Minute Pirate Bug: A Beneficial Generalist Insect Predator

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Introduction

The genus *Orius* is represented by very tiny true bugs commonly known as minute pirate bugs and flower bugs. Their common names are representative of their small size and favorite hangout while on plants. Insect predators of the genus *Orius* are polyphagous which means they are generalist predators that feed on a variety of prey. *Orius* is typically the first and most common predaceous insect to appear during spring. They play a key role in the management of various agricultural pests in greenhouse and field environments. They can be found in numerous crops, pasture land and surrounding areas (e.g. cotton, soybean, faba bean, potato, wheat, alfalfa, maize, orchards, other vegetables and ornamental crops), as well as trees, shrubs, weeds and many wild plants. They prey on thrips, aphids, mites, whiteflies, moths and other tiny arthropods as well as insect eggs, inhabiting mostly herbaceous plants. *Orius* are very effective predators and can thus provide biological pest control in a variety of cropping systems.

Figure 1: *Orius* adult (left) and nymph (right). Photo by Galen Dively

Insect Identification

Adults. An adult *Orius* is approximately 2-3 mm long with an oval-shaped flattened body and black and white markings along each wing (**Fig 1.**). Wings are longer than the body and extend beyond the abdomen. Their mouthparts are constructed into a piercing-sucking straw-like appendage used to stab into and ingest liquid from insect and mite prey and plant material.

Nymphs. *Orius* nymphs are tear drop-shaped with red eyes. Newly hatched nymphs are colorless, but their bodies darken to a yellow, and later reddish-brown color as they mature through their five stages or instars, before finally molting into their adult form. Late stage *Orius* nymphs are of similar size to adults and all stages are predaceous and have identical mouthparts to adults.

Eggs. *Orius* eggs are small and difficult to detect, as they are deposited singly in plant tissue (main stem, leaf vein, flowers or petioles) with the top of the egg sticking out of the leaf. However, eggs are not laid randomly as the mother uses physical and physiological characteristics of plants such as trichome (small hair or other outgrowth from the outer layer of the plant tissue) density and epidermal thickness of leaves to decide egg placement. This leads to direct preferences for specific plants. Preference for particular plant species is correlated with how well newly hatched nymphs can survive on these plants in the absence of prey. Results of a study suggest that plant nutritional quality for newly hatched nymphs is an important consideration for mothers when deciding which plants to oviposit their eggs. For example, a study showed that the insidious flower beetle (*Orius insidiosus*) laid 56.4% more eggs on prey-free common bean (*Phaseolus vulgaris*) than prey-free soybean. When provided a choice of

soybean with prey and common bean without prey, *O. insidiosus* still laid 55.4% more eggs on common bean. This suggests that plant suitability for *O. insidiosus* offspring over-rides the importance of prey availability during egg oviposition.

Life Cycle

Orius overwinter as adults, and begin to enter diapause in late summer when daylight becomes shorter than 13 hours per day. Overwintering locations include protected habitats such as underneath cracks in tree bark or under residual leaf litter, particularly in semi natural areas. Adults emerge from these locations in early spring, after which they mate and begin to lay eggs. *Orius* has a very short generation time. A complete life cycle takes approximately 3 weeks at 70 °F (21°C). Cooler temperatures and lack of prey may slow their development. A single adult female can lay between 80 and 100 eggs during her lifetime. Eggs typically take between 4 to 5 days to hatch, and nymphs then go through five stages over a period of 2 to 3 weeks. After their final molt, adults typically live between 3 to 4 weeks (**Fig 2.**). During the growing season, the dynamics of flowering resources drive their population size and distribution pattern. Species of *Orius* are highly mobile, actively search prey and respond to odors emanating from prey-infested plants. Flowering plants in semi-natural areas provide more balanced but limited resources (i.e., pollen and prey) over the season in comparison to mass-flowering crops. As such, agricultural fields are more attractive to *Orius* because they have greater potential for supplying them resources such as food requirements.

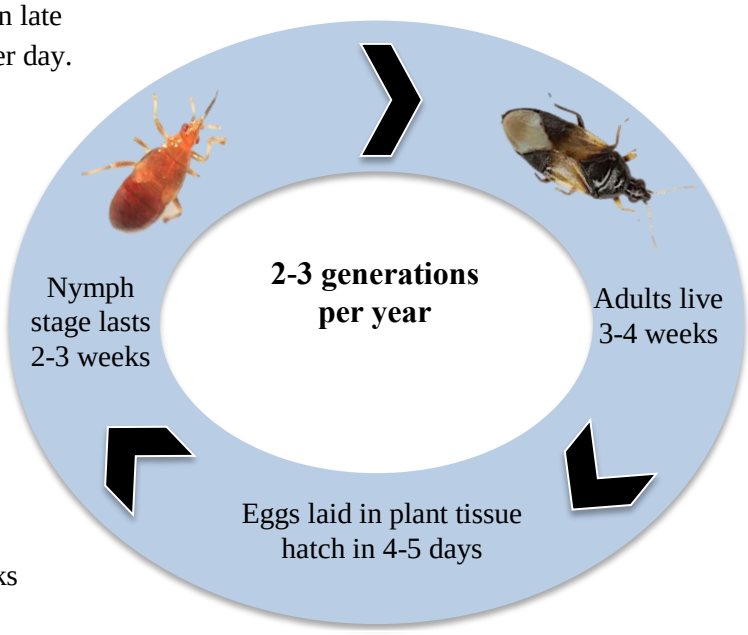

Figure 2: Minute pirate bug life cycle

Sampling for *Orius*

A study indicated that in soybean, *O. insidiosus* oviposit their eggs most frequently in leaf petioles and in the upper soybean canopy. Increased populations and inflight activity of adults have been reported on soybean foliage during flowering. *Orius* adults and nymphs search soybean blossoms, which are known to harbor flower thrips. Because soybean blossoms are located at bases of petioles, adult *O. insidiosus* are likely to pass over plant petioles when moving between blossoms and leaflets. This may explain why there is greater oviposition in petioles. Additionally, adult females may preferentially search the upper trifoliate for soybean thrips, which would account for greater concentration of their eggs in the upper soybean plant strata. Thus, if sampling for *Orius*, it may increase sampling efficiency to sample the upper plant canopy. *Orius* adults and older nymphs are easy to see in crop flowers such as cucumber and pepper flowers, where they are feeding on thrips and pollen. Adults and younger stages can be found also on leaves and along

Fig. 3a: *Orius* feeding on a small caterpillar

stems, but are more difficult to detect in these plant areas. Use of a headband magnifier or hand lens will help with their detection and identification. One could remove flowers from plants and shake them on a white paper to determine *Orius* presence especially if these flowers are harboring thrips.

What role do plants play in *Orius* Survival?

Predaceous *Orius* are omnivorous which means they use both arthropods (e.g., mites, insects) and plants as food. Yes, in addition to feasting on prey, predaceous *Orius* species feed on plant sap/juices and pollen. This may occur even when prey are readily available. This behavior is often referred to as facultative phytophagy (feeding on plants in the presence and absence of prey). Facultative phytophagy allows them to survive periods of prey scarcity, and may provide them nutrients that are limiting in prey. *O. insidiosus* feeds within the xylem and mesophyll of soybean plants and may feed on corn pollen by puncturing individual pollen grains. Research findings suggest that facultative phytophagy for *O. insidiosus* is a means for obtaining needed moisture to supplement their prey diet. However, it is believed that they obtain dilute nutrients during xylem feeding. This suggests that *O. insidiosus* adults obtain minimal nutrition from feeding on soybean plants. Additionally, research has shown also that immature *O. insidiosus* survive better on soybean and other plants than on water alone, which suggests that these developing nymphs are able to use plant tissue for nutrition. Moreover, *O. insidiosus* adults were observed ingesting small amounts of sugars, starches and amino acids while feeding on soybean plants. In addition to feeding on soybean, maize silk has been referred to as an optimal food resource for *Orius* adults and juveniles.

Though some may think their feeding on plants is no different than an insect pests, their feeding does not cause perceptible damage and is important in biological control as it allows for maintenance of their populations in agricultural fields during periods of low insect pest levels. Thus, *Orius* can stick around and be present to "protect" plants when insect herbivores finally arrive. Basically, these predators have the unique ability to build up their populations before pests arrive by using crop plants as alternative food sources. In some instances, *Orius* can develop to the next instar or even complete development on a plant-only diet. The addition of prey into the diet often quickens immature development time and enhances their survival, as well as adult longevity (how long they live) and fecundity (number of eggs a female can lay in her lifetime). As such, plants fulfill several roles throughout the life cycle of *Orius* bugs. They function as an egg-laying substrate but also serve as a source of moisture and supplementary nutrients. However, similar to insect pests, *Orius* can be exposed to systemic insecticides when plant feeding.

Biological Control with *Orius*

Orius are important predators of many agricultural pests, and can significantly decrease pest populations if present at high enough densities. They are considered the most effective predators of mites, thrips and lepidopteran eggs in soybeans. Previous research has shown that nymphs and adults can consume up to thirty spider mites per day and that large populations of *Orius* can be enough to keep flower thrips below damaging levels in peppers. Because of their reputation as good biological control agents of thrips, *Orius* are mass-produced by commercial insectaries and are thus commercially available for purchase. They are widely released to control thrips in several horticultural crops but releases are more common in greenhouse settings. Additional prey include whiteflies, aphids, newly hatched caterpillars, mites, and eggs of several different insects (**Figs. 3a, b & c.**). They are also commonly found in corn silk, where they are important predators of corn earworm eggs. When insect prey is unavailable, *Orius* will feed on pollen and plant juices.

Do *Orius* play a role in protecting agronomic crops?

Predation on European corn borer (ECB) and corn earworm (CEW) in corn. The ECB and CEW are important corn pests. The ability of *O. insidiosus* to search for, find, and destroy ECB and CEW eggs was investigated. *Orius insidiosus* was noted searching in corn silks first, followed by corn leaves but not in the tassel. Interesting enough, expected areas of highest CEW and ECB egg densities are silks and leaves, respectively. *Orius insidiosus* is an important natural enemy of CEW in corn, cotton and sorghum. A study conducted in western Maryland, revealed ECB larvae sustain high mortality in field corn and that *O. insidiosus* was the most important predator of ECB larvae in western Maryland. Their population peak coincides with corn pollen-shedding and silking; during which, they feed on second-generation ECB larvae and corn pollen. Therefore, successful biological control of ECB larvae by *O. insidiosus* is linked to arthropod prey and corn pollen.

Predation on thrips and soybean aphids in soybean. *Orius insidiosus* adults and nymphs are common in soybean fields (**Fig. 4**). Its population dynamics in soybean fields have been linked to thrips population levels and soybean flowering. Nymphs and adults eat soybean aphids in the field. Experimental findings suggest that under certain conditions, *O. insidiosus* can effectively suppress aphid population growth and that they may be key factors influencing aphid population dynamics in soybeans in some areas within the US. In addition to soybean aphids, soybean thrips are believed to be one of the more important thrips prey of *O. insidiosus* in soybean. It is believed that soybean thrips serve as an important prey resource for *O. insidiosus* in soybeans and may be important in sustaining *O. insidiosus* populations before the arrival of soybean aphids. *Orius insidiosus* is known to feed on eggs and 1st instar green cloverworm as well.

Fig. 3b. *Orius* feeding on immature whiteflies. Photo by Jack Dykinga.

Do Orius have weak links?

Because of their small size, *Orius* are vulnerable to predation and being eaten by competitors/predators that utilize the same prey, which is known as intraguild predation. A number of generalist predators, particularly spiders, lace wings and other predaceous true bugs use *Orius* as prey. Additionally, their minute size limits their ability to thrive on plants with abundant leaf hairs. Leaf hair density was shown to have a significant impact on their longevity (how long they live) and fecundity (how many eggs they lay during a lifetime). When plant leaf hairs were thinly dispersed or sparse, *O. insidiosus* could reach the leaf's surface more readily. Their small size limits the number of prey that they can successfully attack. For example, no stages of *O. insidiosus* could feed on green cloverworm beyond the 2nd instar. Additionally, *Orius* effectiveness as predators may be reduced by environmental factors such as weather and intraspecies contact among themselves.

Pesticides have been shown also to have a negative impact on *Orius*. Following a study, several insecticides were classified as harmful or slightly harmful to *O. insidiosus*; and in another study, the acute and sub lethal toxicity of 14 pesticides was tested on *Orius laevigatus* adults under laboratory conditions. Results showed that pesticides greatly differed in their toxicity, in terms of lethal and sub lethal effects, as well as in their persistence. In particular, abamectin was the most noxious and persistent, and was classified as harmful up to 14 d after treatment,

causing almost 100% mortality. Taken as a whole, the study demonstrated that side effects of pesticides can vary greatly depending upon pesticide chemical family and type. In addition, several biopesticides were highly toxic to *O. laevigatus*. Spinosad was very toxic with persistence proving to be relatively high and most effects were still observed when predators were exposed to 7-day old residues. These results matched those of previous studies, which assessed side effects of spinosad on *O. insidiosus* and *O. laevigatus*. It was unclear why *O. laevigatus* was negatively affected by spinosad in the study. It was suggested that its omnivorous behavior which allows it to feed on plants also could have resulted in *O. laevigatus* receiving greater amount of toxins than if consuming only spinosad-contaminated prey.

Fig. 3c. *Orius* feeding on thrips. Photo by Gbohne, creative commons.

A study was conducted in which corn plants were twice sprayed at 3-day intervals during tasseling to evaluate effects of chlorpyrifos on ear damage by corn earworm and their associated natural enemies. *Orius* abundance decreased 21 days after insecticide application. This response was expected because *Orius* tends to forage corn tassel during pollination, which could expose them to insecticide sprays. In addition to *Orius*, insecticide sprays affected populations of several other predators found on the corn foliage. *Orius* may forage more on crops such as corn, which could lead to more contact with insecticide and thus, higher mortality.

Does *Bt* have an effect on *Orius*?

The development of *Bt* crops has led to a reduction of insecticide sprays required to manage crop pests, especially in agronomic crops. Still, there are concerns regarding the impact of *Bt* crops on biological control agents. This is especially important for omnivorous predators such as *Orius*, which can consume *Bt* directly and indirectly by feeding on *Bt* plant material or prey that has ingested *Bt* protein, respectively. However, several studies have shown that *Orius* abundance is not affected by *Bt* crops, and that feeding on *Bt* crops or prey that has fed on *Bt* crops has no negative impact on *Orius* species studied. For example, the ingestion of *Bt* protein by the predator, *Orius majusculus* via plant leaves, pollen or prey that fed on *Bt* plant material had no negative effects on its survival, development, fecundity (how many eggs they laid) and fertility. Similarly, there was no effect on *O. insidiosus* for consuming caterpillars that ingested *Bt* protein. In fact, some researchers have described occasional population density increases in *Orius* spp. in *Bt* maize and suggested that this could be related to their preference for ears and silks free from lepidopteran feeding. Additionally, *O. majusculus* fecundity was increased when they fed on *Bt* plant material, and nymphal development was shortened when nymphs were fed on *Bt*-containing spider mites.

Fig. 4. *Orius* nymph on soybean. Iowa State University, Bugwood.org.

Can *Orius* numbers be increased in the field?

Several practices can be used in the field, to conserve and maximize the natural presence of beneficial insects. One practice to conserve *Orius* populations within crop fields is to avoid the use of broad-spectrum insecticides. However, as indicated earlier, insecticides other than broad spectrum including some biopesticides can have a negative impact on *Orius* survival and population density. In conservation biological control programs, provision of required resources (e.g., shelter, food and oviposition sites) can be achieved by growing insectary plants. This can be especially important for omnivorous predators such as *Orius* that feed on arthropod prey and plant material, and where the availability of plant resources play a significant role in their conservation. For example, pollen resources can allow *Orius* to survive periods of prey scarcity. As such, growing flowering plants in close proximity to crop fields where pest control is needed will provide nectar and pollen resources that can attract *Orius* and other beneficials to the area. A study found that Black Pearl pepper pollen can enhance life history traits of *O. insidiosus* in several ways: increase female longevity, decrease nymphal development time, increase female size and increase predator abundance on flowering peppers. These results indicate that pollen from the Black Pearl pepper plant could be a valuable tool for increasing *O. insidiosus* abundance. However, whether this would result in greater biological control efficacy is still unknown. Similarly, results from another study showed that alyssum (*Lobularia maritima*) can provide resource subsidies for *O. majusculus* during times when prey are scarce in the field. Therefore, insectary plants could be used to help establish *Orius* populations in fields before crops are planted. The addition of prey within insectary plants could further ensure early population development of *Orius* until targeted insect pests colonize the crop field.

Summary

Generalist predators of the genus *Orius* (minute pirate bugs) feed on a variety of prey. They are voracious predators in all their active life stages, which means they can be released at different developmental stages. As biological control agents, minute pirate bugs display some useful characteristics in terms of their establishment in crops prior to pest arrival and their ability to tolerate reductions in prey availability. More importantly, for some soybean producers, there is increasing evidence that the insidious flower bug, *Orius insidiosus* helps prevent soybean aphid outbreaks. However, its population dynamics appear to be more strongly linked to that of thrips. For example, during early-season before soybean aphid arrives, colonization by thrips and *Orius* reproductive response to thrips helps to promote high numbers that can exert significant mortality on soybean aphid populations.

Orius are used worldwide for controlling different thrips pests, but will attack many soft-bodied arthropods such as aphids, whiteflies, mites, young butterfly and moth larvae, leafhopper nymphs and small arthropod eggs. *Orius insidiosus* is one of the most commonly used *Orius* species in biological control programs worldwide, especially for thrips suppression. This preference may be driven more by the predator and prey having overlapping habitats than an inherent prey preference. Even so, species of *Orius* are effective thrips predators and are thought to have a preference for flower thrips. *Orius* predators live concealed in the same habitat as thrips, making thrips an easy target. Another factor that makes *Orius* a desirable insect in biological control programs is the ease of being mass reared. Though, releases of *Orius* are usually undertaken to control thrips on plants in greenhouses, releases on field crops have been carried out successfully.