

Chapter 2. Epidemiology, Dynamics, and Identification of Pest Populations

Understanding how pest populations emerge, develop, and interact with their environment is fundamental to developing effective control strategies. This chapter focuses on epidemiology, which studies the dynamics of these populations, as well as methods for identifying the main groups of pests that threaten crops.

2.1. Epidemiology of Pest Populations

Epidemiology, as applied to crop protection, is the science that studies the factors influencing the appearance, development, and spread of bio-aggressor populations over time and space. For a given pest, its population dynamics depend on the balance between several key factors:

- **Biotic Potential:** This is the innate ability of a species to multiply in the absence of limiting factors. It is determined by the **birth rate** (fecundity, number of generations per year) and the **death rate**.
- **Environmental Resistance:** These are all the environmental factors that slow down population growth. They include:
 - **Abiotic Factors:** Primarily climatic conditions (temperature, humidity, photoperiod, wind). Each pest has an optimal range of conditions for its development. For example, a mild winter can favor pest survival and lead to outbreaks the following spring.
 - **Biotic Factors:** These include the availability and quality of the host plant, competition (between individuals of the same or different species), and the presence of **natural enemies** (predators, parasitoids, and pathogens) that regulate pest populations.

Modern agricultural practices, such as monoculture, can reduce environmental resistance by providing the pest with an abundant and homogeneous food source while limiting habitats for its natural enemies.

2.2. Identification of Pest Populations

Correct and early identification of a pest is the essential first step in any control strategy. Misidentification can lead to the use of an ineffective control method, yield losses, and unnecessary expenses.

Identification relies on two complementary approaches:

1. **Direct Identification of the Pest:** This involves observing the animal itself. It requires good knowledge of the morphology of the different developmental stages (egg, larva, nymph, and adult). Tools like a hand lens are often necessary for smaller organisms.
2. **Identification by Symptoms and Damage:** Often, the pest is discreet or nocturnal. It is then detected by the traces it leaves: holes or cuts in leaves (chewing damage), discolored or curled leaves (piercing-sucking damage), presence of webs, honeydew, or sooty mold, galls on roots, etc.

Field monitoring (scouting) is an essential practice. It consists of regularly inspecting crops to detect the first signs of infestation, assessing the pest population level, and deciding whether an intervention is necessary based on **action thresholds**.

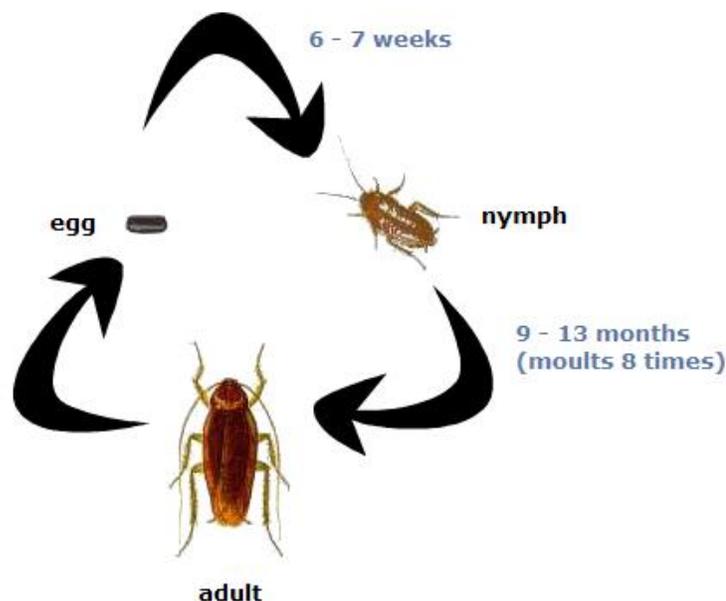
2.3. Biology and Identification of Insect Pests

Insects represent the most significant class of agricultural pests. Their success is linked to their great diversity, reproductive capacity, and adaptability.

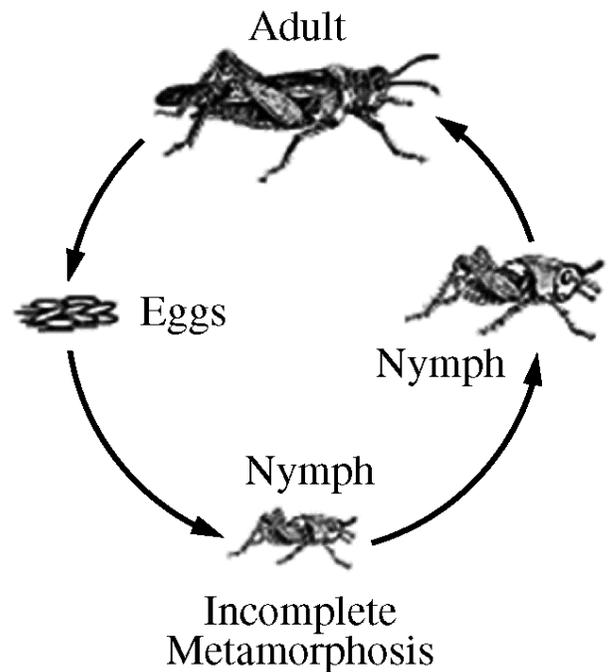
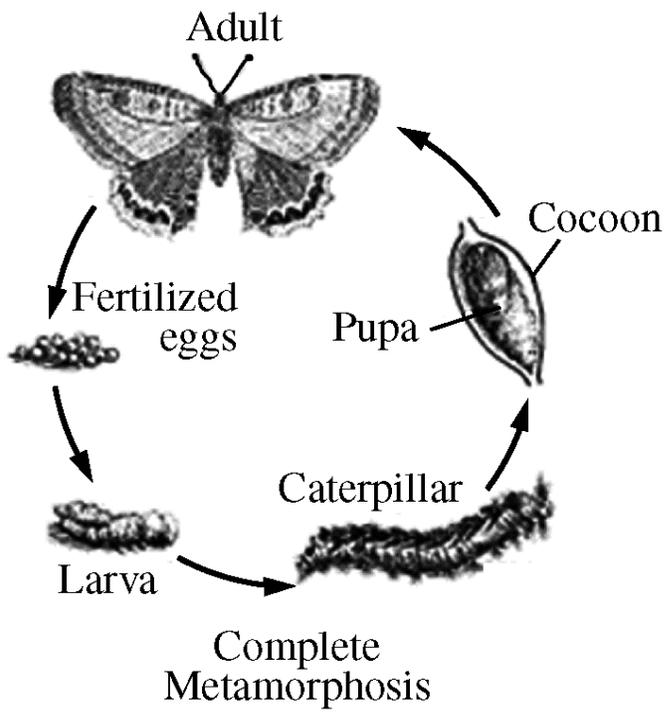
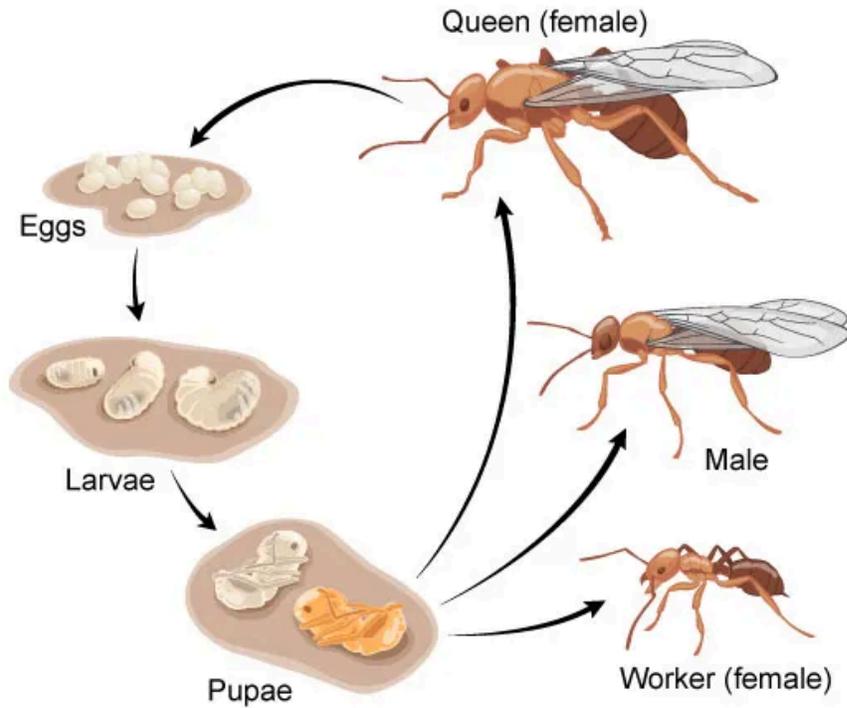
Their life cycle, or development cycle, can be of two types:

2.3.1 Incomplete Metamorphosis: The insect goes through the egg, nymph (resembling a miniature adult), and adult stages. (e.g., grasshoppers, aphids).

No pupal stage: This is key for incomplete metamorphosis



2.3.2 Complete Metamorphosis: The cycle includes egg, larva (caterpillar, maggot, grub), pupa (an immobile transformation stage), and adult (imago) stages. The larval forms are often the most damaging. (e.g., butterflies, beetles, flies).



They are also classified according to their mouthparts and the type of damage they cause:

2.3.3. Chewing Insects: Chewing insects possess prominent mandibles, which are jaw-like structures evolved to cut and grind their food. They include grasshoppers, beetles, caterpillars, ants, earwigs, and some cockroaches. These insects feed by biting off pieces of solid food, especially plant tissue, unlike sucking insects that extract the sap (plant juices).

2.3.3.1 Types and Examples

- Grasshoppers and Locusts: Known for feeding on leaves, causing ragged edges and extensive defoliation.
- Beetles: Various species (e.g., Colorado potato beetle, flea beetle) consume leaf tissue, especially between veins, leaving a skeletonized appearance.
- Caterpillars (Lepidoptera larvae): Cause holes, notches, and sometimes completely consume foliage, some are leaf miners, burrowing inside leaves.
- Earwigs and Cockroaches: Chew on soft plant or organic material, sometimes damaging crops.
- Ants: Many species chew food items, including seeds and other insects.

2.3.1.2 Types of Damage: Chewing insect attacks:

- Leaves: Creating holes, notches, or skeletonized patterns, may lead to complete defoliation in severe infestations.
- Stems: Some bore into plant stems, causing structural weakness and increased disease susceptibility.
- Flowers and Fruits: Damage to petals, buds, or fruit leads to lower yields and poor crop quality.
- Roots: Certain larvae feed underground, affecting water and nutrient access and causing plant wilting or stunted growth.

2.3.2. Piercing-Sucking Insects: They use a needle-like proboscis that contains fine stylets to penetrate plant tissues, such as xylem and phloem, in order to extract sap or other liquids. They weaken the plant and can transmit numerous viruses.

2.3.2.1. Types and Examples

- Aphids (Hemiptera): Feed on plant phloem, excrete sugary honeydew, and often transmit plant viruses.
- Leafhoppers (Hemiptera): Cause stippling and yellowing of leaves.
- Scale insects and mealybugs: Produce honeydew and often cause leaf yellowing and wilting.
- Whiteflies: Like aphids, they feed on plant sap and excrete honeydew.

2.3.2.2 Types of Damage: Piercing-sucking insects cause distinctive types of plant injury:

- Discoloration: Yellow, brown, mottled, or necrotic spots at feeding sites.
- Wilting and curling: Loss of water and nutrients leads to leaf curl and shrinkage.
- Honeydew and sooty mold: Accumulation of sticky honeydew on leaves promotes fungal growth.
- Disease transmission: Many species transmit viral, bacterial, and fungal pathogens.

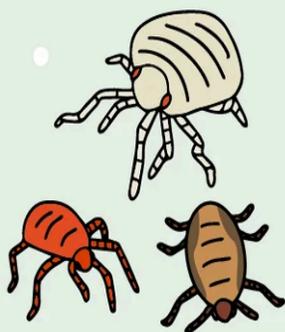
2.4. Mites

Often confused with insects, mites are arachnids, more closely related to spiders. They are very small (often less than 0.5 mm) and difficult to see with the naked eye. They have 4 pairs of legs in the adult stage (compared to 3 for insects). The best known in agriculture are the **spider mites**. With their piercing mouthparts, they empty plant cells, causing small yellowish dots to appear on the leaves, which eventually dry out. Their presence is often associated with hot, dry weather.

PLANT PEST SERIES PART 1

SPIDER MITES

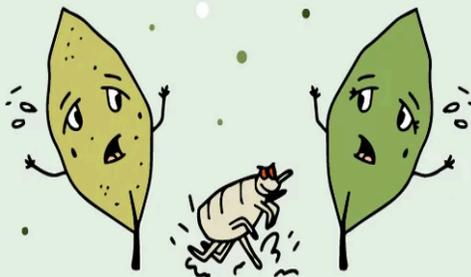
SIGNS + SYMPTOMS



Typically brown, red or almost translucent in color



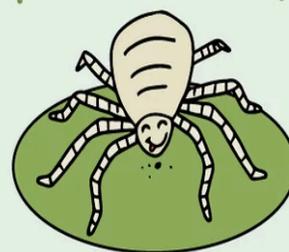
Spider mites are tiny and can be very hard to see



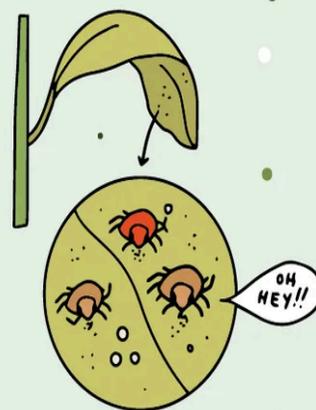
You can see them move but because they're so small, they may be hard to notice



Breed quickly in warm, dry conditions, especially those lacking in humidity



Spider mites feed on plant cells and will eat tiny holes in leaves!



Generally live on the underside of leaves

2.4.1 Mite Reproduction and Life Cycle

Their life cycle typically consists of the following stages: egg, larva, nymph (sometimes passing through several nymphal stages called protonymph, deutonymph, and tritonymph), and adult.

- Eggs: Females lay eggs (often on the underside of leaves). Under optimal conditions, eggs hatch within a few days to a couple of weeks.
- Larva: The larval stage emerges with three pairs of legs. Larvae feed on plant sap and rapidly molt into nymphs.
- Nymph: Nymphs have four pairs of legs and molt several times while feeding and growing.
- Adult: Adults are capable of reproduction, completing the cycle. The duration from egg to adult can be as quick as one to two weeks in ideal conditions, leading to explosive population growth.
- Reproduction: Most mites reproduce sexually. A single female can lay dozens of eggs, contributing to rapid population increases.

2.4.2 Plant Damage Caused by Mites

2.4.2.1 Symptoms:

Infested plants often display:

- Yellow, white, or bronze spots
- Leaf curling, wilting, or premature drop
- Stunted growth and reduced yields
- In severe infestations, plant death may occur.

2.4.2.2 Detection:

Inspection of leaf undersides (often with magnification) is required to confirm mite presence and to distinguish them from other causes of similar symptoms.

2.5. Myriapods

Myriapods are a subphylum of terrestrial arthropods known for their elongated bodies segmented into many parts, each bearing legs.

It includes millipedes (Diplopoda) and centipedes (Chilopoda). It is important to distinguish them:

2.5.1 Millipedes

are mainly detritivores or phytophagous. They have a cylindrical body and two pairs of legs per segment. They are usually black or brown, but can be brightly colored, especially toxic or warning species. They can attack seedlings, tubers, and roots in very humid soils rich in organic matter.



2.5.2 Centipedes

are useful predators. They are primarily carnivorous predators. They have a flattened, elongated body with one pair of legs per segment. Their coloration is typically reddish-brown or tan, and some species display warning colors. They actively hunt small invertebrates, using venomous forcipules to subdue prey, and thrive in moist soils, leaf litter, and under logs, where they help regulate arthropod populations.



2.5.3 Reproduction and Life Cycle

- Reproduction: Centipedes reproduce sexually through indirect sperm transfer. Males produce spermatophores that females collect for internal fertilization.
- Centipedes undergo incomplete metamorphosis.
- Most centipedes live 1-6 years, with some species living longer under favorable conditions.

2.5.4 Plant Damage Caused by Centipedes

Unlike mites, centipedes do not cause plant damage. They are beneficial predators that:

- Hunt and consume harmful insects, spiders, and other small invertebrates
- Help control pest populations in gardens and agricultural settings
- Do not feed on plant material or damage crops
- Are considered beneficial arthropods for natural pest management

2.5.5 Detection

Centipedes can be detected through:

- Visual identification: Look for fast-moving, elongated, flattened arthropods with many legs
- Habitat inspection: Check under stones, logs, leaf litter, and in moist soil where they hide during the day
- Nocturnal activity: Most active at night when hunting prey
- Body characteristics: Distinguished by one pair of legs per segment, long antennae, and visible forcipules near the head
- Size variation: Range from a few millimeters to 30 cm depending on species

Centipedes are valuable predators that contribute to ecosystem balance by controlling pest populations rather than causing plant damage.

2.6. Nematodes

Nematodes, also known as roundworms, are unsegmented, threadlike invertebrates in the phylum Nematoda. They have a cylindrical, bilaterally symmetrical body, usually tapering at both ends and covered with a tough, flexible cuticle. Nematodes are among the most abundant animals on Earth, living in soil, water, and as parasites in plants and animals.



2.6.1 Reproduction and Life Cycle

Reproduction: Most nematodes reproduce sexually, with distinct male and female individuals (sexual dimorphism). Fertilization is internal.

Lifecycle Stages: Typically includes egg, four juvenile (larval) stages, and adult. Development is direct in many free-living and plant-parasitic species, with no intermediate host required.

Eggs: Females lay eggs in soil or within plant tissues. Eggs hatch into larvae, which molt four times before reaching adulthood.

Growth: Nematodes grow by molting their tough external cuticle between each juvenile stage.

2.6.2 Plant Damage Caused by Nematodes

Root Injury: Many nematodes are plant parasites, attacking roots and causing galls, lesions, or stunting, which results in reduced water and nutrient uptake.

Aboveground Symptoms: Infected plants may show yellowing, wilting, poor growth, and reduced yields. Some nematodes (e.g., foliar nematodes) damage leaves directly.

Types of Damage: Damage can be subtle (overall poor vigor) or severe (root knots, excessive branching, or necrosis). Some nematodes also act as vectors for plant viruses.

2.6.3 Detection

Visual Symptoms: Look for unexplained stunting, chlorosis, wilting, and patchy plant health in the field.

Root Inspection: Dig up affected plants to look for root galls, knots, or lesions.

Soil/Plant Testing: Confirm nematode presence by microscopic examination of soil or root samples. Specialized labs can identify particular species and their population densities.

2.7. Rodents and Harmful Birds

2.7.1 Rodents:

Rodents are small mammals of the order Rodentia characterized by a single pair of continually growing incisors in each jaw. Globally, only a minority are agricultural pests, but species such as rats (*Rattus* spp.), mice (*Mus* spp.), and certain field rodents are notorious for attacking a wide range of crops, both in fields and stored produce.

2.7.2 Harmful Birds:

Harmful birds include species like pigeons, starlings, crows, and monk parakeets, which inflict economic losses by feeding on seeds, fruits, grains, and seedlings, contaminating crops, and damaging farm infrastructure.

2.7.3 Reproduction and Life Cycle

2.7.3.1 Rodents:

Most pest rodents reproduce rapidly, with some species breeding year-round in response to food availability. Gestation is short (usually less than one month), and females can give birth to several litters per year, each containing up to a dozen young. Juveniles mature quickly, fueling rapid population outbreaks during favorable crop seasons.

2.7.3.2 Harmful Birds:

Many harmful birds breed seasonally, aligning nesting with crop growing periods for optimal food access. They lay eggs in nests constructed within or near crop fields and often form large flocks that magnify damage.

2.7.4 Plant Damage

2.7.4.1 Rodents:

Damage occurs at sowing (seed consumption), seedling (cutting/pulling seedlings), vegetative (gnawing roots/stems), and maturation stages (hoarding and eating grains and tubers). Rodents damage crops like rice, maize, wheat, vegetables, and fruits, leading to yield losses ranging from 2% up to 100% during severe outbreaks. They also spoil harvested produce with droppings and urine, lowering market quality.

2.7.4.2 Harmful Birds:

Birds uproot seedlings, eat seeds and fruits, peck and trample crops, and defecate on produce, spreading bacteria and reducing value. Damage can exceed 10–40% for key crops during peak flocking periods (e.g., woodpigeons on oilseed rape or starlings in fruits). Birds often target crops at vulnerable growth stages, especially before harvest.