

NATURAL ENEMIES IN THE HARMONY OF RICE ECOSYSTEM AND THEIR CONSERVATION

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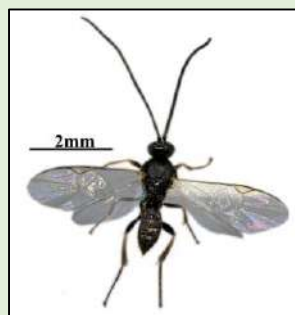
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Natural enemies play an important role in confining the densities of potential pests. Predators and parasitoids are important natural enemies of pests, and they are broadly used in biological pest control. Biological control using parasitoids and predators is an alternate pest control strategy that is currently focussed to displace the role of pesticides that tend to harm the ecosystem and public health. Some of the important natural enemies found in rice ecosystem are discussed here.

1. *Apanteles flavipes* Cameron

Family: Braconidae

Identification: *Cotesia flavipes* is a small black wasp measure approximately 2-4 mm in body length. Adults are characterized by red legs and short antennae, except for the basal part of the hind legs, which is spotted brownish yellow to red. The first segment of abdomen is widened behind, with weak and roundly constricted apicolateral corners. Female adults have a short ovipositor sheath, while males possess feathery antennae, and females have more slender and hairless ones. The abdomen of females is broader, accommodating a visible ovipositor, and both genders measure approximately 2-4 mm in body length.



Biology: The female adult *C. flavipes* lays up to 20 eggs inside a host larva, allowing multiple parasitoids to develop. Its life cycle completed in about 10-14 days under favourable conditions. Eggs hatch in 2-3 days, followed by internal larval feeding for 5-7 days. Pupation occurs on the dead host with cocoon formation, lasting 7-10 days. Adults emerge, mate, and live for 1-2 weeks. A female can lay 200-300 eggs during her lifetime.

Host range: Rice Stem borer and Rice leaf folder larvae



2. *Anagrus optabilis* (Perkins)

Family: Mymaridae

Identification: a small wasp with a reddish-orange to red hue in colour. The forewing's disc is characterized by a narrow and parallel-sided structure, featuring rows of hairs in the basal two-third part and two rows in the apical one-third part. The ovipositor is positioned near the abdominal tip. Male parasitoids possess 13 black antennal segments with a white base, while females have 9-segmented antennae. The wasp's legs have 4-segmented tarsi.



Biology: The life cycle spans about 17 days: egg 2–3 days, larva 6–8 days, pupa 4–5 days, and adult 2–3 days. A female *A. optabilis* parasitizes 15–30 eggs daily. One host egg supports one individual. A female can lay up to 100 eggs during her lifetime.

Host range: Delphacid planthoppers, like *Sogatella furcifera*, *Nilaparvata lugens*

3. *Brachymeria excarinata* Gahan

Family: Chalcididae

Identification: A small, metallic black body with a green or blue sheen, a notably large head wider than the thorax, and prominent green eyes. The antennae are elbowed, dark brown, and consist of 13 segments. Females possess a broader abdomen with a well-developed ovipositor for egg-laying.



Biology: The female wasp lays a single egg inside a host pupa using its ovipositor. The egg stage lasts 1–2 days, larva 5–7 days, pupa 7–10 days, and adult 2–3 days, completing development in 15–22 days. *B. excarinata* can lay up to 100 eggs in its lifetime.

Host range: Scirpophaga incertulas, *Chilo suppressalis*, *Sesamia inferens*

4. *Cardiochiles philippinensis* Ashmead

Family: Braconidae

Identification: a medium-sized black wasp (10–14mm). Hairy eyes and black feet with white hair. Head is large, wider than thorax. Body is black with some metallic sheen, while abdomen slightly compressed laterally.





Brown back with dark tips on both wings. Females are larger and more robust having longer antennae, pointed abdomen while males are smaller and slender than females having shorter antennae and rounded abdomen.

Biology: The development timeline involves the egg stage lasting 1-2 days, larval stage lasting 4-7 days, pupal stage lasting 5-7 days, and the adult stage lasting 2-3 days, summing up to approximately 12-19 days. Fecundity is 200 eggs in their lifespan

Host range: Leaffolder larvae

5. *Charops bicolor* (Szepligeti)

Family: Ichneumonidae

Identification: a wasp, with a black body adorned with yellow-orange markings on the abdomen, legs, and antennae bases. The abdomen, prominently reddish-brown and notably enlarged at the end. The minute size of the legless larvae ranges from 1.2-1.5 mm, boasting a black, slender, slightly flattened body with a metallic sheen.



Biology: The developmental stages encompass 1-2 days for the egg, 5-7 days for the larva, 3-4 days for the pupa, and 2-3 days for the adult, resulting in a total duration of approximately 12 days.

Host Range: Leaffolder, and yellow stem borer larvae

6. *Goniozus nr. triangulifer* Kieffer

Family: Bethyridae

Identification: A bethylid wasp, resembling an ant with flattened body adorned with transparent wings and 13-segmented antennae. Characterized by a metallic sheen, the wasp has an elongated body with a narrow waist, a large head wider than the thorax, and distinctive 13-segmented antennae that are black with a lighter base. The wings are clear with dark veins, while the legs are yellow with dark tips. In terms of sexual dimorphism, females are slightly larger than males. Females possess a wider and slightly flattened abdomen, housing a well-developed ovipositor.



Biology: The developmental timeline is estimated as follows: 2-3 days for eggs, 6-8 days for larvae, 4-5 days for pupae, and 2-3 days for adults. The parasite



undergoes development from egg to adult in a span of 10 to 17 days. The parasitoid infiltrates the folded leaf to lay 3 to 8 eggs externally.

Host range: Leafroller larvae

7. *Macrocentrus philippinensis* Ashmead

Family: Braconidae

Identification: a medium-sized wasp with a thin, orange or dark yellow body. Abdomen is slender with brownish-black dorsal striae. The female's ovipositor is almost as long as its antennae and approximately twice the length of its abdomen. Females are slightly larger than males, and males have feathery antennae, while females have simple antennae. The females also have a broader, slightly flattened abdomen with a well-developed ovipositor.



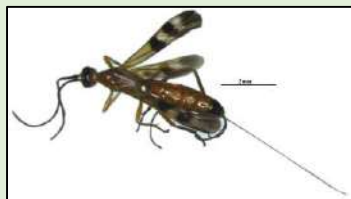
Biology: Adults lays a single egg inside a host larva, producing one parasitoid. Its life cycle spans 17–20 days: egg 2–3 days, larva 6–8 days, pupa 4–5 days, and adult 5–7 days. A female lays up to 20 eggs in her lifetime.

Host range: Primarily leafroller larvae but can also parasitize other rice insect pests like the rice stem borer *Chilo suppressalis*.

8. *Stenobracon Nicevillei* (Bingham)

Family: Braconidae

Identification: The large wasp, measures 9 to 13 mm, characterized by yellowish front wings with three blackish markings. Abdomen is elongated reddish yellow or orange-brown with elevated second segment. The sixth segment of abdomen is black. The female wasp's ovipositor is twice the length of its body, and its body is slender, black with yellow markings on the head, thorax, and abdomen. In terms of sexual dimorphism, females are generally larger, males have longer and more feathery antennae, and only females possess the long, visible ovipositor.



Biology: A female parasitoid lays a single egg inside a stem borer larva using its ovipositor. Development lasts 24–32 days: egg (2–3 days), larva (5–7 days), pupa (7–10 days), and adult (5–7 days). One host larva supports one parasitoid individual.



Host range: Rice stem borers viz., *Scirpophaga incertulas*, *Chilo suppressalis*, other lepidopteran pests.

9. *Temelucha philippinensis* (Ashmead)

Family: Ichneumonidae

Identification: The body is slender and elongated, featuring yellow coloration with black markings. The head is large and wider than the thorax, adorned with long, multi-segmented antennae that are black with a white base. The front wing with a blunt tip on the second discoidal cell. Abdominal segments 3 to 6 alternate between black and reddish brown. Females, slightly larger than males, possess a broader, slightly flattened abdomen equipped with a well-developed ovipositor for egg-laying.



Biology: The parasitoid is solitary, with females laying eggs inside host larvae. Eggs hatch in 2–3 days, larvae develop for 6–8 days, and pupae last 4–5 days. Adults live 2–3 days for mating. A female egg laying capacity 200 eggs in her lifetime.

Host range: *Scirpophaga incertulas*, *Chilo suppressalis*, *Cnaphalocrosis medinalis*

10. *Trichogramma* sp.

Family: Trichogrammatidae

Identification: Trichogrammatids are usually 1mm long with light coloured or moderately pigmented and some are dark coloured. Antenna distinctly shorter with 3-7 flagellomeres. Post stigma vein is absent in fore wing. Tarsi with 3 tarsomeres, which are of same length. The identification of *Trichogramma* species relies on male genitalia, with around 150 known species.



Biology: *Trichogramma* spp. show complete metamorphosis: egg (16–24 h), larva (2–3 days), prepupa (2 days), and pupa (2–3 days). Development lasts 7–8 days in summer, 8–10 in winter. Adults live 6–8 days, with 1:1 sex ratio and 20–200 eggs per female.

Host range: Yellow stem borer and leafroller



11. *Xanthopimpla flavolineata* Cameron

Family: Ichneumonidae

Identification: a medium-sized wasp, with yellow-orange colour. The female is distinguished by a black ovipositor. The body is elongated and slender, predominantly black with yellow markings. Females are larger than males, and they exhibit longer and thinner antennae. Additionally, females have a broader and slightly flattened abdomen with a well-developed ovipositor.



Biology: The egg stage lasts 2-3 days, followed by the larva stage lasting 7-10 days. Subsequently, the pupa stage occurs for 5-7 days, leading to the adult stage, which lasts 7-10 days. In total, the entire life cycle spans approximately 24-30 days. The adult parasitoid can lay 5 to 14 eggs daily. A single female can lay up to 200 eggs in her lifetime.

Host range: Rice stem borers pupae (*Scirpophaga incertulas* and *Chilo suppressalis*), Leafhopper larvae

Predators:

Predators often are the most important group of biological control organisms in rice. Predators occur in almost every part of the rice environment. Most predators are regarded as polyphagous. Amongst the predators of rice pests spiders alone constitute 80 percent of predatory fauna in the paddy ecosystem. Some of the important predators in rice ecosystem are discussed here.

1. *Araneus inustus* (L. Koch)

Common name: Orb Spider

Diagnosis: The legs of both males and females are yellow. They have a brown cephalothorax, yellowish abdomen with a blackish ovoid band on the lateral margins of the dorsal part. The male is 4 to 5 mm long, female is bigger, 5 to 8 mm long. Thin hairs cover the abdomen.

Feeding habit: Builds a web to catch their prey. The web is an irregular pattern located between the leaves. The female lays eggs in folded leaves and covers the eggs by white silken thread.



Host: Planthoppers, Leafhoppers and flies.



2. *Brumoides suturalis* (Fabricius)

Common name: Three striped beetle

Diagnosis: Head and pronotum orange yellow; Elytra glossy white to creamy yellow, scutellum black, three black stripes present on mid-dorsal position of each elytron extending towards apex. Adult females lay 2–20 yellowish eggs in leaf crevices. Larvae have four instars, becoming spiny. Females lay 180–210 eggs, and adults live up to 40 days.



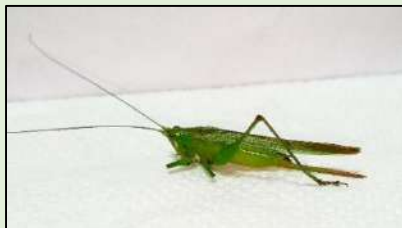
Feeding habit: An adult feed on 11 aphids or 2-3 nymphs of mealybugs per day.

Host range: Both grub and adult are predacious on aphids & pseudo coccids.

3. *Conocephalus longipennis* (De Haan)

Common name: Meadow grasshopper

Diagnosis: Green in colour is differentiated from other grasshoppers with its long thread-like antennae. Slanted face with yellowish thorax and abdomen. The female with elongated ovipositor. Adult life span 3-4 months.



Feeding habit: consume 3 to 4 yellow stem borer egg masses daily.

Host: Nymphs of planthoppers and leafhoppers, Eggs of stem borers and rice bugs

4. *Cyrtorhinus lividipennis* Reuter

Common name: Mirid bug

Diagnosis: Green in colour with membranous wings and black spotted thorax. Body is oval and elongated. first antennal segment tip is greenish yellow. It has green legs with yellowish tibiae. It lays eggs inside plant tissue. A female mirid bug produces 10 to 20 young ones, development period completes in 14–21 days.





Feeding habit: Feeds on 1 to 5 hoppers or 7 to 10 eggs daily. Both the Nymphs and adults suck the hopper eggs by inserting their mouth parts causing the eggs to collapse.

Host: Leafhopper and planthopper eggs and nymphs

5. *Harmonia octomaculata* (Fabricius)

Common name: Ladybird beetles

Diagnosis: Reddish brown in colour. Measures 6 to 7 mm long with black-spots on the body. Each elytron has five black spots and the pronotum with 2-4 quadrate to sub-ovate black spots. produces 150–200 individuals; life cycle completes in 7–14 days.

Feeding habit: The larvae are more voracious feeders than adults. They catch slow-moving prey. Larvae consume 5-10 preys of plant hopper eggs, nymphs and adults daily.

Host: Leafhoppers, planthoppers, aphids, and leafrollers.



6. *Libellula* sp.

Common name: Dragonfly

Diagnosis: Eyes situated on anterior fourth of head and raised above dorsal surface. Abdomen gradually narrowing towards sharp point. Larvae are uncommonly hairy and generally covered with silt. The naiads are aquatic and can live as long as two years underwater.

Feeding habit: Feed on hopper nymphs by moving up on rice stems. The adults may prey on flying insects such as butterflies and moths

Host: Planthoppers, leafhoppers, butterflies and moths



7. *Lycosa pseudoannulata* (Boesenberg and Strand)

Common name: Wolf spider

Diagnosis: Adults abdomen with white markings and the back portions with a fork-shaped mark. They are highly mobile. Males have enlarged palps. Female lays 200–400 eggs; 60–80 spiderlings hatch and ride on the back of the female.



Feeding habit: Wolf spiders feed 5-15 nymphs per day. It was found that in a 14-day period one adult can consume nearly brown plant hopper nymphs or 15–20 adults per day.

Host: Spider lings attack planthopper, leafhopper nymphs and stem borer moths.



8. *Menochilus sexmaculatus* (Fabricius)

Common name: Zigzag ladybird beetle

Diagnosis: A black-spotted beetle with long and narrow black band at the pronotal base is connected to the transverse oval black discal spot by a small and slender longitudinal constriction. Each elytron having rounded black sub-apical spot and two wavy black bands. Total development period takes 6 to 10 weeks. Egg laying capacity is 150 to 200.



Feeding habit: The lady beetles catch slow-moving prey. When disturbed, they fly off. Both the larvae and adults prey on planthopper eggs, nymphs and adults. They can consume 5 to 10 prey daily.

Host: Planthoppers

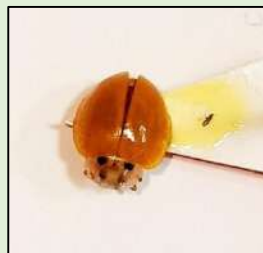
9. *Micraspis* sp. (Mulsant)

Common name: Ladybird beetle

Diagnosis: Yellow oval beetle with two black spots on the head or pronotum. The Adult is 4 to 5 mm long. The elytra lacking any markings.

Feeding habit: They are active during daytime in the top portion of the canopy. Both grub and adults feed on plant hopper nymphs as well as early instars of lepidoptera larvae and exposed eggs.

Host: Planthoppers, leafhoppers, Aphids and leaf-feeding insects





10. *Ophionea nigrofasciata* Schmidt-Gobel

Common name: Ground beetle

Diagnosis: Adults are reddish-brown in colour with a bluish band on the elytra. The beetle has a shiny black head. Two white spots are located at tips of the bluish band.

Feeding habit: Adults always found inside the folded leaf made by the larvae of leaffolder. They can prey on 3 to 5 larvae per day. They also feed on planthoppers.

Host: Leaffolder larvae and planthoppers.



11. *Oxyopes javanus* Thorell

Common name: Lynx spiders

Diagnosis: The female abdomen having four diagonal white bands on the sides and the male with enlarged palps. Brownish patches present on lateral side of cephalothorax. Dorsal surface of the cephalothorax with a pale V-shaped mark. Abdomen elongated with dark brown lateral sides and having median white patch. Legs are long with black line on ventral sides, covered with spines. Female egg laying capacity 68–120 eggs.



Feeding habit: They kill 2-3 moths daily.

Host: Stem borer, leaf folder moths, leafhoppers and rice bug nymphs

12. *Tetragnatha maxillosa* Thorell

Common name: Long-jawed spider

Diagnosis: Adults with long body and legs, measuring 6 to 10 mm in length. Generally seen lying outstretched along the paddy leaf. The males are diagnosed by the enlarged jaws. Their eyes are arranged in two distinct rows. Abdomens is brownish-yellow, and are usually longer than their width. The life span of these insects ranges from 1–3 months and can lay 100–200 eggs. Female egg laying capacity is 100-200.





Feeding habit: They spin a ring- shaped web and catch the flying, prey that hit the web will be quickly wrapped with silk. The eggs are laid in the upper half of rice plants in masses covered by cottony silk. Each individual consumes 2-3 prey daily.

Host: leafhopper, flies, moths



Enhancing spider population in rice field through straw bundle

Details of Important Parasitoids or Predators of Insect pest of Rice

Parasitoid / Predator	Pest Name	Time of release	Dosage
<i>Trichogramma japonicum</i>	Yellow Stem Borer	Release of egg parasitoid, <i>T. japonicum</i> thrice at weekly interval starting 28 days after transplanting , 35 and 42 days after transplanting or Inundative release of <i>T. japonicum</i> 5 to 6 times	5 cc (1 lakh egg parasitoids)/ha/release



Parasitoid / Predator	Pest Name	Time of release	Dosage
		@ 100,000 adults/ha starting from 15days after transplanting.	
<i>Trichogramma chilonis</i>	Leaf folder	Release of egg parasitoid, <i>T. chilonis</i> thrice on 37, 44 and 51 days after transplanting or from 15 days after planting for 5-6 times at 7-10 days intervals or Inundative release of egg parasitoid, <i>T. chilonis</i> 5 to 6 times @ 100,000 adults/ha starting from 15 days after transplanting	5 cc (1 lakh egg parasitoids)/ha/release.
<i>Habrobracon hebator</i>	Leaf folder	Release of <i>H. hebator</i> from 15 days after transplanting	Eight bracon cards (consisting of ~4000-4500 pupae) per hectare.
<i>Platygaster oryzae</i>	Gall midge	10 days after transplanting	Release larval parasitoid, through parasitized galls @ 1 per 10 m ² in the main field
<i>Xanthopimpla flavolineata</i>	Rice stem borers pupae (Scirpophaga incertulas and Chilo suppressalis), leaffolder larvae	Tillering stage/ 30 DAT	50-100 wasps per 1000 m ²



Parasitoid / Predator	Pest Name	Time of release	Dosage
<i>Cyrtorhinus lividipennis</i>	Leaffolder	Release of mirid bug <i>C. lividipennis</i> @at 10 days interval.	50 – 75 egg/ m ²
<i>Cyrtorhinus lividipennis</i>	Brown Plant Hopper	<i>Cyrtorhinus lividipennis</i> @at 10 days interval.	100 bugs or 50-75 eggs/m ²
<i>Lycosa pseudoannulata</i>	Brown Plant Hopper	During peak infestation	200-250 bugs/ha





Conservation practices for natural enemies of insect pest of Rice

Pest Name	Natural Enemies	Conservation practices which needs to be encouraged for preservation and increase in natural enemies population
Yellow Stem Borer	<i>Tetrastichus schoenobii</i> <i>Telomomous rowani</i> <i>Stenobracon nicevillei</i> <i>Cotesia flavipes</i>	Non-pesticide management by growing trap crop like vetiver which serve as a trap crop for stem borer. Adult stem borer has high preference to oviposit but cannot complete its life cycle which can be complemented with light trap and sex pheromone trap in rice ecosystem.
	<i>Lycosa pseudoannulata</i>	Trap crops, like molasses grass or sugar beet, hold an irresistible fragrance for the pests. Once attracted, they congregate in these trap crops, making them easier targets for natural enemies or other control measures. Nectar-rich flowering plants like marigold, cosmos, sunflower and sesame should be grown on rice bunds surrounding rice fields which can provide food, shelter nourishment for biocontrol agent development and reproduction in the rice landscape.
Leaf folder	<i>Temelucha philippinensis</i>	Refuges like field margins, hedgerows, and beetle banks offer crucial overwintering grounds for predators like spiders. Rotate rice with other crops to disrupt the life cycle of specific pests and provide alternative hosts for natural enemies.
	<i>Xanthopimpla flavolineata</i> <i>Goniozus nr. triangulifer</i> Kieffer <i>Macrocentrus philippinensis</i>	
		Minimize the use of broad-spectrum pesticides, as these can harm not only the target pests but also beneficial insects. Growing green manure crops in fields during winter leaving grasses on the bunds at other times of the



Pest Name	Natural Enemies	Conservation practices which needs to be encouraged for preservation and increase in natural enemies population
	Ashmead <i>Lycosa pseudoannulata</i>	year can serve as the overwinter habitats for the natural enemies. Install shelters or refuge areas to protect spiders from extreme weather conditions and predators like straw woven comb shells. Use cover crops, such as legumes or grasses, to create a protective environment for spiders. planting nectar rich plants on the bunds enhances the parasitoid population
Gall midge	Conserve larval parasitoids viz <i>Apanteles</i> sp., <i>Elasmus</i> sp., and <i>Bracon</i> sp., Conserve the pupal parasitoids like <i>Eupteromalus parnarae</i>, <i>Pediobius</i> sp., <i>Apsilops</i> sp.,	Diverse cropping systems promote a variety of habitats and food sources for beneficial organisms. Adopt conservation tillage practices to maintain natural enemy populations by preserving their habitats and reducing soil disturbance. Identification and protection of areas that serve as reservoirs for natural enemies. These areas could include uncultivated patches, weedy margins, or natural habitats.
Brown Plant Hopper	Hydrophilid and Dytiscid beetles, Damselflies, Dragonflies, Nepid and Microveliid bugs, Mesoveliid, <i>Anagrus optabilis</i>	Encourage flowering plants to be grown on rice bunds. Growing sesame plants on the bunds during the rice cropping season encourage <i>Anagrus nilaparvatae</i> and <i>Anagrus optabilis</i> female life span. Sesame flowers have been found to significantly improve searching success for planthopper egg parasitoids of the genus <i>Anagrus</i>.



Pest Name	Natural Enemies	Conservation practices which needs to be encouraged for preservation and increase in natural enemies population
		Application of judicious and need based agrochemicals to protect the beneficial macrofauna associated with paddy. Install straw bundles in the field @ 8/acre to conserve spider population.



Natural enemies in the harmony of rice ecosystem and their conservation

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