

Role of Predators and Parasitoids in Agriculture

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Biological control, defined as the suppression of pest populations through the actions of natural enemies, serves as a cornerstone of sustainable agriculture and integrated pest management (IPM) (Colmenarez *et al.*, 2020). Predators and parasitoids are vital components of agroecosystems, acting as trophic regulators that utilize distinct mechanisms such as direct predation or host-dependent development to suppress herbivore populations (Pijnakker *et al.*, 2020). Beyond simple consumption, these natural enemies often exhibit complex behavioral responses, including the use of herbivore-induced plant volatiles (HIPVs) to locate hosts or prey within diverse agroecological landscapes (Gómez-Cabezas *et al.*, 2023). Strategies to leverage these organisms, ranging from conservation biological control to augmentative releases, are essential for reducing reliance on synthetic chemical pesticides while maintaining crop productivity (Pijnakker *et al.*, 2020). Consequently, understanding the life cycle and searching behaviors of these natural enemies remains critical for developing robust, eco-friendly pest management programs (Schmidt *et al.*, 2021).

Important Predators and Their Life Cycle

1. Lady Bird Beetle (*Coccinella septempunctata*):

Life cycle: *Coccinella septempunctata* larvae progress through four instars, initially consuming egg casings and infertile eggs before transitioning from sucking aphid liquids to devouring whole prey. Following a temperature-dependent pupal stage (lasts from 3 to 12 days), adults emerge with soft elytra that eventually develop characteristic red and black pigmentation derived from carotenes and melanin. These beetles typically overwinter in protected areas and emerge in spring to deposit two hundreds of eggs near aphid colonies, completing their development from egg to adult in as little as two to three weeks. This efficient life cycle allows for one to two annual generations, with adult longevity varying based on prey availability and environmental conditions (Fig. 1).



Fig. 1 Life cycle of *Coccinella septempunctata*

2. Mealy Bug Destroyers (*Cryptolaemus montrouzieri*):

Life Cycle: The mealybug destroyers, which breeds year-round with multiple annual generations, undergoes a complete life cycle that varies from 31 to 45 days depending on temperature. Adult beetles, characterized by their black and brown coloration, deposit eggs within mealybug or scale insect colonies, where the resulting larvae, which mimic mealybugs with a white waxy covering, prey on the pests for 12–17 days. Following four larval instars, the insect pupates in a sheltered location (pupal stage- 7-10 days) before emerging as an adult, with a single female capable of laying up to 500 eggs during her 50-day lifespan (Fig. 2).

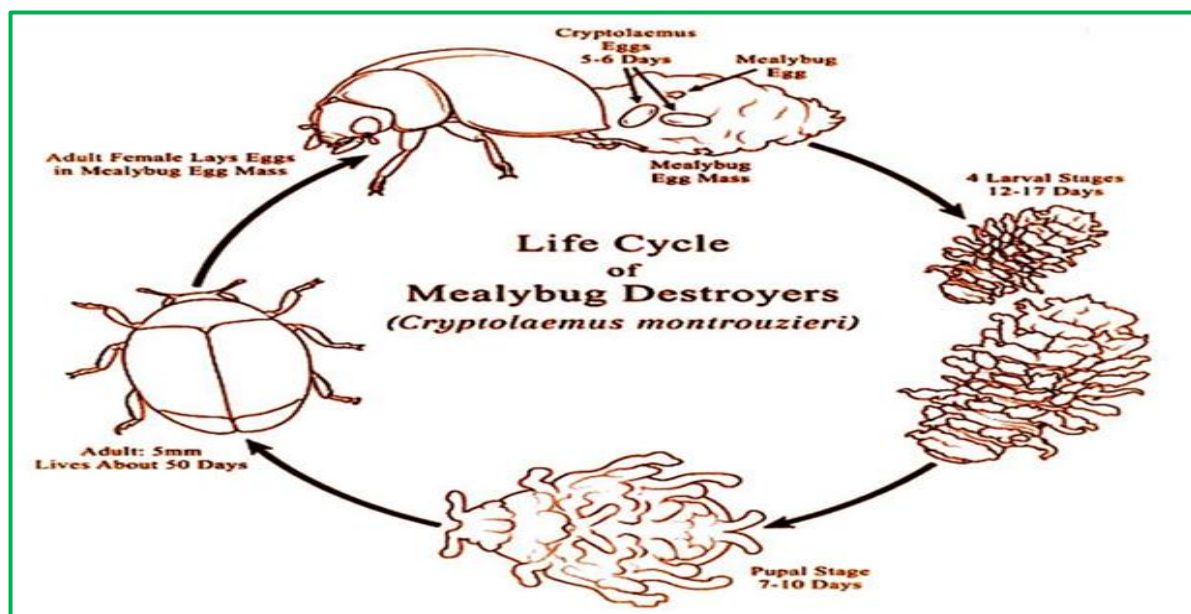


Fig. 2 Life Cycle of *Cryptolaemus montrouzieri*

3. Six spotted Tiger Beetle (*Cicindela sexpunctata* or *Cicindela sexguttata*):

Life Cycle: Tiger Beetle eggs are deposited in soil or substrate where larvae excavate tunnels up to 200 cm deep, utilizing specialized dorsal hooks on the 5th abdominal tergite to remain anchored while seizing prey with their mandibles. These larvae exhibit significant environmental resilience, such as surviving floods, while the adult imagos are active diurnal hunters that mate by having the male clasp the female's thorax with his mandibles. To ensure the cycle continues, females utilize their antennae and mandibles to probe the ground before using their abdomen to bore holes for the next generation of eggs (Fig. 3).

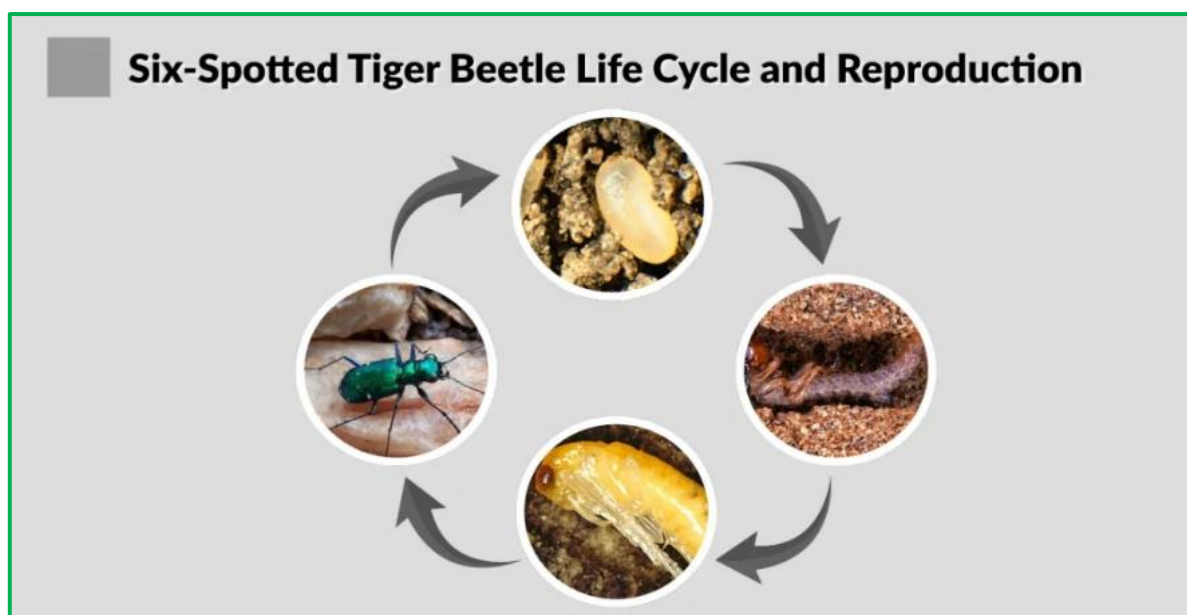


Fig. 3 Life cycle of *Cicindela sexpunctata* or *Cicindela sexguttata*

4. Green Lace Wing (*Chrysoperla zastrowi sillemi*):

Life Cycle: The development of *C. zastrowi sillemi* on cabbage aphid, *Brevicoryne brassicae* spans 20 to 23 days, encompassing egg, three larval instars, and a pupal stage. Female adults demonstrate a significantly higher mean longevity of 40.8 days compared to 29.4 days for males, a characteristic that supports successful biocontrol programs through increased offspring contribution. Given that these results align with established biological data for this predator, *C. zastrowi sillemi* is identified as an effective natural enemy suitable for inclusion in integrated pest management strategies against the cabbage aphid (Fig. 4).

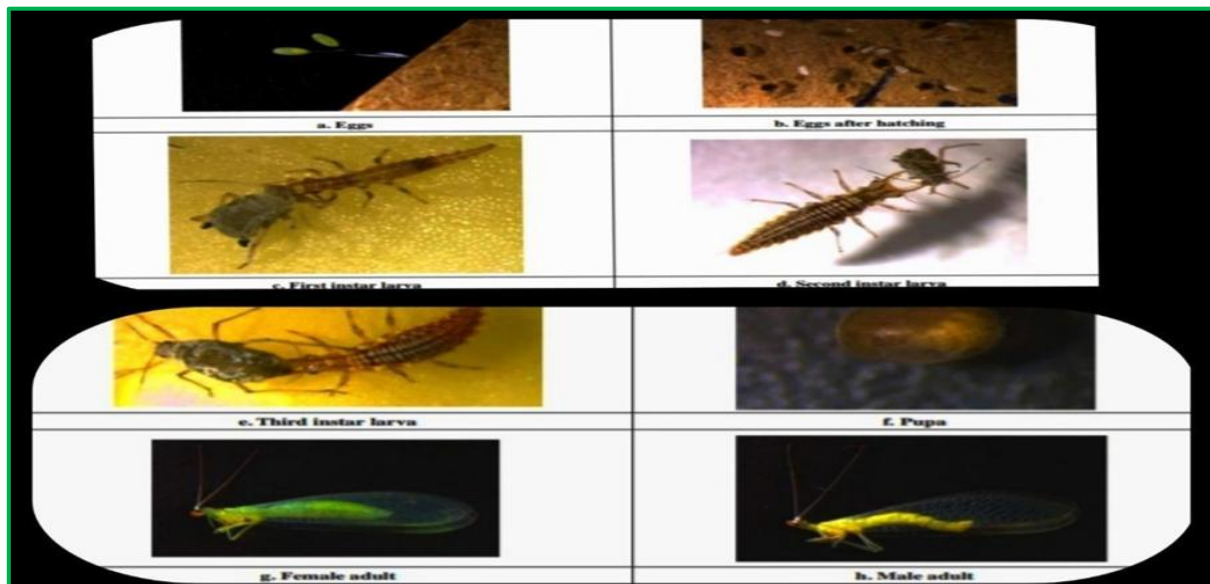


Fig. 4 Life Cycle of *Chrysoperla zastrowi sillemi*

5. Assassin Bug (*Platymeris laevicollis*)

Life Cycle: Assassin bugs undergo incomplete metamorphosis through egg, nymph, and adult stages, typically beginning with ritualized summer mating followed by the deposition of cylindrical egg clusters on plants. Emerging wingless nymphs moult four to seven times over several months to a year before reaching maturity and developing functional wings. In colder regions, these hemipterans survive by overwintering in a dormant state within protected crevices or logs, a strategy that often results in a longer lifespan compared to those in warmer climates.

6. Rice Bug or Mirid Bug (*Cyrtorhinus lividipennis*)

Life Cycle: The mirid undergoes an egg stage of 6–9 days and a four-instar nymphal stage of 10–17 days, with adults living up to 25 days unless mortality occurs after 2–3 days of starvation. During development, nymphs consume a daily average of 7.45 *Nephotettix* (Green Leaf Hopper) eggs or 1.35 nymphs, while adults exhibit higher predation rates over a 10-day span. Specifically, both adult sexes consume approximately 10 eggs and 4.7 nymphs daily, though males average 2.45 adult prey compared to the 1.25 consumed by females (Fig. 5).



Fig. 5 Life cycle of *Cyrtorhinus lividipennis*

Table 1: Different Types of Important Predators Present in Agricultural Field

Predator Species	Family with Order	Target Pest
<i>Novius cardinalis</i> (Vedalia Beetle)	Coccinellidae (Coleoptera)	Cottony Cushion Scale (<i>Icerya purchase</i>)
<i>Platymeris laevicollis</i> (Assassin Bug)	Reduviidae (Hemiptera)	Coconut Rhinoceros Beetle (<i>Oryctes rhinoceros</i>)
<i>Cyrtorhinus lividipennis</i> (Rice Bug or Mirid Bug)	Miridae (Hemiptera)	Brown Plant Hopper (<i>Nilaparvata lugens</i>) Green Leaf Hopper (<i>Nephotettix</i> sp.)
<i>Menochillus sexmaculata</i>	Coccinellidae (Coleoptera)	Mealybugs and Scales
<i>Chilocorus nigritus</i> (Malaysian Ladybird Beetle)	Coccinellidae (Coleoptera)	Sugarcane Scale Insect (<i>Melanaspis glomerata</i>)
<i>Cicindela sexpunctata</i> (Six Spotted Tiger Beetle)	Carabidae (Coleoptera)	Small soil borne insects, caterpillar

Important Parasitoids and their Life Cycle

1. *Trichogramma japonicum* (Egg Parasitoid):

Life cycle: The *Trichogramma* life cycle completes in 14 days at 21°C, with females depositing 60–70 eggs into host moth eggs within 1–2 days of mating. Within the host egg, larvae develop and pupate over 10 days, causing the egg to darken before minute adults emerge through chewed holes under optimal temperature and humidity. These adults, which feed on nectar and pollen, can produce over 30 generations per season with a variable lifespan of 7–75 days depending on the species parasitized and environmental conditions (Fig. 6).

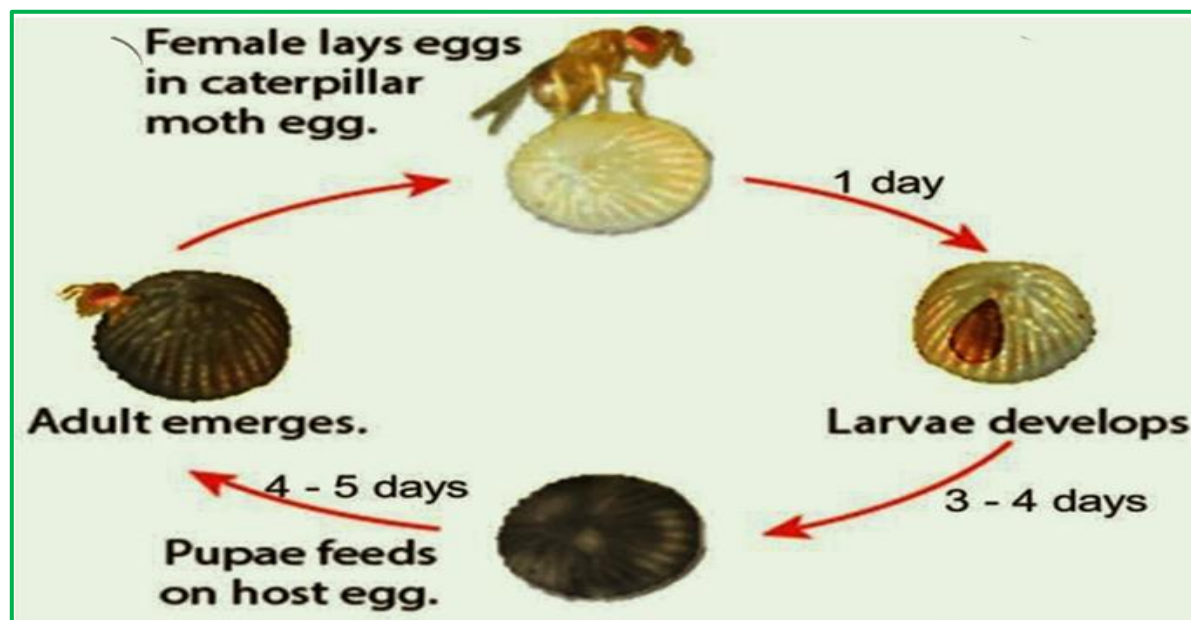


Fig. 6 Life Cycle of *Trichogramma japonicum*

2. *Chelonus blackburni* (Egg-Larval Parasitoid):

Life Cycle: *Chelonus blackburni* is a uniparental egg-larval parasitoid that targets various bollworms like *Pectinophora gossypiella* and *H. armigera* globally, utilizing factitious hosts such as *C. cephalonica* and *P. opercullella*. The parasitoid develops internally until the host's last instar, eventually exiting the stunted larva to complete external consumption and spin a cocoon. After discharging its meconium and undergoing pupation within the cocoon, the adult emerges through a hole cut at the anterior end (Fig. 7).

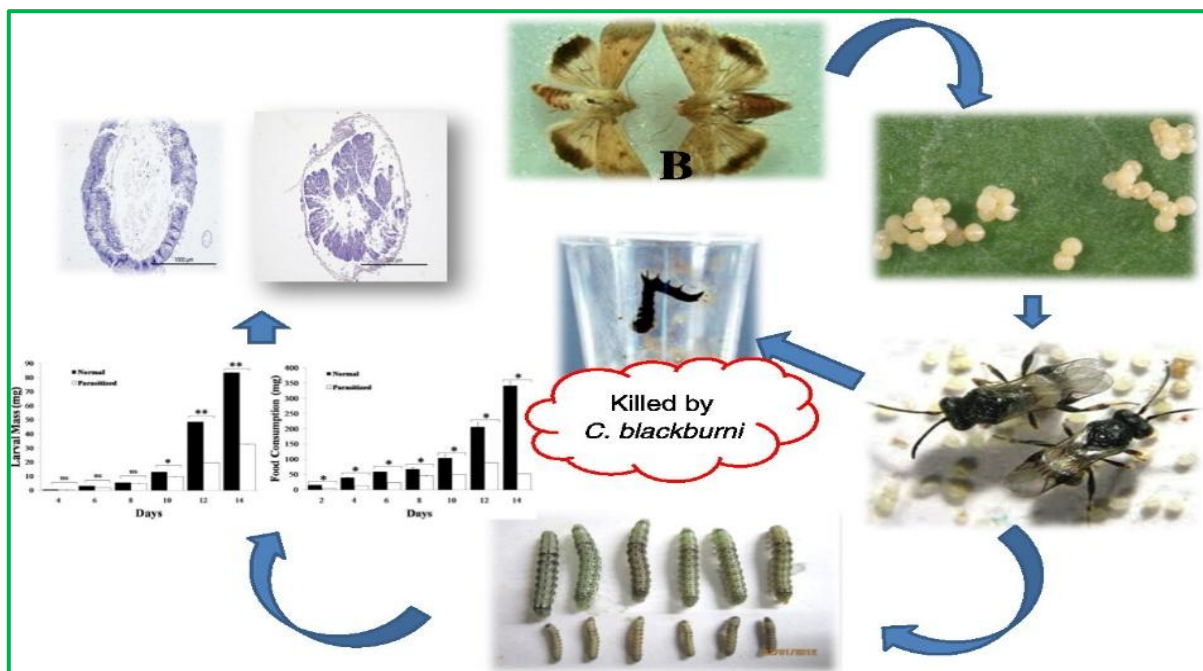


Fig. 7 Parasitism by *Chelonus Blackburni*

3. Bracon hebetor (Larval Parasitoid):

Life Cycle: At 30°C, development from egg to adult occurs in 9 to 10 days, with female longevity estimated at approximately 20.88±0.97 to 23 days. Females demonstrate a fecundity of about 100 eggs, depositing 65% of their total eggs during an oviposition period that begins immediately upon emergence. While the progeny sex ratio is initially female-biased, it shifts toward a male-bias over time, maintaining an overall estimated ratio of 0.66 (Fig. 8).

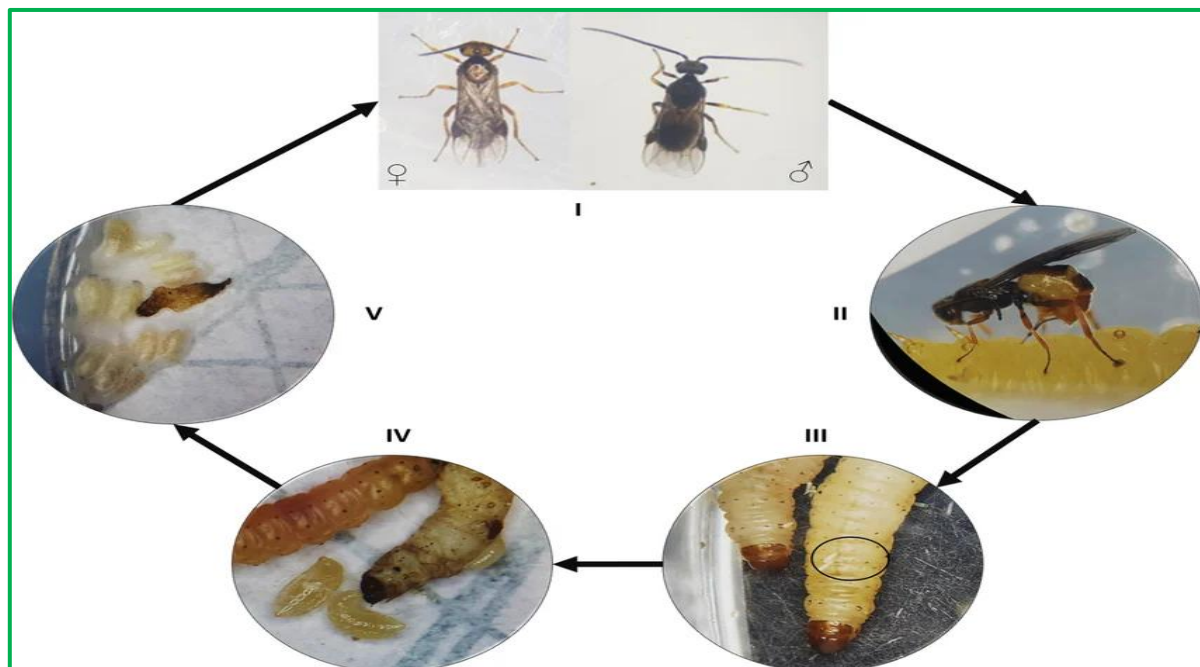


Fig. 8 Life cycle of *Bracon hebetor* I: female and male wasps, II: female wasp injects venom, III: parasitoid eggs on host (encircled), IV: parasitoid larvae, V: pupated parasitoid larvae.

4. Carcelia illota (Larval-Pupal Parasitoid):

Life Cycle: *Carcelia illota* deposited white, oval, and flat eggs frequently on caterpillars or the shoulders of stink bugs, where the maggot then develops internally. While some species deposit larvae directly onto the host, others transition into a dark reddish-brown, wheat-shaped pupa following the larval stage. The emerging adult is typically hairy or bristly,

ranging in appearance from dark grey to black and often resembling a common housefly in size (Fig. 9).

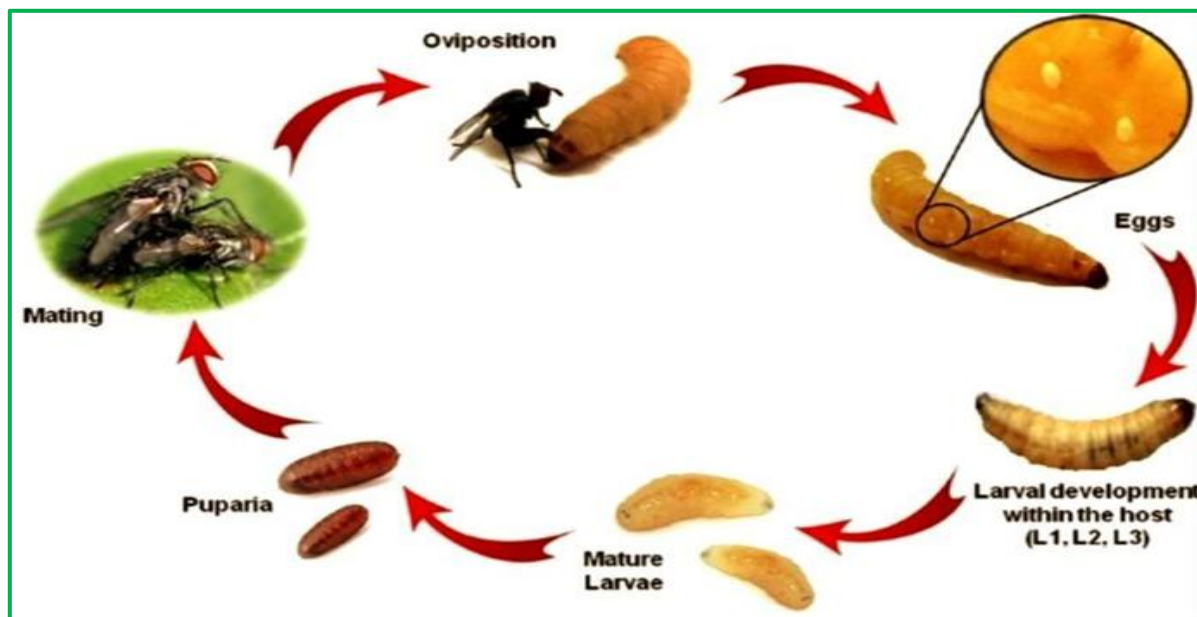


Fig. 9 Life Cycle of *Carcelia illota*

5. *Xanthopimpla punctata* (Pupal Parasitoid):

Life Cycle: The white, elongate eggs of *Xanthopimpla sp.* possess a smooth, translucent chorion and a broader anterior end that swells prior to hatching into yellowish larvae characterized by fat globules. During the prepupa and pupa stages, the organism develops brown eyes and specific abdominal punctations, including a centrally placed conical marking on the final segment. Emerging adults vary in size and ovipositor sheath length depending on whether they were reared on *O. arenosella* or *A. peponis*, though parasites emerging from the former host demonstrate increased longevity.

Table 2 Important Parasitoid Species Present in Agricultural Field

Parasitoid Species	Family with Order	Target Host
<i>Trichogramma japonicum</i>	Trichogrammatidae (Hymenoptera)	Cotton Boll worm (<i>Helicoverpa armigera</i>)
<i>Chelonus blackburni</i>	Braconidae (Hymenoptera)	Spotted Boll Worm (<i>Earias vittella</i> , <i>E. insulana</i>)
<i>Bracon hebetor</i>	Braconidae (Hymenoptera)	Coconut Black Headed Caterpillar (<i>Opisina arenosella</i>)
<i>Carcelia illota</i>	Tachinidae (Diptera)	<i>Helicoverpa armigera</i>
<i>Xanthopimpla punctata</i>	Ichneumonidae (Hymenoptera)	Coconut Black Headed Caterpillar (<i>Opisina arenosella</i>)
<i>Blaesoziphae kellyi</i>	-	Locust

Conclusion

Natural enemies like predators and parasitoids function as essential trophic regulators that offer a sustainable alternative to synthetic pesticides by suppressing pest populations through direct predation or host-reliant development. These organisms, ranging from aphid-consuming lady bird beetles to specialized egg parasitoids like *Trichogramma*, utilize complex behaviors such as tracking herbivore-induced plant volatiles to efficiently locate their targets. Implementing biocontrol strategies that leverage these natural allies helps maintain crop productivity while fostering ecological balance. Consequently, gaining a

comprehensive understanding of their varied life cycles, including the overwintering strategies of assassin bugs and the internal larval development of parasitoids is vital for the creation of effective, eco-friendly integrated pest management (IPM) programs. Prioritizing the use of these biological agents is a fundamental step toward achieving long-term sustainability in modern farming.

References

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