Hypolimnas bolina male butterfly.

Anne Duplouy

# **Survival** of the **fastest**

What happens when a butterfly population is threatened by a bacterium that kills males? The butterflies rapidly adapt or die, says **Greg Hurst** and colleagues.

In most animal species, the number of males and females are roughly equal but in many insect species this is not the case. The sex ratio can be biased towards daughters by the action of inherited parasites. These are usually bacteria that live inside the cells of an insect and pass from a female into her eggs. They either favour the production of daughters directly, for example, by promoting asexuality or the feminisation of males, or indirectly through killing the sons. This behaviour makes sense to the bacterium: if it finds itself in a male, it has reached a dead end.

Ecologists have found 'male-killers' in a wide range of insects, from beetles and flies to butterflies and true bugs. Their existence in a population can lead to interesting and unusual population dynamics but until recently, their ecology and evolution have been poorly understood.

We investigated the conflict between host and parasite. While we expected an evolutionary arms race, what surprised us was the pace of change.

The male-killing bacterium (*Wolbachia*) lives in the butterfly species *Hypolimnas bolina*. This butterfly is good to study. First, it exists on islands in the Pacific. As well as a scenic backdrop, this crucially allows us to observe variation within the species. We can find the butterfly on hundreds of islands in Polynesia. The host-parasite interaction varies between the islands, with the male-killer absent on some but present on others. This is reflected in dramatic variation in the sex ratio between populations, which allows us to dissect the causes and consequences of current variation. Second, the species has a rich history of study. There are records of female-biased sex ratios on many of the islands from the early 20th century and in Fiji this is accompanied by substantial breeding data. This allows us a rare chance to gain insight into changes in sex ratio over time, as evolution progresses.

We know that 30 years ago, ecologists could find fully active male-killers in south-east Asian *Hypolimnas* butterflies. Today, the bacterium is still present but no longer kills males. The reason for the change is host evolution. The butterfly now possesses a gene that suppresses the action of the male-killer, effectively rescuing males. The initial 'rescue' mutation must have spread very quickly. Males would have been very rare in the affected populations (killed by the male-killer), and rescued males would have mated with many females, passing on the rescue mutation.

We recently gained a more precise observation of the speed of this process. On the islands of Independent Samoa, the male-killer was still prevalent as recently as 2001, with 100 adult female butterflies for every male. Today, the sex ratio is near 1:1, due to the spread of the 'rescue' gene. The timescale of the change is a mere blink of the eye in evolutionary terms – the rate of evolution is expected to be swift when males are so rare.

When males are rare, we thought that female mating rate would decrease. This was true at extreme sex ratios (when there are more than 20 females per male). However, when males were relatively (but not very) uncommon, female mating rate actually increased. The reason for this is uncertain. Males transfer smaller sperm packets to females when mates are abundant, owing to reproductive fatigue. In many butterflies, large sperm packets make females less likely to remate because they have received sufficient sperm from one mating to fertilise all their eggs. A tempting hypothesis is that when females are common, male fatigue occurs making females more willing to remate in search of additional sperm.

We have revealed that in the *Hypolimnas* at least, the effects of one bacterium produce some of the most rapid evolutionary and ecological changes recorded in natural systems. Evolution, far from being a slow process working over geological time, is one that can create considerable flux, even during the period of a standard NERC grant. ❖

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