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Biology, Ecology and Integrated Management of Two Major Maize Insect Pests: *Chilo partellus* and *Spodoptera frugiperda*

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Maize (*Zea mays* L.) is a globally important cereal cultivated for food, animal feed and industrial uses. It is grown across a wide range of agroclimatic environments and supports both farm income and food security. Its productivity, however, is constrained by insect pests that attack different plant parts throughout crop development. Among the important maize pests are *Chilo partellus* and *Spodoptera frugiperda*. Both are lepidopteran insects, and their larvae are responsible for most of the crop injury. Their feeding patterns differ: *C. partellus* is principally a stem borer, whereas *S. frugiperda* feeds mainly on foliage and within the maize whorl; older larvae can also injure stems and reproductive structures (Dhillon *et al.,* 2021; Deshmukh *et al.,* 2021). The importance of these pests is related to their capacity to reproduce rapidly, develop quickly, use a broad range of hosts and persist under varying environmental conditions. Management becomes more difficult once larvae enter protected plant parts, such as stems or the tightly enclosed whorl. Early and correct identification, routine crop inspection and integrated pest management are therefore necessary to limit losses (FAO and DPPQS, 2021; Muniappan, 2024).

Keywords: Maize, *Chilo partellus*, *Spodoptera frugiperda*, spotted stem borer, fall armyworm, insect biology, life cycle, crop damage, integrated pest management.

Historical Background and Geographical Distribution

Spotted stem borer – *Chilo partellus*

Chilo partellus (Swinhoe) referred to as the spotted stem borer or maize stem borer, is a major pest of maize, sorghum and other cereal crops in tropical and subtropical Asia and Africa. It is regarded as native to the Indian subcontinent and has long been recognised as an important cereal pest in South Asia (Kfir *et al*., 2002; Dhillon *et al*., 2021). During the twentieth century, it was also recorded in eastern and southern Africa and became established in several countries. Its ability to develop on different grass hosts and persist between crop seasons has supported its establishment in varied farming environments. In India, it continues to cause economic damage to maize, sorghum and other cultivated grasses (Kfir *et al*., 2002; Dhillon *et al*., 2021). Infestation levels are affected by temperature, rainfall, cropping sequences, host availability and crop-management practices. Populations can build up quickly when environmental conditions are favourable and suitable hosts remain available (Dhillon *et al*., 2021).

Fall armyworm – *Spodoptera frugiperda*

The fall armyworm, *Spodoptera frugiperda* (J.E. Smith), is a destructive invasive pest originating from tropical and subtropical areas of the Americas. It was recognised as a serious

pest of maize and several other crops in Central and South America. Its spread to other continents increased after it was detected in West Africa in 2016 (FAO; Deshmukh *et al*., 2021). In India, the first report was made in May 2018 in Shivamogga district, Karnataka. The insect later spread to major maize-producing states, including Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra and Odisha (Siddhapara *et al*., 2021; Navik *et al*., 2020). Its migratory adults, high reproductive capacity and access to suitable host plants have contributed to this rapid expansion. The species can feed on more than 80 plant species, making it a concern for crops beyond maize (FAO; Deshmukh *et al*., 2021).

Taxonomy and Classification

Both species are members of the order Lepidoptera, but they are assigned to separate families.

Taxonomic category	*Chilo partellus*	*Spodoptera frugiperda*
Kingdom	Animalia	Animalia
Phylum	Arthropoda	Arthropoda
Class	Insecta	Insecta
Order	Lepidoptera	Lepidoptera
Family	Crambidae	Noctuidae
Genus	Chilo	Spodoptera
Species	partellus	frugiperda
Common name	Spotted stem borer	Fall armyworm
Major damaging stage	Larva	Larva

Chilo partellus is classified in the family Crambidae and subfamily Crambinae, whereas *S. frugiperda* is a member of the family Noctuidae (Dhillon *et al.,* 2021; Deshmukh *et al.,* 2021).

Biology and Morphology of *Chilo partellus*

Chilo partellus develops through complete metamorphosis, passing through egg, larva, pupa and adult stages. Larvae cause the direct injury to maize, while adults are involved in reproduction and dispersal. Temperature, relative humidity, host quality and other environmental factors affect its development (Rajak *et al*., 2024; Dhillon *et al*., 2021).

Egg: Eggs are small, flattened, oval and scale-like. Females usually deposit them in overlapping batches on the underside of maize leaves, often close to the midrib. Newly laid eggs are creamy white or pale, becoming darker as the embryo develops. A female can lay several hundred eggs in its lifetime. Under suitable conditions, hatching generally takes about 3–5 days, with variation according to temperature and humidity (Dhillon *et al.,* 2021; Rajak *et al.,* 2024).

Larva: The larval stage causes the greatest damage. Newly emerged larvae first feed on tender leaf tissue before moving towards the whorl and growing point and later boring into the stem. Mature larvae are usually yellowish-brown or brown, with a dark brown head capsule and distinct dark spots on the body. Larvae commonly pass through six instars, although conditions and food quality can influence development. The larval period may last approximately two to four weeks under favourable conditions (Rajak *et al.,* 2024; Dhillon *et al.,* 2021).

Pupa: After completing larval development, the insect ceases feeding and pupates, usually within the maize stem or among plant debris. The pupa is pale at first and darkens as it matures. The pupal period is generally about one week, but its length is affected by temperature and other environmental conditions (Rajak *et al.,* 2024).

Adult: The adult is a medium-sized moth, typically straw-coloured. Differences in wing markings and body features can be observed between males and females. Moths are usually active during evening and night and may disperse to nearby maize fields. After mating, females lay eggs on suitable host plants, beginning the next generation. Several generations may overlap when cropping and weather conditions are favourable (Kfir *et al.,* 2002; Dhillon *et al.,* 2021).

Life Cycle of *Chilo partellus*

The development of *C. partellus* proceeds through four distinct stages.

Developmental stage	Approximate duration
Egg	3–5 days
Larva	14–30 days or longer, depending on conditions
Pupa	5–12 days
Total development	Variable; commonly around 30–50 days

The durations listed are approximate and should not be considered fixed values. Temperature, host plant and experimental conditions influence development. Larvae may persist in crop residues or enter a resting state when conditions are unsuitable (Kfir *et al.,* 2002; Rajak *et al.,* 2024).

Nature of Damage and Symptoms Caused by *Chilo partellus*

Maize may be attacked by *C. partellus* from the early vegetative period through later crop stages. The extent of injury is determined by plant age, larval density and how long infestation continues. The main symptoms are outlined below.

Leaf feeding and shot-hole symptoms

Young larvae feed on tender, folded leaves. Once these leaves expand, rows or parallel arrangements of small holes become apparent; this characteristic injury is called the shot-hole symptom (TNAU; KAU.).

Window-pane formation

At an early stage, larvae scrape the leaf surface and consume tissue beneath it without removing the entire leaf. The affected areas consequently appear as translucent, window-like patches (Dhillon *et al.,* 2021).

Dead-heart formation

Larvae that reach the central shoot may injure the growing point. As a result, the central leaves turn yellow or brown, dry out and may die, producing the typical dead-heart symptom. This damage is especially important in young plants (TNAU; KAU.).

Stem tunnelling

Older larvae tunnel into the stem and feed on its internal tissues. These galleries weaken the plant, while entry holes and frass may be visible on the stem surface, particularly around nodes (Dhillon *et al.,* 2021; NBAIR, n.d.).

Reduction in plant growth and yield

Internal stem feeding can disrupt the movement of water and nutrients, lower plant vigour and increase the risk of lodging. Under severe attack, cob development and grain filling may be affected, leading to reduced yield (Dhillon *et al.,* 2021).



Figure 1. Typical symptoms of spotted stem borer infestation in maize

Biology and Morphology of *Spodoptera frugiperda*

Like *C. partellus*, the fall armyworm has four stages of complete metamorphosis: egg, larva, pupa and adult. Its larvae differ in feeding behaviour because they mainly consume leaf tissue and feed inside the maize whorl. Older larvae may also injure tassels, ears and developing cobs (Deshmukh *et al.,* 2021; Siddhapara *et al.,* 2021).

Egg: Fall armyworm eggs are small and dome-shaped and are laid in clusters on either surface of maize leaves. Females may cover egg masses with abdominal scales, giving the clusters a fuzzy appearance. Depending on host and environmental conditions, a female may produce several hundred or more than one thousand eggs. Under favourable conditions, eggs generally hatch in about 2–4 days (Ahir *et al.,* 2020; Siddhapara *et al.,* 2021).

Larva: Larvae are the damaging stage of fall armyworm. Newly hatched individuals often feed together, scraping the leaf surface. As they grow, they disperse and move into the central whorl. Mature larvae range from greenish to brownish and may bear longitudinal stripes and dark spots. Two useful diagnostic features are:

1. An inverted Y-shaped marking on the head capsule.
2. Four prominent dark spots arranged approximately in a square pattern on the eighth abdominal segment.

Fall armyworm usually completes six larval instars, although variation can occur under some conditions. Mature larvae may also show cannibalism, which can reduce the number of individuals sharing a plant (Deshmukh *et al.,* 2021; Siddhapara *et al.,* 2021).

Pupa: At maturity, the larva leaves the plant and enters the soil, where it constructs a pupal chamber. The chamber is generally formed a few centimetres below the soil surface, with depth influenced by soil conditions. The pupa is reddish-brown and remains underground until the adult emerges. Under favourable conditions, pupation commonly lasts around 7–14 days (Ahir *et al.,* 2020; Deshmukh *et al.,* 2021).

Adult: The adult fall armyworm is a moth with nocturnal activity. The sexes can be distinguished by their wing patterns: males generally have more conspicuous forewing markings, while female markings are usually less contrasting. Adults are capable of strong, long-distance flight. Following mating, females lay egg masses on suitable host plants, particularly maize. This migratory ability contributes to the pest's rapid spread (Muniappan, 2024; Deshmukh *et al.,* 2021).

Life Cycle of *Spodoptera frugiperda*

The length of the fall armyworm life cycle is not constant; it changes with temperature, humidity, food quality and other environmental factors.

Developmental stage	Approximate duration
Egg	2–4 days
Larva	14–21 days
Pupa	7–14 days
Adult	Usually, several days
Total development	Commonly around 30–45 days under favourable conditions

Indian laboratory investigations on maize have recorded complete life-cycle periods of approximately 32–47 days, with differences between sexes and experimental conditions (Ahir *et al.,* 2020; Siddhapara *et al.,* 2021).

Nature of Damage and Symptoms Caused by *Spodoptera frugiperda*

Fall armyworm injury is caused mainly by larval feeding. Infestation can occur at several crop stages, although damage is often conspicuous in seedlings and plants at the whorl stage.

Leaf scraping: Newly hatched larvae scrape the epidermal layer of young leaves. This feeding produces pale, translucent or silvery marks on the leaf surface (Deshmukh *et al.,* 2021).

Window-pane symptoms and irregular holes: As larvae become larger, they remove greater amounts of leaf tissue. The damage becomes visible as irregular holes and elongated feeding marks when the leaves unfold (FAO and DPPQS, 2021).

Whorl damage: Larvae commonly feed within the central whorl, where they consume young, developing leaves. Newly exposed leaves may therefore have irregular holes, torn edges and a ragged appearance (FAO and DPPQS, 2021).

Frass accumulation: A useful sign of fall armyworm activity is the accumulation of sawdust-like faecal material, termed frass, in the whorl. Fresh frass together with recent feeding injury can help identify an active infestation (Deshmukh *et al.,* 2021).

Damage to tassels and cobs: Older larvae can feed on tassels, silks, developing ears and kernels. Such injury may disrupt pollination and grain development and can lower both the quality and market value of the harvested crop (Navik *et al.,* 2020; Deshmukh *et al.,* 2021).

Stunting and yield reduction: Heavy attack during early growth can reduce leaf area, restrict plant growth and cause stunting. Feeding on reproductive parts can additionally reduce kernel formation and overall productivity (Navik *et al.,* 2020).



Figure 2. Characteristic fall armyworm damage symptoms in maize

Comparative Importance of the Two Insect Pests

Although the two pests are both lepidopterans that attack maize, they can be distinguished by their feeding habits and the symptoms they produce.

Characteristic	*Chilo partellus*	*Spodoptera frugiperda*
Common name	Spotted stem borer	Fall armyworm
Geographical origin	Indian subcontinent/Asia	Tropical and subtropical Americas
First major report in India	Established pest	2018, Karnataka
Family	Crambidae	Noctuidae
Main damaging stage	Larva	Larva
Egg laying	Batches on leaves	Egg masses, often covered with scales
Main feeding site	Whorl, growing point and stem	Leaves and central whorl
Typical symptom	Dead heart and stem tunnelling	Whorl damage and frass
Larval identification	Yellowish-brown larva with brown head	Inverted Y on head and four dark spots in a square pattern
Pupation	Commonly inside plant stem or residues	Generally, in soil
Major management concern	Concealed stem feeding	Rapid spread and whorl feeding

Both species may be present in the same maize-growing area and contribute to pest pressure at the same time. Their co-occurrence should be established by examining and identifying larvae, rather than diagnosing the pest from nonspecific leaf injury alone (Navik *et al.,* 2020; Dhillon *et al.,* 2021).

Integrated Management of *Chilo partellus* and *Spodoptera frugiperda*

Integrated pest management (IPM) provides a sustainable framework for suppressing these insects. It brings together cultural, mechanical, biological, botanical and chemical options, selected in response to field observations and crop conditions. The aim is to keep pest populations below economically damaging levels, conserve beneficial organisms and avoid pesticide applications that are not needed (FAO and DPPQS, 2021; NIPHM).

Cultural management

Cultural methods alter crop and field practices in ways that can make pest establishment, survival and multiplication less favourable.

A. Timely sowing: Sowing the crop uniformly and at the recommended time can help prevent a continuous supply of susceptible maize for successive pest generations. Where coordinated community planting is feasible, staggered sowing should be avoided, particularly as part of fall armyworm management (FAO and DPPQS, 2021).

B. Crop rotation: Including suitable non-host crops in rotation can interrupt the continuous availability of host plants. The crops selected for rotation should reflect local production systems and the host range of the pest being managed.

C. Intercropping: Growing maize with appropriate legumes, including cowpea, green gram or black gram, can diversify the cropping system and may reduce pest incidence. Maize–legume intercropping is also included in Indian maize IPM recommendations (NIPHM; FAO and DPPQS, 2021).

D. Field sanitation: Removing and properly destroying heavily infested crop residues after harvest can reduce the survival of stem borer larvae and pupae between seasons. Infested maize stalks should therefore be managed rather than left in the field (KAU; NIPHM).

E. Balanced nutrient management: Appropriate irrigation and balanced nutrient supply support healthy crop growth. Excess nitrogen should be avoided because it can promote excessive vegetative growth and may change crop susceptibility to certain insect pests.

F. Deep summer ploughing: Ploughing deeply before planting can bring soil-dwelling pupae and other resting stages to the surface, where predators, sunlight and adverse conditions may affect their survival. This practice is particularly relevant to fall armyworm management (FAO and DPPQS, 2021; PPQS).

Mechanical management

Mechanical measures are most practical during the early stages of infestation, when egg masses and young larvae can still be reached.

1. Regular field scouting should be conducted from seedling emergence onwards.
2. Egg masses and young larval clusters should be collected and destroyed where feasible.
3. Infested whorl leaves and heavily damaged plant parts may be removed in limited areas when this can be done without damaging the crop.
4. Dead-heart plants caused by stem borers should be removed and destroyed to reduce further pest development.
5. Pheromone traps can be installed for monitoring adult moth activity and determining periods of increased pest activity.
6. Bird perches can encourage insectivorous birds to visit the field and feed on exposed caterpillars.

Pheromone traps are mainly intended to monitor adult activity. Their catches should be interpreted together with field scouting and should not be used alone as an estimate of larval infestation (FAO and DPPQS, 2021; PPQS).

Biological management

Biological control supports sustainable pest suppression through the activity of natural enemies and insect-pathogenic microorganisms.

A. Egg parasitoids

- *Trichogramma chilonis*
- *Trichogramma pretiosum*
- *Telenomus remus*

Egg parasitoids attack the egg stage and prevent larvae from emerging. The species selected and the timing of releases should follow local guidance and should be appropriate for the target pest (FAO and DPPQS, 2021; Muniappan, 2024).

B. Larval parasitoids

- *Cotesia flavipes*
- *Bracon species*
- Other locally occurring larval parasitoids

Cotesia flavipes is an important parasitoid of stem-boring lepidopteran pests, including *C. partellus*. Protecting naturally occurring enemies can therefore support the longer-term suppression of stem borers (Kfir *et al*., 2002; NIPHM).

C. Predators

Ladybird beetles, spiders, lacewings, predatory bugs and ants may help suppress insect eggs and young larvae. Limiting unnecessary use of broad-spectrum insecticides helps protect these beneficial organisms (FAO and DPPQS, 2021).

D. Microbial insecticides

Microbial agents that can be considered in pest management programmes include:

- *Bacillus thuringiensis* (Bt).
- *Beauveria bassiana.*
- *Metarhizium anisopliae.*
- *Metarhizium rileyi.*

These microbial agents act on susceptible insect stages. Their performance is influenced by formulation, weather, application timing and larval age (Deshmukh *et al.,* 2021; Kumar *et al.,* 2025).

Botanical management

Products derived from plants may be incorporated into insect-management programmes with the aim of reducing reliance on conventional insecticides. Neem-based preparations are among the botanical products studied against maize pests.

Important botanical products include:

A. Neem-based formulations: Azadirachtin-containing neem products can interfere with feeding, growth and development. They may be useful in early-stage IPM programmes when applied in accordance with registered product directions.

B. Neem seed kernel extract: Neem seed kernel extract has been studied for insecticidal and antifeedant effects on several crop pests. Results can vary with the method of preparation, concentration and conditions of application.

C. Other plant-based products: Karanj-based products and other plant oils or extracts have also been assessed against maize pests. Their performance needs to be evaluated under local field conditions using standardised formulations.

Chemical management

Insecticides may be considered when pest numbers reach locally accepted economic action thresholds and non-chemical measures alone are inadequate. Product choice must take account of the pest species, larval stage, crop stage, current registration status and local recommendations.

Important principles include:

1. Conduct regular field scouting before deciding on insecticide application.
2. Prefer selective insecticides that are effective against the target pest and less harmful to natural enemies.
3. Apply insecticides when larvae are young and exposed, before they become deeply concealed inside stems or whorls.
4. Ensure adequate coverage of the target feeding site.

5. Rotate insecticides with different modes of action to delay resistance development.
6. Follow the registered label dose, waiting period, personal protective equipment requirements and other safety instructions.
7. Avoid unnecessary applications, especially during flowering and periods of high pollinator activity.

For fall armyworm, Indian guidance emphasises scouting from seedling emergence and stage-specific assessment of fresh damage. The national advisory gives different action criteria for seedling, early-whorl and later-whorl stages, rather than recommending routine spraying throughout the crop season (PPQS, n.d.; FAO and DPPQS, 2021).

For stem borer management, the NIPHM maize IPM package includes cultural, mechanical and biological measures, including conservation of natural enemies and use of recommended egg parasitoids. Chemical control should be based on current local agricultural recommendations (NIPHM).

A pesticide should not be selected solely because a research trial reported good performance. Before use, confirm that the formulation is currently registered for the crop and target pest, and follow the latest label directions and advice from the local agricultural university or plant-protection authority.

Field Monitoring and Identification

Correct diagnosis matters because the recommended management options are not identical for the two insect pests.

Monitoring of *Chilo partellus*

- Examine young maize leaves for shot-hole and window-pane symptoms.
- Look for drying of the central shoot.
- Inspect stems for boreholes and frass.
- Split suspicious stems to confirm larval presence and tunnelling.
- Record the percentage of plants showing fresh infestation.

Monitoring of *Spodoptera frugiperda*

- Start field scouting soon after seedling emergence.
- Examine the upper and lower leaf surfaces for egg masses.
- Inspect central whorls for larvae and fresh frass.
- Identify larvae using the inverted Y-shaped head marking and four dark spots arranged in a square on the eighth abdominal segment.
- Record the percentage of plants showing fresh whorl damage.
- Use pheromone traps to monitor adult moth activity.

The FAO–DPPQS farmer field school manual outlines field-surveillance procedures and integrated management practices for fall armyworm in Indian maize systems (FAO and DPPQS, 2021).

Challenges in Management

Several biological and production-related characteristics make *C. partellus* and *S. frugiperda* difficult to manage.

Concealed feeding: *C. partellus* larvae bore into stems, whereas older fall armyworm larvae often remain deep within the whorl. In both cases, the larvae become less accessible to contact insecticides and natural enemies.

High reproductive capacity: Under favourable conditions, both insects can produce large populations, creating the potential for rapid increases in infestation.

Overlapping generations: When host plants are continuously available, successive generations can develop and maintain pest populations across the agricultural landscape.

Insecticide resistance: Repeated applications of insecticides that share the same mode of action can favour resistant individuals and gradually reduce control performance.

Weather and cropping systems: Temperature, rainfall, host availability and agronomic practices affect pest development, survival and dispersal.

These constraints demonstrate why management should combine monitoring, crop and field practices, biological control and careful insecticide use (Dhillon *et al.,* 2021; Deshmukh *et al.,* 2021; Muniappan, 2024).

Future Research Priorities

Research is still needed to develop management programmes that are sustainable and suited to local maize-growing conditions. Key priorities include:

1. Identification and development of maize genotypes resistant or tolerant to stem borer and fall armyworm.
2. Investigation of morphological and biochemical traits associated with host-plant resistance.
3. Evaluation of locally available parasitoids, predators and entomopathogens.
4. Development of effective botanical formulations and microbial biopesticides.
5. Monitoring of insecticide resistance and evaluation of suitable insecticide rotation programmes.
6. Molecular identification and population genetic studies to understand pest diversity and geographical spread.
7. Development of forecasting and early-warning systems based on weather and field monitoring.
8. Evaluation of combined management strategies under different maize-growing environments.

Combining resistant or tolerant maize material with biological control and insecticide applications made only when justified may strengthen long-term management and reduce dependence on conventional chemical control (Dhillon *et al.,* 2021; Muniappan, 2024; Kumar *et al.,* 2025).

Conclusion

Chilo partellus and *Spodoptera frugiperda* are important constraints on maize production in India and other maize-growing regions. Although both are members of Lepidoptera, they differ in geographical origin, biology, feeding behaviour and the symptoms they cause. *C. partellus* mainly injures the growing point and stem, producing shot holes, dead hearts and internal stem tunnels. In contrast, *S. frugiperda* primarily feeds on leaves and within the whorl, resulting in irregular holes, extensive foliage injury and frass accumulation. Successful management depends on timely identification, regular field inspection and the coordinated use of several control measures. Cultural practices, removal of infested plant material, conservation and use of natural enemies, botanical products and responsible insecticide use should be combined according to local conditions. A well-designed IPM programme can suppress pest populations, conserve beneficial organisms, improve maize productivity and reduce unnecessary pesticide use (FAO and DPPQS, 2021; NIPHM; Muniappan, 2024).

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