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INSECTS AND MICROBES- A HIDDEN PARTNERSHIP

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ABSTRACT

The insect microbiome plays a crucial role in host survival, development, and adaptation. Dominated primarily by Proteobacteria and Firmicutes, gut microbial communities vary widely among insect groups such as Coleoptera and Diptera. This article highlights two major forms of mutualism: nutritional symbiosis, in which microbes aid digestion and nutrient synthesis, and defensive symbiosis, where beneficial bacteria produce antimicrobial compounds that protect hosts from pathogens. Understanding these intricate microbial interactions offers promising opportunities for advancing sustainable agriculture, biological pest management, medicine, and biodiversity conservation.

KEYWORDS: Defensive symbiosis, insect gut microbiome, nutritional symbiosis, symbiotic bacteria

INTRODUCTION

Beneath the tough outer shell of every insect lies a hidden world filled with life. This tiny universe, made up of bacteria, fungi, and other microorganisms, represents one of the most interesting partnerships in nature. The bond between insects and their microbial partners is not just about living alongside each other; it is a deeply interconnected alliance that has developed over hundreds of millions of years.

From the termite that eats wood to the honeybee that helps pollinate our crops, insects depend on their microbial partners to survive. These small allies assist in breaking down food, creating essential nutrients, protecting against diseases, and even shaping behavior. Recent advances in DNA sequencing technology have uncovered the incredible complexity of these relationships. This discovery opens up new paths for understanding insect biology and finding new ways to manage pests and promote conservation.

THE GUT MICROBIOME: A MICROSCOPIC UNIVERSE

COMPOSITION AND DIVERSITY

The insect gut microbiome is one of the most diverse microbial communities on Earth. A detailed study of 305 individual insects from 218 species and 21 taxonomic orders showed that insect gut bacteria are

dominated by two main groups: Proteobacteria, which account for 62.1% of total sequences, and Firmicutes, making up 20.7%. These results, based on 16S rRNA gene sequencing, highlight the diversity and patterns in insect-microbe relationships (Yun et al., 2014).

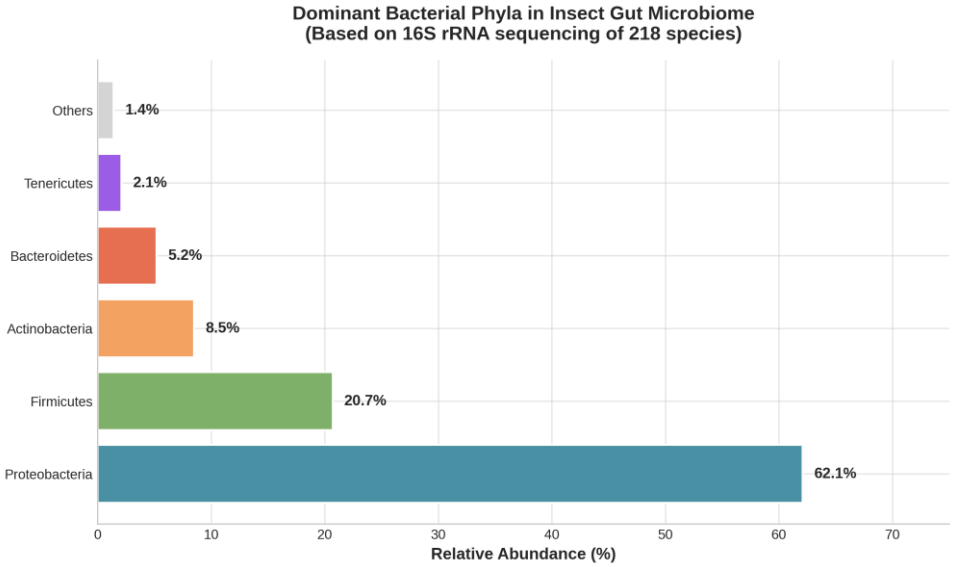

Figure 1. Dominant bacterial phyla in the insect gut microbiome based on 16S rRNA gene sequencing of 218 insect species (adapted from Yun et al., 2014).

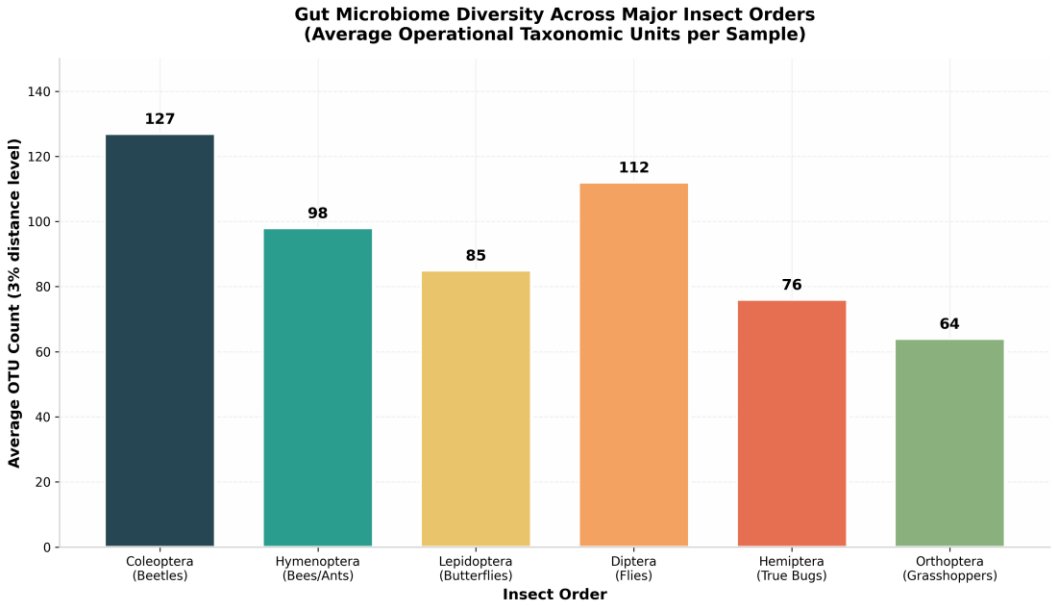

Figure 2. Gut microbiome diversity across major insect orders based on average operational taxonomic unit (OTU) counts per sample.

The makeup of the gut microbiome differs greatly among insect orders. Beetles (Coleoptera) have the highest bacterial diversity, averaging 127 operational taxonomic units (OTUs) per sample. Flies (Diptera)

follow with 112 OTUs. This variation reflects the different ecological roles, diets, and evolutionary backgrounds of these insect groups.

SYMBIOTIC BACTERIA: PARTNERS IN SURVIVAL

NUTRITIONAL SYMBIOSIS

One of the most important roles of gut bacteria is nutritional support. Many insects eat diets low in essential nutrients, and their microbial partners make up for these gaps. Termites, for example, depend on a complex group of bacteria and protists to break down cellulose from wood into digestible sugars. Without these microbes, termites would starve even though they eat wood (Brune, 2014). Grain pest beetles offer another interesting example. These insects have symbiotic relationships with bacteria and yeasts that provide crucial amino acids and vitamins. Recent research at the Max Planck Institute for Chemical Ecology showed that Bacteroidetes bacteria help with cuticle production in beetles. This improves their defense against predators and helps them resist drying out (Engl et al., 2025).

DEFENSIVE SYMBIOSIS

In addition to nutrition, symbiotic bacteria act as strong protectors against pathogens and parasites. Fungus-growing ants cultivate specific bacteria from the Pseudonocardia and Streptomyces genera on their bodies. These bacteria produce antibiotics that safeguard the ants' fungal gardens from parasitic fungi, especially Escovopsis. This mutualism is one of the most advanced examples of defensive symbiosis in the animal kingdom (Chen et al., 2023).

Table 1. Examples of Defensive Symbiotic Bacteria Associated with Insects

Bacteria	Host Insect	Defensive Function
Pseudonocardia	Leaf-cutter ants	Produces antibiotics against Escovopsis
Streptomyces	Fungus-growing ants	Produces candicidin D antifungal
Burkholderia	Bean bugs	Detoxifies pesticides, primes immunity
Bacillus	Termites	Inhibits pathogenic fungi in fungus gardens
Lactobacillus	Honeybees	Stimulates an immune response against pathogens

CONCLUSION

The symbiotic relationship between insects and microorganisms represents one of nature's most remarkable and enduring partnerships. Microbial communities play essential roles in digestion, nutrient synthesis, immunity, and protection against pathogens, contributing significantly to insect survival and adaptation. Advancing insect research is enhancing our understanding of ecological and evolutionary processes while offering valuable applications in sustainable agriculture, biological pest management, medicine, and biodiversity conservation. These hidden microbial associations demonstrate that life is sustained through interconnected biological networks, emphasising the importance of symbiosis in maintaining ecosystem health and resilience.

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