Pathogen avoidance by insect predators

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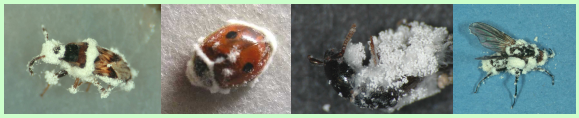
Adaptations to detect and avoid infectious diseases

Insects have evolved adaptations to avoid attack from natural enemies. Among the natural enemies of insects are pathogens (viruses, microsporidia, bacteria and fungi). In addition to the immune response (physiological resistance) potential hosts may also show adaptations to detect and consequently avoid contact with pathogens (behavioural resistance). Insect societies (ant, termites and some bees) are particularly at risk of infection and social insects have evolved behavioural mechanisms to prevent disease establishment. These adaptations are termed 'social immunity'.

However, little is known about the ability of non-social insects to avoid pathogens. We show here that insect predators have also evolved adaptations to detect and avoid the potentially lethal entomopathogenic fungus *Beauveria bassiana*



Beauveria bassiana can infect insects from many orders, including predators.

Photos:

N.V. Meyling and E. Ormond

Reference: Social immunity. Cremer, S. *et al.* (2007). *Current Biology*, 17, R693-R702

Pathogen avoidance on phylloplanes by a predatory bug

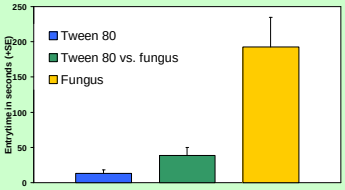
The generalist predator *Anthocoris nemorum* is common on nettles where it hunts actively for prey (A). The bug is naturally infected by *B. bassiana* and the fungus is naturally occurring on nettle leaves (B).

A. nemorum preys on nettles and attacks various prey, including aphids.

Photos:

N.V. Meyling

In laboratory bioassays (C), we tested if *A. nemorum* would respond to the presence of *B. bassiana* when searching for prey and oviposition sites on nettle leaves. Selecting areas without pathogens should benefit survival and fitness.



Entry time onto nettle leaf

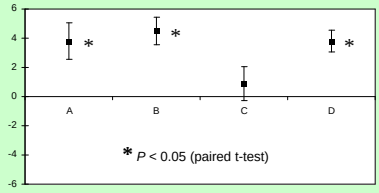
In choice arenas, bugs always entered the leaves on the control side

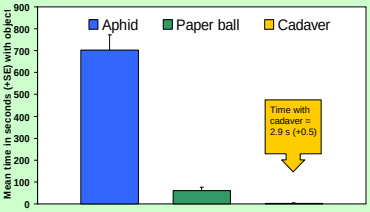
In no choice arenas, bugs readily entered the leaves in control treatments (Tween 80)

In no choice arenas, bugs spent >3 min before entering the *B. bassiana* inoculated leaves

Eggs laid on control side minus eggs laid on *B. bassiana* side (± SE)

On three of four occasions female bugs inserted significantly more eggs into control (Tween 80) leaf halves than into leaf halves with *B. bassiana*





Time spent in contact with objects

Upon encounter:

-freeze-killed aphids were inspected and readily consumed by bugs

-paper balls were inspected by the bugs

-bugs withdrew immediately from sporulating cadavers

Reference:

Detection and avoidance of an entomopathogenic fungus by a generalist insect predator. Meyling, NV & Pell, JK (2006). *Ecological Entomology*, 31, 162-171.

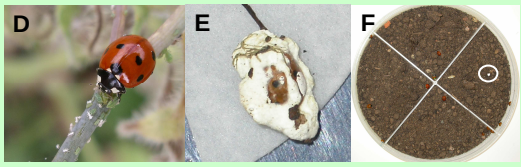
Ladybirds avoid pathogens during foraging and overwintering

The seven-spot ladybird *Coccinella septempunctata* is an actively searching aphid predator on plants (D). During winter, it overwinters in the litter layer and is thus exposed to pathogens in the soil environment. This ladybird is particularly susceptible to infection by *B. bassiana* during diapause (E).

C. 7-punctata is naturally infected by *B. bassiana* during overwintering (E). Aggregation response to the presence of infected cadaver (white circle) was tested in laboratory arenas (F).

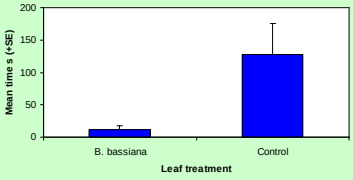
Photos:

H.E. Roy and E. Ormond



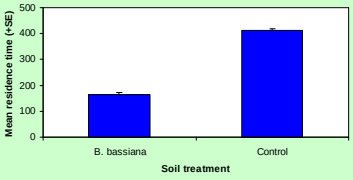
Direct behavioural responses to *B. bassiana*

Actively foraging adult *C. septempunctata* were observed in experimental choice arenas consisting of leaves or soil (*B. bassiana* or control). Time spent on each treated (*B. bassiana* or control) substrate was recorded.



Ladybirds on leaves with *B. bassiana*

Adult ladybirds spent significantly less time on *B. bassiana* inoculated leaves than on control leaves (paired t-test; P<0.001)



Ladybirds on soil with *B. bassiana*

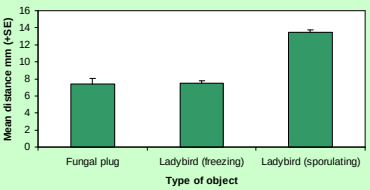
Soil treated with *B. bassiana* was not a favourable substrate for ladybirds compared to control soil (paired t-test; P<0.001)

Response by overwintering ladybirds to *B. bassiana*

Adult *C. septempunctata* overwinter in the litter layer, often in aggregations. In soil arenas (photo F), distances were measured from overwintering ladybirds to three types of objects; 1) fungal plug sporulating with *B. bassiana*; 2) dead ladybird killed by freezing; and 3) dead ladybird sporulating with *B. bassiana*

Aggregation and source of *B. bassiana*

The distance between ladybirds and dead conspecifics sporulating with *B. bassiana* was greater than the distance to either conspecifics killed by freezing or to *B. bassiana* growing on an artificial medium (fungal plug).



Reference:

Behavioural responses of *Coccinella septempunctata* to the presence of the entomopathogenic fungus *Beauveria bassiana.* Ormond, EL, Thomas, APM, Pell, JK & Roy, HE. In prep.

Conclusions

- Both the ladybird and the bug showed an ability to detect and avoid the presence of *B. bassiana*; an entomopathogenic fungus which they are naturally infected by
- Pathogen avoidance occurred in the habitat niche that the predators occupy
- Adaptations to avoid pathogens will increase fitness for the predators

Perspectives

- Behavioural resistance may be widespread among insect predators
- Presence of pathogens may affect predator behaviour in the field
- Avoidance of pathogens will benefit actively foraging predators and insects that must overwinter in habitats where pathogens are prevalent