

## The role of pathogens in butterfly population declines: interactions with habitat fragmentation and climate change

### [What are insect diseases?](#)

### [Lepidoptera and pathogens](#)

### [Hitch-hiking pathogens and escaping hosts](#)

### **What are insect diseases?**

Insect diseases are also called “entomopathogens” and include bacteria, viruses, microsporidia and fungi.

#### **Viruses**

Viruses are non-cellular genetic elements (RNA or DNA) deriving energy from the host. Indeed, viruses can only replicate within a living cell and so are obligate, intracellular parasites which can be highly host specific. Viruses are classified on the basis of their nucleic acid composition, genome structure and external coat morphology. Entomopathogenic viruses are known from 13 viral families and one of these, Baculoviridae, is only known from insects (Lepidoptera, Hymenoptera and Diptera).

The Baculoviridae (and also Poxviridae and Reoviridae) produce a structure called an occlusion body that enhances viral survival by providing protection from environmental factors. Host infection occurs when an occlusion body is ingested allowing the virus to enter the midgut cells, where it replicates. Non-occluded forms of the virus are then released into the insect blood system (haemocoel) and these spread to infect further cells throughout the host. At late stages of infection the virus begins to produce the occluded form of the virus which is released after host death. Other groups of virus (for example: cytoplasmic polyhedrosis virus) do not produce occlusion bodies or even lethal infection but instead persist chronically. Such chronic infections can, however, affect host life history traits such as fecundity and development.

#### **Fungi**

There are over 700 species of entomopathogenic fungi and these are mostly within two distinct groups of fungi: Ascomycota (higher fungi) and Zygomycota (lower fungi and a phylum, which is soon to become redundant as others replace it). Fungi within the Ascomycota are often more generalist than those within the Zygomycota. Indeed, one family within the Zygomycota (Entomophthorales) contains only obligate pathogens that are highly host specific.

The fungi are unique amongst entomopathogens because unlike the others they do not require ingestion by the host but can penetrate the host cuticle directly. The reproductive propagules of fungi are called spores. Spores germinate on the host cuticle and through enzymatic activity and mechanical pressure invade the host haemocoel initially as single cells. The fungus then proliferates through the insect body utilising available resources until these are exhausted, at which point the host dies and spores are produced on the insect exoskeleton. Some fungi can also kill the host at early stage of infection through toxin production.

## **Microsporidia**

Microsporidia have historically been considered as protozoans. However, recent studies suggest that they are more closely grouped with fungi. These strange organisms live within the host cells and so, like viruses, they are obligate pathogens and often highly host specific. The life histories of microsporidia are complex. A single microsporidia spore comprises of a long coiled tube contained within a capsule. The tube is extruded after contact with host digestive enzymes to pierce the midgut cells facilitating injection of the spore contents into the host cell. Microsporidia use the metabolic machinery of the host cell to reproduce eventually bursting from the cell as infective spores. Microsporidia usually cause chronic rather than fatal infections.

## **Lepidoptera and pathogens**

A quick literature search on Lepidoptera and pathogens reveals a plethora of studies. However, these relate mainly to the role of pathogens in regulating economically important insect populations (pest insects). There are a number of landmark studies on Lepidoptera that exemplify this, including those on gypsy moths, *Lymantria dispar* and the fungus *Entomophaga maimaga* pine beauty moth, *Panolis flammea* and nucleopolyhedrosis viruses; European corn borer, *Ostrinia nubilalis* and *L. dispar* and the bacteria *B. thuringiensis*. The potential of entomopathogens to control Lepidoptera (and other insect) populations is apparent from the density-dependent nature of horizontal transmission of many pathogens. However, whether entomopathogens are the prime regulating agents in natural populations, principally responsible for maintaining Lepidoptera below outbreak densities, remains unclear.

## **Hitch-hiking pathogens and escaping hosts**

The potential interactions between environmental change and host-pathogen dynamics are many and varied. This is reflected in the diverse and intriguing theories that relate to pathogens and hosts in fragmented habitats and at range edges. Pathogens of declining species that occupy increasingly fragmented habitats will be adversely affected, especially if they do not have an alternative host or refuge (such as persisting as a resting stage in soil). As a consequence the host will be protected as the pathogen declines; referred to as a "host refuge" effect. Lepidoptera that expand in range could escape their pathogens by leaving them behind or by moving into areas which are unsuitable for the pathogen. Equally as a species expands in range it could carry hitch hiking pathogens to the new locations.

**Centre for Ecology & Hydrology**  
**July 2008**