

# CLASSIFICATION AND ECOLOGY OF MAJOR TROPICAL INSECT GROUPS

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**Keywords:** Coleoptera, Diptera, Hymenoptera, Lepidoptera, species richness

## Contents

- 1. Introduction
- 2. Characteristics and Success
- 3. Hypotheses on the Origin of the Latitudinal Species Richness Gradient
- 4. Evolution
- 5. Geographic Distribution
- 6. Classification
- Acknowledgments
- Glossary
- Bibliography
- Biographical Sketches

## Summary

This contribution is about tropical insects. We emphasize the high insect diversity and latitudinal species richness gradient, insect characteristics and some reasons for their success, their evolution and classification. Insects belong to the Phylum Arthropoda, superclass Hexapoda (six-legged invertebrates), along with the Entognata, which include: Protura (proturans), Collembola (springtails), and Diplura (diplurans). The Class Insecta is commonly known as that of true insects and is composed of about 30 Orders. The two most primitive orders, Archaeognatha (bristletails) and Zygentoma (=Thysanura, silverfish) are wingless insects (apterygota). Within the informal group known as Pterygota, the two most primitive orders are Ephemeroptera (mayflies) and Odonata (dragonflies and damselflies), also called Paleoptera. The other orders belong to the informal group Paleoptera, Neoptera. Within this group some orders present incomplete metamorphosis and nine orders present complete metamorphosis and contain the most speciose groups. Insects present the highest species richness usually close to the Equator, and associated with areas of high rainfall and low altitude. Insects have a fundamental role in all aquatic and terrestrial ecosystems. The group occupies an astonishing diversity of habitats and niches, and exhibits varied life styles and behaviors. Estimates of insect species richness are considerably controversial. It is impossible to know with certainty the number of insect species in the tropics with the data currently available. Several hypotheses attempt to explain the biodiversity latitudinal gradient, but how and why this gradient developed in the first place remains to be answered. Diversification rates of several taxa are higher in the tropics than in

temperate zones, implicating a higher speciation rate in the region. The larger extension of tropical forests, especially during the Cenozoic, could have allowed higher diversification rates due to area effects upon speciation and extinction rates. Other ecological explanations for the higher species richness in the tropics include: spatial heterogeneity and competition.

## 1. Introduction

Insects are a highly diverse and abundant group, occurring in every corner of the globe and absent only in the extreme conditions of the north and south poles, on certain mountain tops, and in ocean areas far from the coast. They represent 80% of the animal species and three quarters of the combined animal and plant species known. More than one million insect species have been described, in contrast, for example, with 60,000 Chordata species. There is a widely recognized pattern for insect richness, where the highest species richness is usually associated with areas of high rainfall and low altitude and elevation. The latitudinal species gradient, which is the increase in species richness of most taxa towards the equator, is one of the most consistent in the natural world. Thus, there are many more species in the tropics than in other parts of the world. Coleoptera (Beetles) and Lepidoptera (butterflies and moths), for example, increase dramatically in species number from temperate to tropical regions.

Insects have a fundamental role in all aquatic and terrestrial ecosystems. They dominate food chains and webs both in volume and number and present an enormous variety of feeding specializations, feeding on debris, fungi, plants, and animals (predation and parasitism). They constitute important diet items for other insects and invertebrates as well as insectivore vertebrates. Insects are also key nutrient recyclers, and participate in plant propagation through pollination and seed dispersal. Particularly in the humid tropics, wind pollination is inefficient and most plants are pollinated by animals, especially insects. Even grasses, in which pollination takes place through the wind in most parts of the world, are most likely pollinated by insects in the tropics. Community composition and structure of plants (e.g., disease transmission, herbivory, and seed predation) and animals (e.g. disease transmission, predation, and parasitism) are also maintained and regulated by insects. Approximately 15% of the insects are parasites, while herbivores, due to their numerical preponderance, encompass a significant fraction of the insect fauna: about half of all insects chew, scrape or suck algae and vascular plant living tissues. Part of these insects live and feed on internal tissues of plants: they are the wood-boring, gall-inducing, and leaf-mining insects.

## 2. Characteristics and Success

Even though it is relatively easy to characterize insects, the group exhibits an astonishing diversity of habitats, niches, life styles, and behaviors. Their body shape is somewhat constant, and conserved parts can be used to describe their body structure, while body size varies significantly and ranges from 0.2 to 300 mm in length. Their most distinguishable characteristic is the specialization of body segments, forming three tagmata: head, thorax, and abdomen. Sensitive structures, located on the head, are responsible for environmental perception and include antennas, compound eyes

(sometimes reduced or absent), and mouth parts (chewer or sucker). Three segments in the thorax are responsible for movement (legs and wings); each thoracic segment harbors a pair of legs, while the second and third may contain a pair of wings each (ranging from wingless to two pairs). Finally, the eleven abdominal segments contain the sexual apparatus and the anal aperture.

Estimates of insect species richness are considerably controversial. Estimates for the tropics, for example, tend to underscore the fact that there are more species to be described than are currently recognized. The most recent analyses suggest that there are from four to six million insect species in the world. The elevated richness, high abundance and biomass make insects one of the most successful groups of organisms. What is the reason for this success? Several aspects are responsible for this trend. The **metameric** body segmentation and its appendixes were fundamental to achieve such success. These coupled structures, which allowed morphological modifications needed to meet specific ends, allied to tubular tracheal respiration and an exoskeleton with a light and impermeable cuticle were certainly determinant factors. Each trachea provides muscles with 800,000 times more oxygen than simple diffusion would, and while still limited compared to a vertebrate circulatory system, the tracheal system allows insects to grow much larger than diffusion alone would permit.

The small size is very advantageous, allowing a shorter generation time and, hence, several generations in a short period of time, making insects more prone to mutations and thus producing higher genotypic and phenotypic variation. This in turn made it possible for insects to inhabit a vast variety of microhabitats in the soil, plants, and animals, significantly increasing the availability of niches. The immense array of evolutionary interactions among insects and plants, as well as with other organisms, also contributed to this great diversification.

Insects perceive the environment more efficiently than any other group of terrestrial invertebrates through highly sophisticated sensory and neuromotor systems. Their light and resistant exoskeleton makes flight possible, increasing mobility of insects towards a more efficient search of new environments and food in fragmented habitats. It further facilitates escape from flightless predators, the search for mates, and allows migration and egg dispersal.

The development of a pupae phase in the reproduction of insects was an evolutionary landmark that increased the success of the group. Insects of the Endopterygota group exhibit a complete metamorphosis (egg-larvae-pupae-adult) and are the ones with the highest abundance and species richness: Coleoptera, Diptera, Hymenoptera, and Lepidoptera. Complete metamorphosis opened a vast array of opportunities, allowing the exploitation of new niches and alternative feeding strategies between larvae and adults and consequently eliminating intraspecific competition.

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