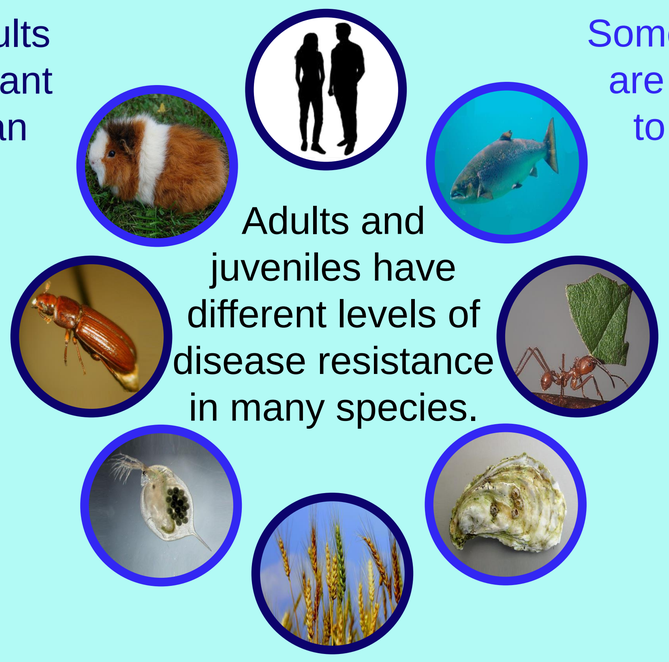
Trade-offs and the evolution of age-specific resistance to infectious disease

Lydia Buckingham[1,2], Emily Bruns[3], Ben Ashby[1,2,4]

1. Department of Mathematical Sciences, University of Bath, Bath. UK
2. Milner Centre for Evolution, University of Bath, Bath. UK
3. Department of Biology, University of Maryland, College Park, Maryland. US
4. Department of Mathematics, Simon Fraser University, Burnaby. Canada

Contact: ljb74@bath.ac.uk

Sometimes adults are more resistant to disease than juveniles.

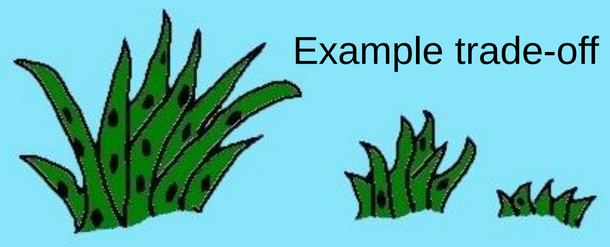


Adults and juveniles have different levels of disease resistance in many species.

Sometimes juveniles are more resistant to disease than adults.

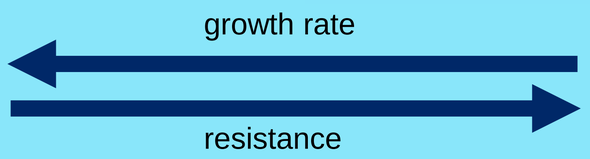
Why are adults sometimes, but not always, more resistant to disease than juveniles?

Variation in the resource requirements of different organisms at different life stages may provide an explanation.



Example trade-off

Allocating resources to reproduction (a), maturation (g) or juvenile mortality (b_J) may reduce juvenile resistance (r_J).



Allocating resources to reproduction (a) or adult mortality (b_A) may reduce adult resistance (r_A).

We model these relationships using trade-off functions.

We describe these ecological interactions using the following system of equations:

$$\frac{dS_J}{dt} = a(1-qN)(S_A + fI_A) - \left(b_J + g + \lambda_J\right)S_J$$

$$\frac{dS_A}{dt} = gS_J - (b_A + \lambda_A)S_A$$

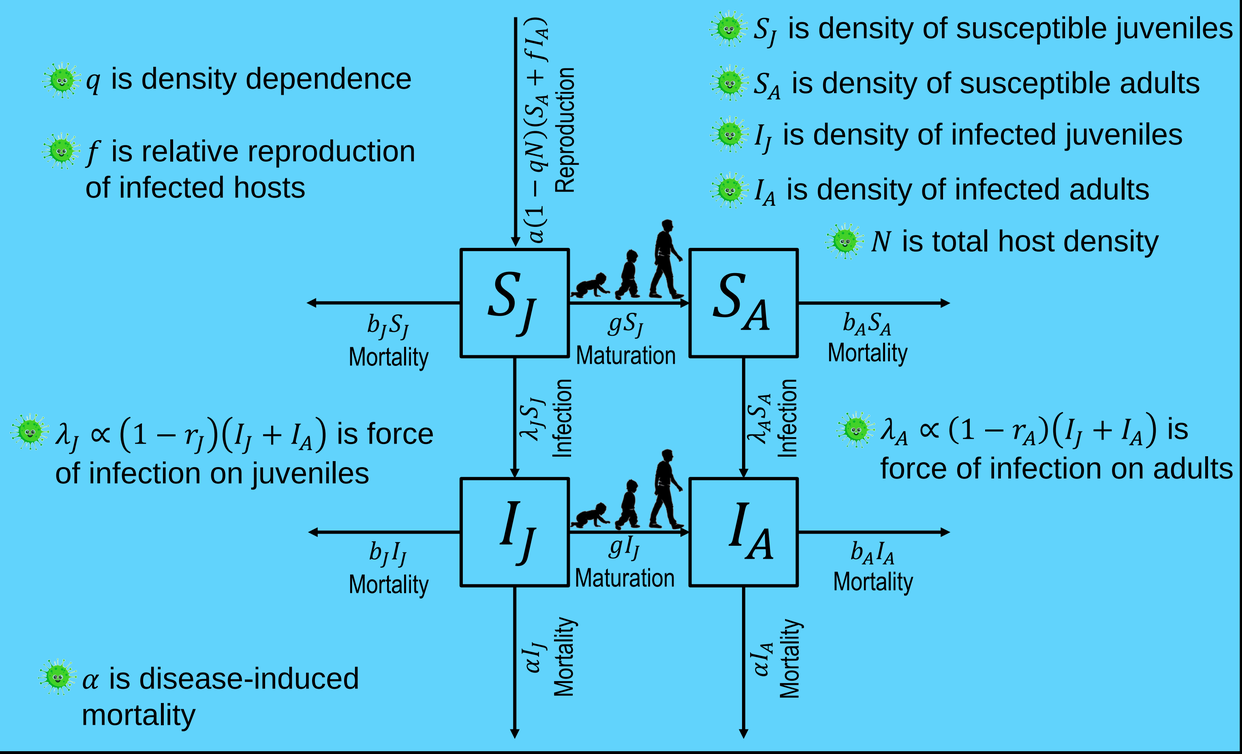
$$\frac{dI_J}{dt} = \lambda_J S_J - (b_J + g + \alpha)I_J$$

$$\frac{dI_A}{dt} = gI_J + \lambda_A S_A - (b_A + \alpha)I_A$$

The juvenile and adult resistance traits are allowed to evolve independently between zero and one.

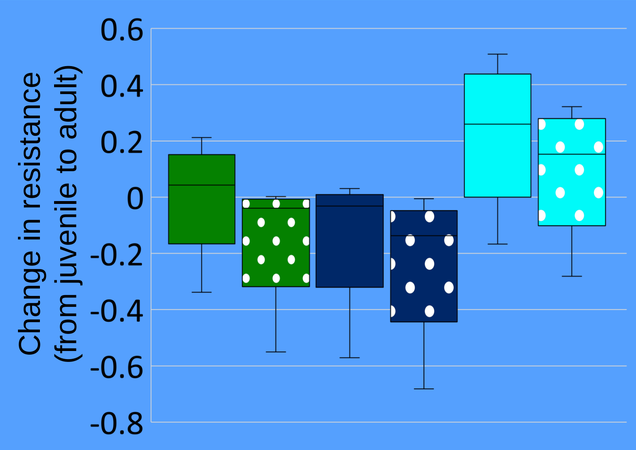
We use adaptive dynamics (evolutionary invasion analysis) and simulations to determine the evolutionary dynamics.

Consider a host-pathogen system with these ecological dynamics:



We consider six different combinations of juvenile and adult resistance trade-offs.

For each combination, we calculate the difference between juvenile and adult resistance for many parameter sets. The box plots show the distributions of these differences.



- Juvenile resistance trade-off with maturation
- Juvenile resistance trade-off with mortality
- Juvenile resistance trade-off with reproduction
- Adult resistance trade-off with mortality
- Adult resistance trade-off with reproduction

Adult resistance is generally higher than juvenile resistance when juvenile resistance trades off with reproduction but juvenile resistance is generally higher than adult resistance in all other cases.

Trade-offs between juvenile resistance and adult reproduction are inherently more costly than other trade-offs (e.g. with maturation or mortality).

Differences in the costs of resistance may therefore help to explain why adults are sometimes, but not always, more resistant to disease than juveniles.

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References

More Information

This research has been published in Proceedings of the Royal Society B: