection them for a different reason as biocontrol agents. This is wondering that these tiny little ladybugs are predators, and what on earth is small enough for them to hunt these predate. The answer to that is aphids, which are insects that suck out the sap from plants. An infestation of them can destroy whole gardens and decimate crops. A single ladybug can eat up to 5000 aphids in its lifetime, which means they are invaluable to farmers trying to control an aphid population. A good ladybug colony in a garden can eliminate an aphid problem in an instant [3, 4].

2. Feeding habits of Ladybugs
Ladybugs are opportunistic feeders; they prefer to feed on large aphid populations, but do not always stay around until the last aphid is gone. Ladybugs can move on to larger aphid colonies to continue feeding on hosts. Ladybugs also feed on plant pollen and nectar flowers, and leafy weeds such as dandelion, wild carrots and yarrow. If contained in a greenhouse, ladybugs should have access to simulated honeydew nectar such as a yeast-sugar mixture. While most of coccinellids are

predaceous, some are specialists on plant material (e.g., leaves), whereas others feed on fungi. Even among the predaceous coccinellids, feeding preferences vary widely. Most of their preferred prey belong to the hemipteran suborder Sternorrhyncha (aphids, aldelgids, scales, mealybugs, whiteflies, and psyllids), but there are significant deviations from this pattern. Some coccinellid species are known to feed on ants (Hymenoptera: Formicidae). Other coccinellid species are specialists on non-insects; for example, all members of the tribe Stethorini prey on tetranychid mites [5-8].

Three major categories of feeding habits generally are recognized for coccinellids, predation (zoophagy), plant feeding (phytophagy) and fungus feeding (mycophagy). Most coccinellid species are predaceous on honeydew-producing insects from the hemipteran suborder Sternorrhyncha, although some prefer other arthropod prey. Departing from this predatory habit are the leaf-eaters, which are grouped within Epilachninae and the genus Bulaea, and the fungus feeders, which comprise two small groups from within Coccinellinae, Halyziini and some Tytthaspidini. Many coccinellid species are known to utilize alternative food items in the absence of their preferred ones, leading to the distinction between essential foods source i.e., those sufficient for larval development and adult oviposition and merely facultative food sources. The use of honeydew, pollen, sap, nectar and various fungi as alternative food sources is widespread among the predaceous groups, as is the exploitation of secondary or less favorable prey species. In addition, studies suggest that species generally regarded as predaceous may regularly supplement their basic diet with small amounts of leaf material even in the presence of abundant prey and water (zoophytophagy). Polyphagy also occurs among at least some mycophagous coccinellids which often complement their diet with pollen. The most dietary restricted coccinellids seem to be the Epilachninae and thus far, there are no reports of these phytophagous species feeding on anything other than plant tissue [9-12].

2.1. Innocuous Ladybug Feeding on Mildews

Ladybugs of the tribe Halyziini (of the subfamily Coccinellinae) feed on fungal growths (mildews) on the leaves of plants. This tribe is mainly represented by the West Indian *Psyllobora nana* Mulsant and *Psyllobora schwarzi* Chapin which have invaded the few areas extremely, and by the widespread of *Psyllobora parvinotata* Casey which also occupies other areas. Mildew-eating lady beetle *Psyllobora vigintimaculata* also feeds on mildew spores unlike to most other lady beetles which are carnivorous [13, 14].

2.2. Predator Feeding on Mites

Mites feeding on plants are little yellow speckles on leaf surfaces, and when a leaf is turned over, tiny and oval shaped mites, about pin head in size, pests are scurrying around. Their eggs are best seen with a magnifier, which can be scattered around at random. Spider mite eggs are all perfectly round and of the same size, ranging from clear to amber in color. With larger infestations, fine webbing, crawling with mites, covers the plant tops, and soon the leaves are browning and dying. Spider mite predators not only feed on spider mites and their eggs, but they also breed twice as fast than pest. Adults and larvae of the tribe Stethorini (of the subfamily Scymninae) feed on tetranychid mites. This tribe is represented only by *Stethorus utilis* (Horn), which is a tiny ladybird that is also distributed in many global states. The adults are solid black and covered with tiny hairs. This small beetle only measures 1½ mm long, but that does not mean it cannot eat a lot of prey. This ladybug likes to feed on spider mites and the adults can consume 75 to 100 mites per day. Predators should noticeably begin to gain control within 4 weeks and then continue until the spider mites are nearly or completely wiped out. Predators Stethorini disappear when the spider mites are gone to wipe. They can often be found feeding among high numbers of spider mites in landscapes and orchards [15, 16].

2.3. Predators Feeding on Whiteflies

Nearly, four ladybirds appear to be more or less specialized predators of whiteflies. They are *Delphastus catalinae* (Horn), *D. pallidus* (LeConte) and *D. pusillus* (LeConte) (tribe Serangiini), and *Nephaspis oculatus* (Blatchley) (Tribe Scymnini). The first ladybird *D. catalinae* seems to be an immigrant or native species in some of the regions, but the deliberate attempts to introduce that species from some regions seem to have no success. The next two beetles (*D. pallidus* and *D. pusillus*) are considered to be native in some of the regions. The fourth beetle (*N. oculatus*) may be an immigrant or native species in some regions. After *D. pusillus* is found to be a very useful biological control agent against sweetpotato whitefly (*Bemisia tabaci* (Gennadius) including the other form that later has been given name silverleaf whitefly (*Bemisia argentifolii* Bellows and Perring), it is made available commercially and used in other states. Unfortunately, the ladybird beetle that is called by *D. pusillus* seems to have been a mixture of *D. catalinae* and *D. pusillus*. Somehow this may be resulted in commercial biological control companies by selling *D. catalinae* under the name *D. pusillus* [17, 18].

2.4. Predators Feeding on Cottony cushion Scale

The cottony cushion scale (*Icerya purchasi* Maskell), belongs to the homopterous family Margarodidae (commonly called ground pearls, although this name hardly fits this species) in the superfamily Coccoidea (scale insects). It is a major pest of citrus, and an important pest of several other trees and shrubs including *Acacia*, *Casuarina* and *Pittosporum*. After its arrival to hosts, presumably as a contaminant of imported plants, it can threaten to ruin citrus industry in some regions. It can be controlled by importation, release and establishment (as classical biological control agents) of *Rodolia cardinalis* (Mulsant), and a parasitoid fly *Cryptochetum iceryae* (Williston). When cottony cushion scale became a problem, the same two biological control agents can be imported if these do not exist locally; anyhow, *R. cardinalis* is a highly effective control agent for cottony cushion scale [19].

2.5. Predators Feeding on Mealybugs

The mealybugs are the homopterous family Pseudococcidae, which includes some notable pests of plants. The most notable ladybird predator of mealybugs is *Cryptolaemus montrouzieri* Mulsant. This aggressive feeder is 3-4 mm long and has a dark brown body and orange head, and the larvae are white and fluffy. It has been marketed commercially as a control agent for mealybugs and is often effective, but has one unfortunate

characteristic that its larvae produce waxy filaments making them look to the uninitiated like their mealybug prey. Many owners of plants have sprayed the larvae with chemicals in the mistaken belief that they are pests. But, this misidentification must be overcome by grower's education. These ladybugs are often purchased from commercial insectaries and released in lieu of using pesticides. This beetle is a specialized feeder and it likes to predate munch on mealybugs and other soft scales, and it can also control to citrus mealybug. The *C. montrouzieri* does not confine its attentions to mealybugs, but also eats soft scales (Coccidae) and armored scales (Diaspididae). Such a catholic diet is normal for a long list of ladybirds, so that their diet cannot neatly be pigeonholed as armored scales or soft scales or mealybugs and they may eat some prey in all of these families, and a few of the larger ones may even eat an aphid from time to time [20].

2.6. Predators Feeding on Armored Scale Insects

About, eight species in four genera seem to feed largely or entirely on armored scale insects (Diaspididae). They include *Microweisea coccidivora* (Ashmead), *M. misella* (LeConte) and *M. ovalis* (LeConte) of the tribe Microweiseini; *Zilus horni* Gordon, *Z. eleutherae* Casey, *Z. subtropicus* (Casey) and perhaps *Zagloba bicolor* (Casey) (its diet is a guess) of the tribe Scymnillini; and *Cryptognatha nodiceps* Marshall in the tribe Cryptognathini. One of these, especially *Cryptognatha nodiceps*, if is not native, it can be imported, released and established as a classical biological control agent for coconut scale (*Aspidiotus destructor* Signoret) [21].

2.7. Predators Feeding on Scale Insects

A total of thirteen genera containing 66 species are placed here into this large trophic group that has scale insects as its prey, belonging to members of the superfamily Coccoidea (the scale insects). This superfamily includes various related families, notably Coccidae (soft scales), Diaspididae (armored scales), Pseudococcidae (mealybugs), Dactylopiidae (cochineal scales), Kermesidae (gall-like scales), Eriococcidae (felt scales), Cerococcidae (ornate pit scales) and Asterolecaniidae (pit scales). The most important ladybird genera are named below, each followed by a number in parentheses, representing the number of species known from various regions, *Decadomius* (1), *Diomus* (9), *Nephus* (3), *Pharoscymnus* (1) and *Scymnus* (16) (all in tribe Scymnini); *Brachiacantha* (7), *Hyperaspidius* (5), *Hyperaspis* (17) and *Thalassa* (1) (all in tribe Hyperaspini); *Axion* (1), *Chilocorus* (4), *Curinus* (1), *Egius* (1) and *Exochomus* (2) (all in tribe Chilocorini); *Rhyzobius* (1) (tribe Coccidulini); and *Azya* (1) (tribe Azyini). It is not yet clear how, or whether, they divide up the scale insects between them, because reliable prey records are too incomplete. However, there is at least some level of prey specialization in these [and groups (e), (f) and (g) above] that feed on scale insects, which seems not to be the case for the next discussed trophic group (those that feed on aphids). The *Brachiacantha* has a curious life history in that its larvae so far are known to feed on scale insects within ant nests [22].

The *Rhyzobius lophanthae* if not locally found, it can be imported to introduce in other regions to control scale insects, and somehow later may be cultured on its way to use. The *Chilocorus circumdatus* (Schoenherr) [few writers give the author name as Gyllenhal] has been released and is adventive against citrus snow scale *Unaspis citri*, and it can establish successfully. The *Chilocorus nigrita* (Fabricius) and *Pharoscymnus flexibilis* (Mulsant), both are native to this fraction of world, but also have been detected in other regions. The *Azya orbigera* Mulsant has been detected in some areas and also seems to be an immigrant from other regions. The *Decadomius bahamicus* (Casey) has been detected in other regions and is also an immigrant from the other areas. The *Diomus roseicollis* Mulsant is also another immigrant, from other areas as is *Egius platycephalus* Mulsant. The *Hyperaspis trifurcata* Schaeffer and *Thalassa montezumae* Mulsant are both native to some localities and have also been detected in other few areas [23, 24].

2.8. Predators Feeding on Aphids

Aphids are small, soft-bodied insects with long slender mouthparts that they use to pierce stems, leaves and other tender plant parts, and suck out fluids. Many aphid species are difficult to distinguish from one another; however, management of most aphid species is similar. Aphids have long legs and antennae, and may be green, yellow, brown, red, or black depending on the species and the plants they feed on. A few species appear waxy or woolly due to the secretion of a waxy white or gray substance over their body surface. Most species have a pair of tube-like structures called cornicles projecting backward out of the hind end of their body. The presence of cornicles distinguishes aphids from all other insects. Almost every plant has one or more aphid species that occasionally feed on it. Low to moderate numbers of leaf-feeding aphids are not usually damaging in gardens or on trees. However, large populations can turn leaves to yellow and stunt shoots, and aphids can also produce large quantities of a sticky exudate known as honeydew, which often turns black with the growth of a sooty mold fungus. Some aphid species inject a toxin into plants, which causes leaves to curl and further distorts growth. A few species cause gall formations and aphids may transmit viruses from plant to plant on certain vegetable and ornamental plants. When an aphid outbreak occurs, beneficial insects are attracted to the field by either volatile chemicals emitted from plants after injury or by the honeydew exuded by the feeding aphids. Adults and larvae of 12 of the remaining species (the tribe Coccinellini) probably feed primarily on aphids. They include *Coccinella novemnotata* Herbst, *C. septempunctata* L., *Coelophora inaequalis* (F.), *Coleomegilla maculata* DeGeer, *Cycloneda munda* (Say), *Cycloneda sanguinea* (L.), *Harmonia axyridis* Pallas, *Harmonia dimidiata* (Fabricius), *Hippodamia convergens* Guérin-Méneville, *Mulsantina picta* (Randall), *Naemia seriata* (Melsheimer) and *Neoharmonia venusta* (Melsheimer). Although the 13th species (*Olla vnigrum* Casey) feeds on some aphid species, it has been shown to be an important predator of psyllids [25].

Four of these, *C. septempunctata* (from Europe), *C. inaequalis* (from Australia), *H. dimidiata* (from China), and *H. axyridis* (from Japan) are not native in some regions. The first three are introduced and the last one is detected from other localities, and it can subsequently spread widely. In some habitats, it has built large populations and its adults in their search for overwintering sites, sometimes are able to enter loosely

constructed houses; there they die of desiccation, or they are evicted or destroyed by the householders who accuse them of being pests. Two of these genera, *Coleomegilla* and *Mulsantina*, include adelgids (Adelgidae), which are closely related to aphids in their diet. Further, *Coleomegilla* also includes pollen, whereas *Mulsantina* also includes scale insects in the broad sense [26].

3. Feeding to a Pet Ladybug

Ladybugs are small and hardy survivors that are making them a great first pet for kids. One way to help a ladybug as well as to teach the children is their responsibility to let them free over the winter. A terrarium or specially designed box can be preferred to keep as pet, but an ordinary jar can also be used to keep them. Just punch some holes in the lid to keep air flowing inside the box. Stock the ladybug's house with some leaves and twigs to make them feel more naturally at home. Ladybugs like humidity, so if kids notice that their enclosure is starting to dry out, then spritz some water on the leaves to keep things damp. Do not worry about hunting down some aphids and ti offer these to beetles; captive ladybugs can be fed raisins that have been soaked for a few minutes, or small globs of honey. It is best to not keep standing water around the pets, but instead provide them with a wet paper towel or cotton ball, which they will be able to drink from as needed. Then, in spring, let the kids to release the ladybugs to rejoin their companions. If kids want to enjoy for keeping these cute little bugs, adult can order larvae and food for them from certain stores, which can guide to keep them year-round [27].

4. Taking Care of Ladybug

Lady bugs like to feed on aphids that are their main source of food and aphids are garden pests which can be found on leaves. For finding of a ladybug, look in an area where ladybugs shelter, this may be under the leaves of plants where aphids are hanging about (try roses and other flowers or fruit trees in blossom). They also like to hide in crevices and cracks on houses, such as around window frames. For collecting of the ladybug, look around the area and catch the ladybug with a small net or catch it with finger or hand, but be careful not to let it fly away. Cover it gently with other hand and be careful not to squeeze it. Place the ladybug gently in the jar and it is ready to be looked after. For keeping the ladybugs for more than 24 hours, use a hermit crab house, they would not be able to get out of it, but these can enjoy it. Place fresh leaves inside of crab house daily and it needs to feed the ladybugs every day. Provide the food to the ladybug with small amounts of honey or sugar and use a small bottle cap or similar to contain the food. Growers can also feed to ladybug with raisins or lettuce and add a piece of bark from a tree. Bark from trees tends to have bug larvae and ladybug can spend most of its time on and under the bark. Use a plastic water bottle cap for water and add only a little water so that the ladybug cannot drown. Be gentle when holding a ladybug, lower the finger and leave it near the ladybug, wait for it to walk or fly on it and now a person can hold a ladybug, but be careful. Consider releasing the ladybug back into the wild after 24 hours, observe its habits, and then let it get back to the job it has to do, which might be keeping the pests down in the garden [28].

5. Protecting and Encouraging of Native Ladybugs

Far more beneficial than purchasing, steps can be taken to conserve and enhance the activity of native species of ladybugs. Ladybugs require food for themselves and their young, and an important way to encourage ladybugs is to have a source of aphids or other preferred prey for them to feed on. Since ladybugs are actively moving about and seeking food during most of the growing season, they can eventually find the gardens. Adult ladybugs may also feed on other foods such as pollen and nectar. A garden environment that provides these things is also important. Ladybugs most often visit and use shallow flowers that are accessible to their mouthparts such as dill, coriander or alyssum. Artificial foods, such as sugar-water sprays or mixtures of sugar/ water/ yeast, are sometimes used to retain lady beetles in a garden. Sometimes the efforts of lady beetles are inhibited and growers can take actions to eliminate these limiting factors. Ants that tend to live with aphids and collect their honeydew can often attack and drive off lady beetles and other predators. By controlling ants, lady beetle activity can increase in many cases. Of course, use of insecticides in and around gardens can also greatly affect lady beetles, which are susceptible to many garden insecticides. Certain selective insecticides, such as *Bacillus thuringiensis*, soaps, horticultural oils, pyrethrum and neem are largely compatible with lady beetles. Adults and larvae feed on a variety of pest insects and mites, notably aphids and scales are good prey. Lady beetles can be invited into a garden by providing plants that adults use as nectar, pollen sources, sustaining levels of aphids or other prey, and using insecticides with care [29, 30].

6. Beneficial Insect Food

Ladybird larvae and adults may supplement their normal prey in times of scarcity with other types of food. In predatory species, for example, it may be that prey mobility, surface features (e.g., cuticular waxes and degree of sclerotization), or seasonal availability are of equal importance. Some lady beetles have very clear and narrowly defined feeding preferences, but for others the host plant or habitat may largely determine which prey species are consumed. Many beneficial insects, including ladybugs and green lacewings, appreciate the pollen and nectar substitutes found in beneficial insect food. Of course, that is in addition to the protein sources they get by eating insect pests on the plants. Mix an artificial sugar solution with water and spray wherever growers do like to have beneficial insects to hang out the pests. Give them the food they love, so they would not go looking for it at the neighbor sites. Many ladybugs do exceptionally well on processed moth eggs which have been sterilized to prevent hatching, removed from the ovipositional substrate, cleaned of obstructing debris, such as scales and webbing, and offered in unnatural densities [31].

7. Conclusion

Most ladybugs are predators and they eat other insects, most of which are considered pests to humans who like to grow plants for food or beauty. However, the question of what do ladybugs eat is much more complex than this. There are exceptions to most every rule, for example sub family Epilachninae can actually be considered vegetarian ladybugs. Some of them eat

fungus, like mushrooms and there are some that like to dine on mildew. Still others prefer eating of leaves and can even become pests of some plants. Results indicate that the ancestral feeding condition for Coccinellidae is coccidophagy. From the ancestral condition, there have been at least three transitions to aphidophagy and one transition to leaf-eating phytophagy. A second transition to leaf-eating phytophagy arose within an aphidophagous or pollinivorous clade. The mycophagous condition in Halyziini originated from aphidophagy. Findings suggest that polyphagy served as an evolutionary stepping stone for primarily predaceous groups to adopt new feeding habits. The analyses recovered a clade comprising Serangiini plus Microweiseini as the sister group to the rest of Coccinellidae. The subfamilies Coccinellinae and Epilachninae are monophyletic; however, Sticholotidinae, Chilocorinae, Scymninae and Coccidulinae are paraphyletic. The ladybugs can be fed raisins that have been soaked for a few minutes, or small globs of honey and sugar. Overall, it is felt that the use of the molecular data to map the evolution of lady beetle feeding preferences is a significant step toward a better understanding of this interesting topic.

8. References

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