

Comparative Study of Sap-Sucking vs Chewing Insects

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Insects are the most diverse and abundant group of organisms on Earth, with more than a million described species and several million more yet to be documented. They occupy virtually every ecological niche and play critical roles in agriculture, either as pollinators, decomposers, or herbivores. Among herbivorous insects, feeding strategies are diverse, ranging from external chewing to specialized sap-sucking. Two dominant feeding guilds in agriculture are sap-sucking insects and chewing insects, both of which are notorious for their destructive impact on crop plants.

Sap-suckers, including aphids, whiteflies, planthoppers, leafhoppers, and psyllids, belong largely to the order Hemiptera. They feed by inserting slender stylets into plant tissues to extract sap, typically from phloem or xylem. Their feeding often appears subtle, with little visible damage at first glance, but it induces chronic physiological stress and enables the spread of viral and phytoplasma diseases.

Chewing insects, on the other hand, include Lepidopteran larvae (such as *Spodoptera frugiperda* and *Helicoverpa armigera*), Orthopterans (grasshoppers and locusts), and Coleopterans (beetles).



These insects possess heavily sclerotized mandibles designed for biting and tearing plant tissues. Their feeding causes acute and obvious destruction, ranging from leaf skeletonization to

direct consumption of reproductive parts like flowers, pods, and fruits.

This comparative study explores the biology, ecology, damage mechanisms, and management strategies of sap-sucking versus chewing insects. It integrates case studies, ecological dimensions, and future prospects to highlight their importance in pest management research.

Literature Review

Research on insect feeding guilds has expanded significantly in the last century. Early entomologists, such as Wigglesworth (1939), provided fundamental

insights into insect mouthpart morphology and feeding behavior. Later, studies by Painter (1951) emphasized host–plant resistance, highlighting the importance of insect–plant coevolution.

Recent molecular research has revealed the complexity of sap-sucking interactions. Aphid saliva contains effector proteins that modulate host defenses, suppressing salicylic acid signaling (Will et al., 2007). Studies on whiteflies (*Bemisia tabaci*) demonstrate their capacity to transmit over 100 plant viruses (Navas-Castillo et al., 2011).

Chewing insects have been extensively studied due to their devastating outbreaks. Fall armyworm (*Spodoptera frugiperda*), native to the Americas but recently invasive in Africa and Asia, has been the focus of genomic studies revealing rapid resistance evolution (Gouin et al., 2017). Helicoverpa armigera, another major chewing pest, shows remarkable adaptability and resistance to multiple insecticides, as documented in Sharma et al. (2005).

Despite extensive research, gaps remain in understanding how sap-sucking and chewing guilds interact with plant defense pathways differently, and how climate change might alter their outbreak dynamics.

Morphological and Physiological Adaptations

Sap-Sucking Insects

Possess piercing-sucking mouthparts: a proboscis containing maxillary and mandibular stylets. Specialized digestive system includes a filter chamber, which allows the rapid processing of dilute plant sap while concentrating nutrients. Depend on endosymbiotic bacteria (e.g., *Buchnera aphidicola*) for

essential amino acids absent in plant sap. Small body size, short life cycles, and parthenogenesis (in aphids) enable rapid multiplication. Exhibit wing polymorphism (alate vs apterous forms), facilitating both sedentary feeding and dispersal.

Chewing insects

- Possess mandibulate mouthparts with heavily sclerotized mandibles.
- Salivary secretions contain proteases, amylases, and lipases, aiding in enzymatic digestion of solid plant tissues.
- Exhibit polyphagy: many lepidopteran larvae feed on dozens of host plants.
- Chewers display strong muscular development in the head capsule to support mandibles.
- Larger body size and higher food intake result in visible, large-scale plant damage.

Feeding Mechanisms

Sap-suckers

- Insert stylets intercellularly until they reach vascular tissues.
- Secrete watery and gelling saliva to lubricate stylets and suppress plant defenses.
- Feed for extended periods, continuously extracting sap.
- Excrete excess sugars as honeydew, which promotes secondary fungal growth (sooty mold).

Chewers

- Use mandibles to bite, tear, and macerate plant tissues.
- Cause direct removal of photosynthetic area, reducing productivity.
- Feeding is most destructive during larval stages.

- Trigger systemic wound responses in plants, activating jasmonic acid-mediated defenses and protease inhibitors.

Damage Symptoms and Economic Losses

Sap-suckers

- Leaf curling, chlorosis, stunting, and wilting.
- Transmission of plant viruses and phytoplasmas (e.g., rice tungro virus, cotton leaf curl virus).
- Hopper burn in rice due to massive brown planthopper infestations.
- Honeydew-induced sooty mold growth, reducing photosynthesis and contaminating fiber quality (in cotton).

Chewers

- Skeletonization of leaves, notches, and defoliation.
- Direct attack on flowers, pods, fruits, and seeds (e.g., pod borer in legumes).
- Stem boring and tunneling, weakening plants structurally.
- Locust swarms capable of devastating entire landscapes, threatening food security.
- Both guilds are capable of inflicting multi-billion-dollar economic losses annually.

Plant–Insect Interactions

Plants have evolved diverse strategies to resist insect attack.

Sap-sucker interactions: Plants produce secondary metabolites (alkaloids, phenolics) that reduce feeding. However, sap-feeders inject salivary effectors to suppress defense pathways. The salicylic acid pathway is often activated, but it may compromise jasmonic acid defenses against other pests.

Chewer interactions: Chewing damage induces jasmonic acid signaling, leading to production of defensive proteins such as proteinase inhibitors and polyphenol oxidases. Volatile organic compounds are released, attracting natural enemies of herbivores. Thus, sap-suckers manipulate plant defenses to their advantage, while chewers trigger stronger and more direct defensive responses.

Ecological and Evolutionary Dimensions

Sap-suckers reproduce rapidly and adapt quickly to resistant varieties. Their population explosions are favored by monocropping and excessive nitrogen fertilization.

Mutualisms: many sap-suckers (e.g., aphids) form relationships with ants, which protect them in exchange for honeydew.

Chewers such as armyworms and locusts exhibit migratory and gregarious behavior, enabling them to exploit large areas.

Climate change: rising temperatures accelerate insect development rates and expand their geographic ranges. Elevated CO₂ levels may increase sap-sucking pest fitness by altering plant nutritional quality. Both groups show rapid resistance evolution under pesticide pressure, albeit via different pathways: metabolic detoxification in chewers vs symbiont-mediated and behavioral resistance in sap-feeders.

Case Studies

Brown Planthopper (*Nilaparvata lugens*): Sap-sucker causing hopper burn in rice; notorious for repeated outbreaks in Asia.

Cotton Whitefly (*Bemisia tabaci*): Transmits cotton leaf curl virus and other plant viruses.

Cotton Aphid (*Aphis gossypii*): Sap-sucker that reduces lint quality by honeydew contamination.

Fall Armyworm (*Spodoptera frugiperda*): A chewing pest of maize, invasive in Africa and Asia; causes up to 50% yield losses.

***Helicoverpa armigera*:** Pod borer of pulses, tomato, and cotton; polyphagous and highly resistant to insecticides.

Desert Locust (*Schistocerca gregaria*): Migratory chewer capable of consuming its own body weight in vegetation daily, leading to regional famines.

Pest Management Strategies

Conventional

Sap-suckers: controlled by systemic insecticides such as neonicotinoids (imidacloprid, thiamethoxam).

Chewers: managed with contact insecticides including pyrethroids and organophosphates.

Biological

Natural enemies like coccinellids (ladybird beetles), syrphid flies, and parasitoid wasps control sap-suckers. Parasitoids such as *Trichogramma* and predators like birds and spiders regulate chewing insects.

Cultural

- Crop rotation, trap crops, and resistant varieties reduce pest buildup.
- Intercropping suppresses population growth of both guilds.

Biotechnological

- Bt crops (cotton, maize) highly effective against chewing insects but less so for sap-feeders.
- Emerging technologies: RNA interference (RNAi) and CRISPR gene editing hold promise for both sap-suckers and chewers.

Integrated Pest Management (IPM)

- Combines monitoring, threshold-based spraying, biological control, and cultural methods.
- Emphasizes sustainability and reduced reliance on chemicals.

Future Prospects & Research Gaps

- Need for climate-smart pest management frameworks.
- Exploitation of endosymbionts in sap-suckers as novel control targets.
- Development of multi-gene resistant crops combining Bt toxins with RNAi constructs.
- Predictive modeling of outbreaks using remote sensing and AI.
- Greater focus on ecological engineering to conserve natural enemies.

Conclusion

Sap-sucking and chewing insects represent two contrasting but equally destructive feeding guilds in agriculture. While sap-suckers exploit vascular tissues and serve as efficient vectors of plant pathogens, chewers cause direct tissue destruction and rapid yield losses. Their differences in morphology, physiology, feeding, and ecology demand distinct management approaches. However, both groups share the ability to adapt rapidly, evolve resistance, and exploit human agricultural practices.

Sustainable management will depend on integrating modern biotechnology with ecological approaches, minimizing pesticide dependence, and strengthening natural pest regulation. Understanding their comparative biology is not only crucial for

immediate crop protection but also for future food security under changing climatic conditions.

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