Host suitability and biocontrol under abiotic stress

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Natural pest control

Natural Pest Control has great potential

- Alternative to pesticides which are increasingly restricted
- Contribution to sustainable pest control
- Important part of Integrated Pest Management (IPM)

Need better understanding of pest-natural enemy interactions and emergent population dynamics to fully harness these potential benefits .

This talk illustrates how a combination of modelling and empirical investigation can help to address this knowledge gap

Model System

Bird Cherry-Oat Aphid *Rhopalasiphum padi*

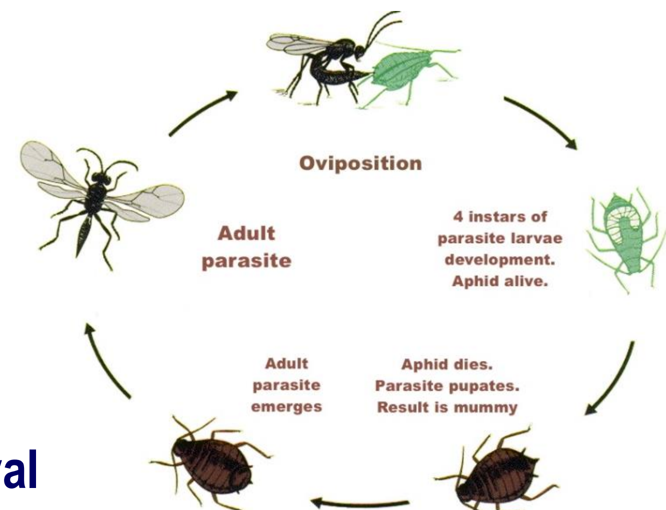
Major Pest in cereals, particularly in northern Europe

- ***Sucks sap from the phloem***
  - Uses nutrients
  - Contorts Leaves
  - Vector for viruses

Aphidius colemani

Common natural enemies of aphids in the field supplied commercially for biocontrol

- **Will attack adults but strong preference for nymphs**
- **Handling time is negligible (60 per hour) compared to searching time (~1-2 per day)**



***R. Padi, A colemani* have similar development and survival times**

Why learning?

Aphid populations often include phenotypes resistant to parasitoid attack

e.g symbiont *Hamiltonella defensa*

- ***Confers 80% resistance to parasitoid attack in R. padi***
- ***Without H. defensa there is 30-70% resistance***

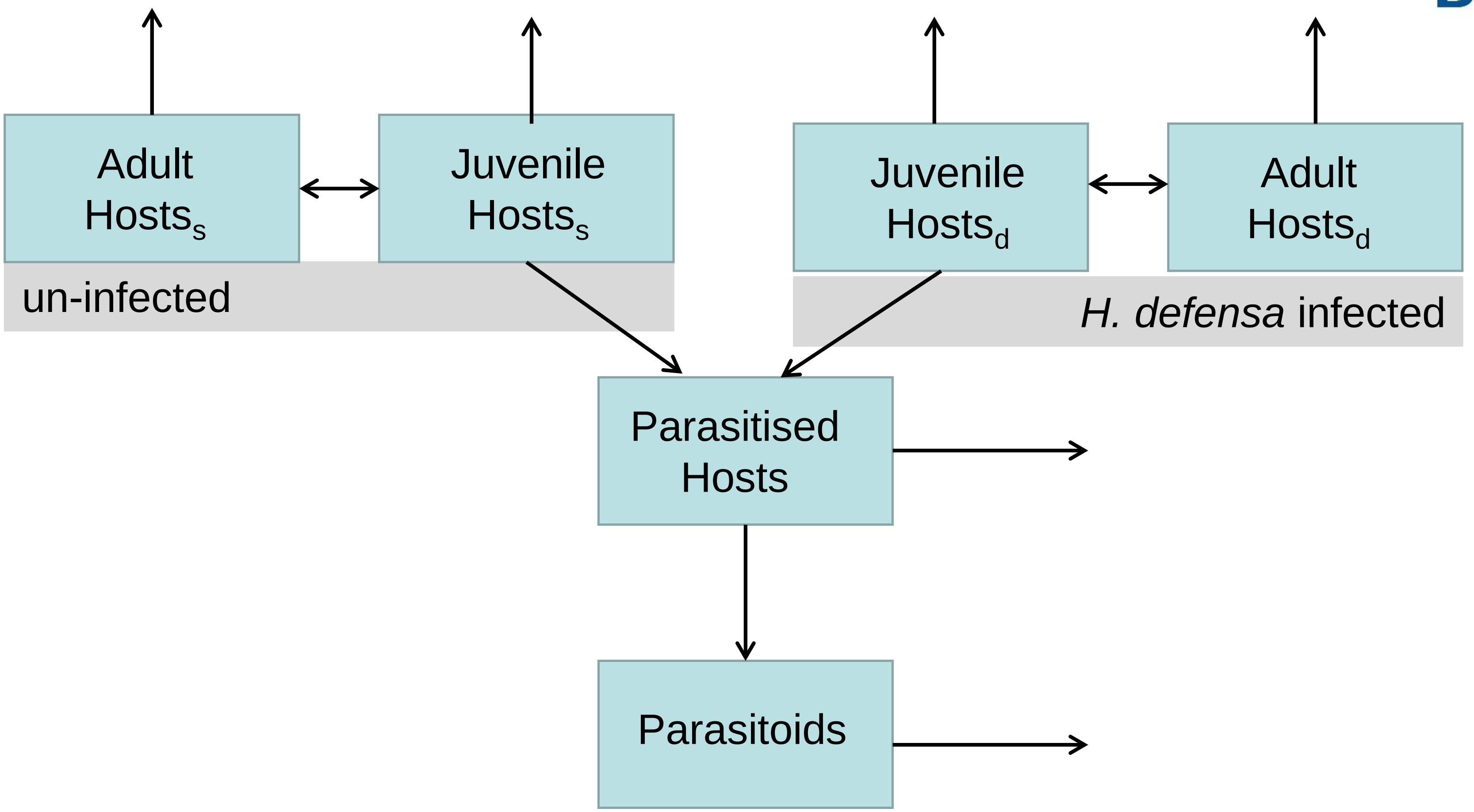
Resistant and Susceptible phenotypes co-exist

Observed fitness costs are insufficient to explain this coexistence

Empirical evidence of stabilising effect of learning in parasitoids – in bruchid beetle system on a scale of 24 hours

Parasitoids can distinguish between different aphid phenotypes

The Model


Adult Hosts$_s$
Juvenile Hosts$_s$
un-infected
Juvenile Hosts$_d$
Adult Hosts$_d$
H. defensa infected
Parasitised Hosts
Parasitoids

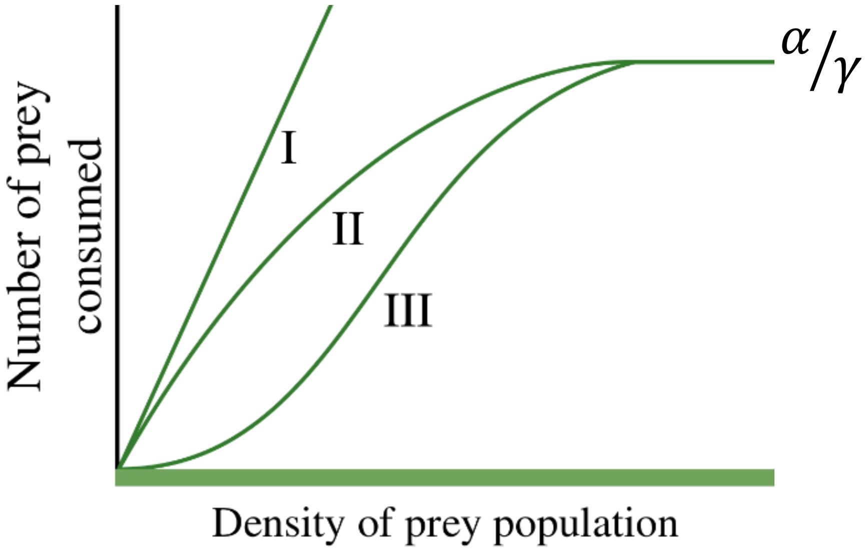
Parasitism Rates

Holling Type II functional response.

No learning

Attack rate α

handling time γ



Success rate (aphid immune system fails to defend) ε_i

Coexistence (H_s,H_d,P) exists only ε_s=ε_d

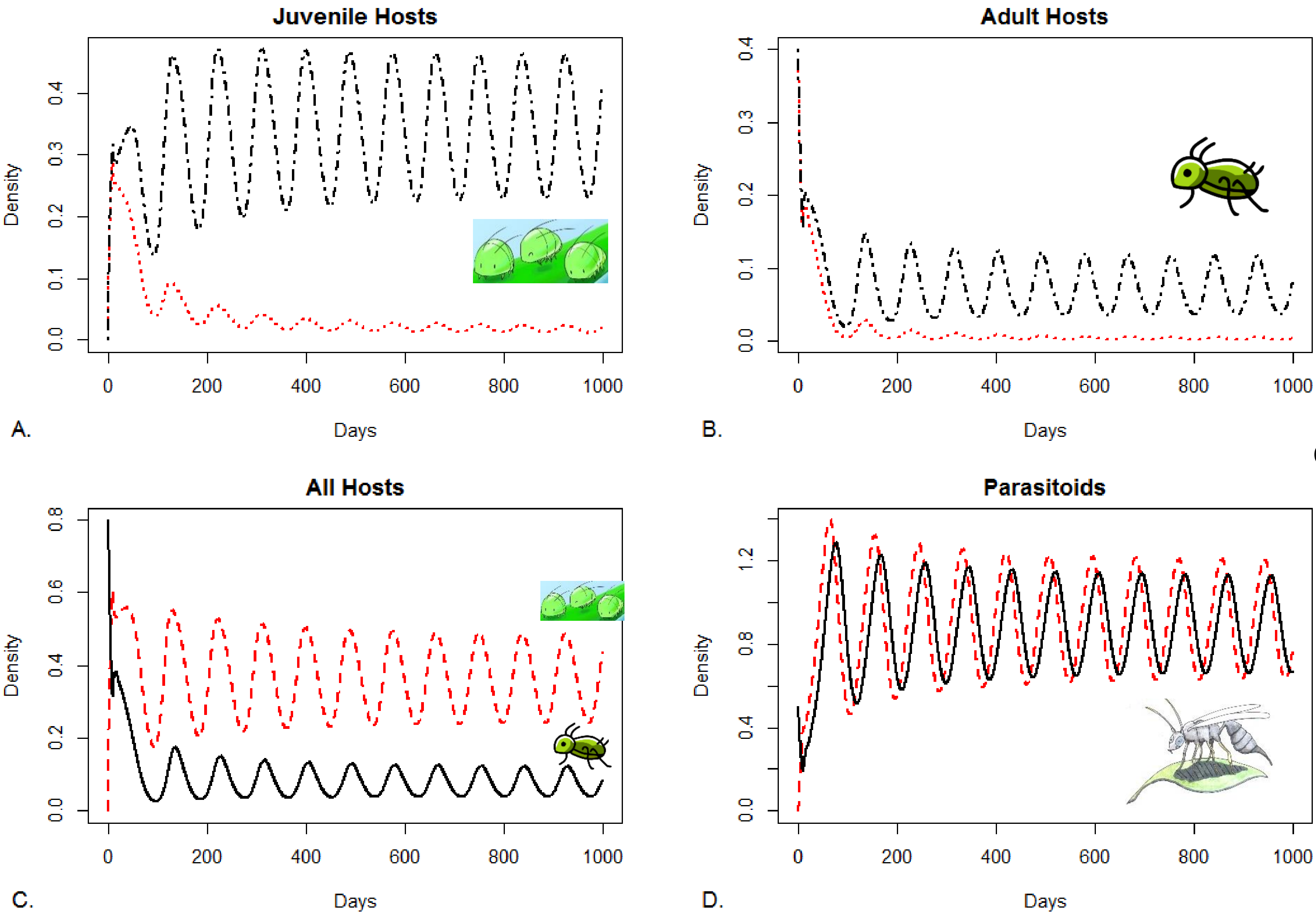
Learning

Reduced attack rate α if switching host type – switching costs

Stabilises System

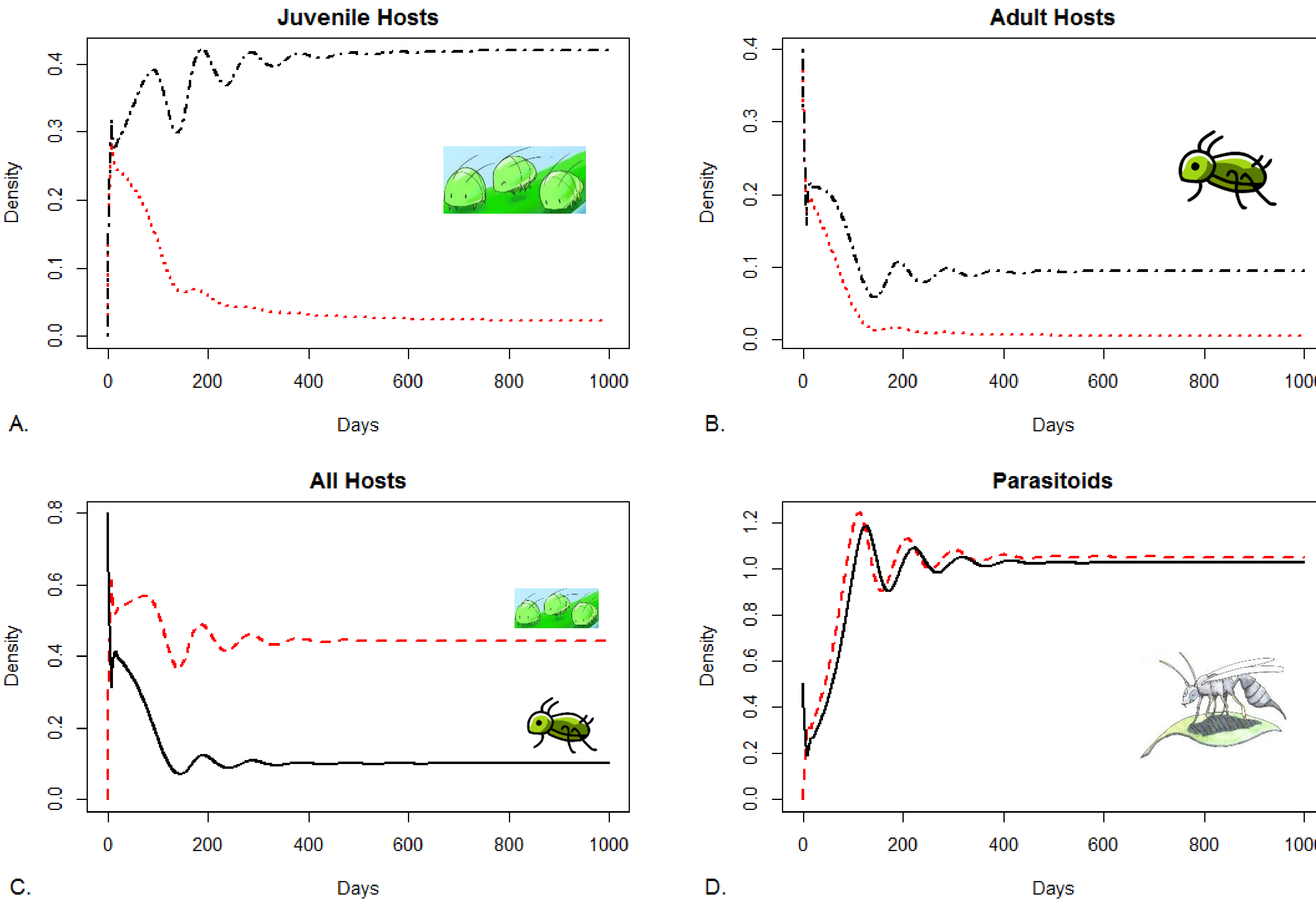
Attack rate α is key to system dynamics

Large attack rate α



α = 2

Lower attack rates



α = 1.2

IPM in a changing environment

Effects of climate change uncertain but expect more extreme events including drought

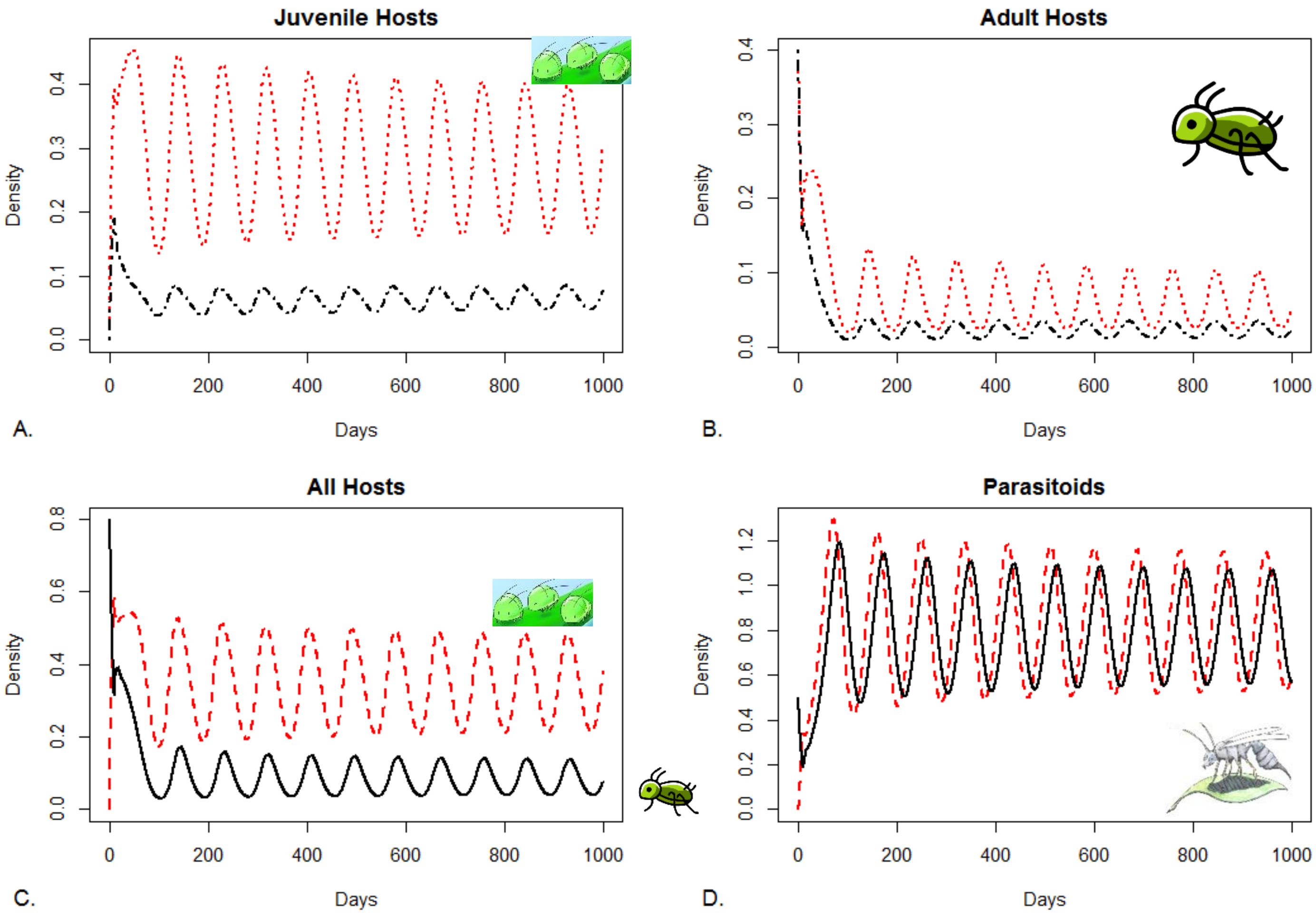
Increasing pressure to reduce pesticide use

Parasitoids alternative means of pest control

Limited research on the how aphids react to drought stress

- Some evidence of reduced development time
- Some evidence that *H. defensa* carrying phenotypes may have reduced fecundity on wild type (poorer quality) plants

Drought Stress



α = 1.2

Reduced fecundity of defended phenotypes destabilises the system

Reduced aphid development time has little effect

So……..

Theory

- Attack rate is key to system dynamics
- Learning effect is a strong stabiliser

Implications for practical use

- External stress factors on aphids can have significant influence on population dynamics
- Drought induced changes could destabilise systems used for IPM

It raises as many questions as it answers

- Does learning actually occur in this system?
- How do we estimate attack rates in a heterogeneous environment?
- What about multi-species systems?

Part of larger programme of work to understand pest-natural enemy interactions

Thank you

Preedy K.F., Chaplain M.A., Leybourne D., Marion G. and Karley A.J. (2020) Learning-induced switching costs in a parasitoid can maintain diversity of host aphid phenotypes although biocontrol is destabilised under abiotic stress. *Journal Animal Ecology*. In Press