Inducible defense destabilizes predator-prey dynamics

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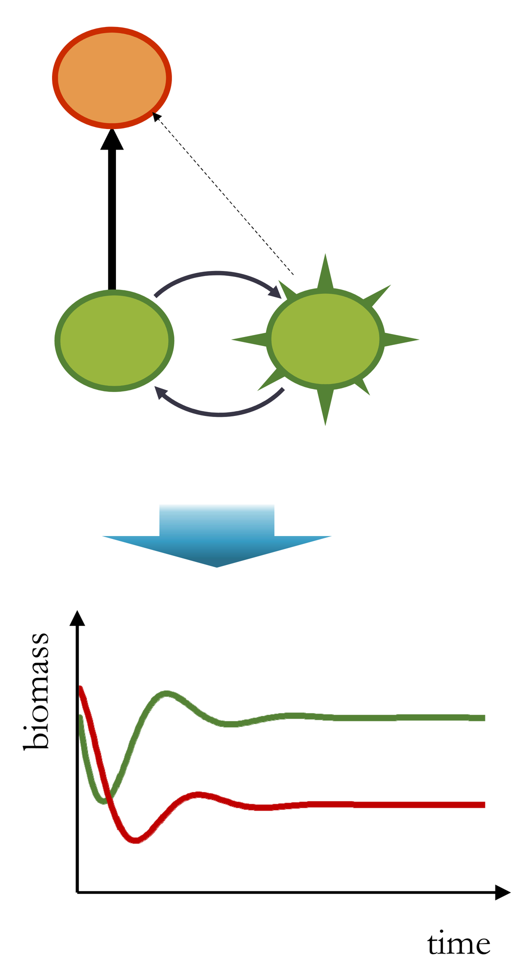
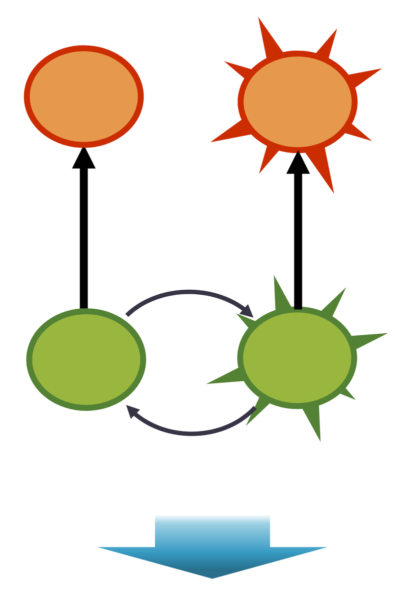
Introduction



Inducible defenses are ubiquitous in many prey species. Defended phenotypes are induced only if the benefits outweigh the costs.

Theoretical studies have universally shown that this **stabilizes** predator-prey dynamics[1-3].



However

In **incompatible defense**, induction of defense against some predators increases vulnerability to others[4].

How this affects stability of predator-prey dynamics is unexplored.

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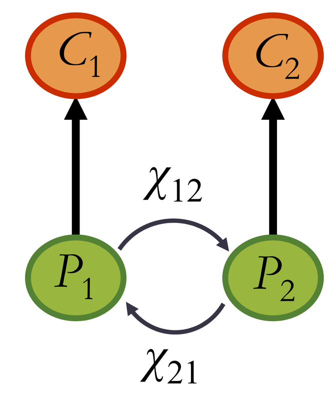
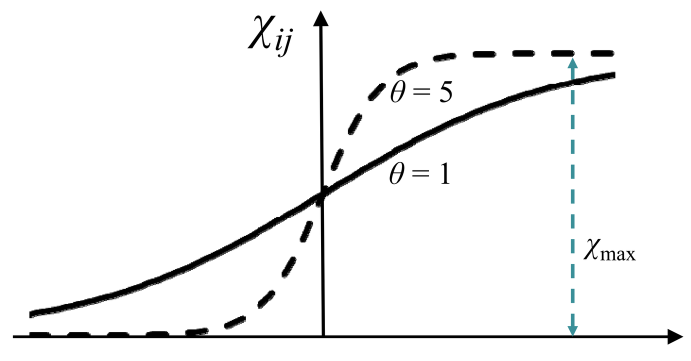
Does incompatible defense stabilize dynamics in a two-predator system?

Numerical simulations of a mathematical predator-prey model:



- two predators
- two prey phenotypes
- incompatible inducible defense
- switching between phenotypes depends on predation risk

➔ **what is the effect of increased switching rates?**



Target parameters:

χ_{max}: maximum switching rate

θ: sensitivity to predation risk φ

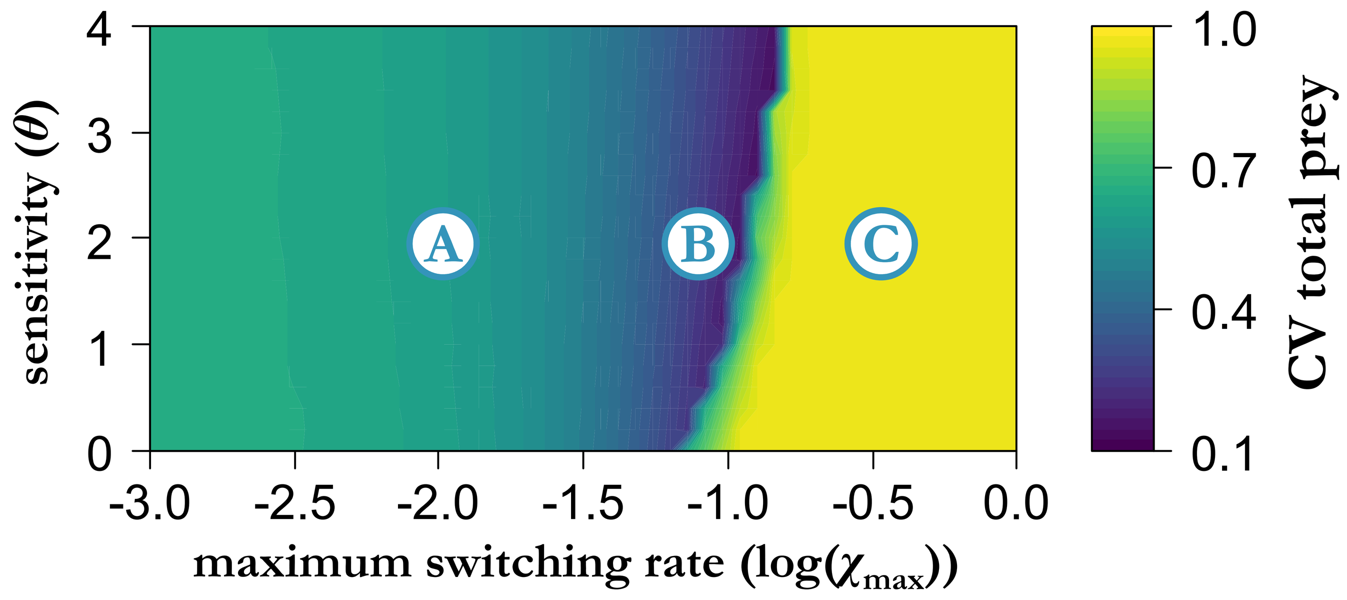
Model equations

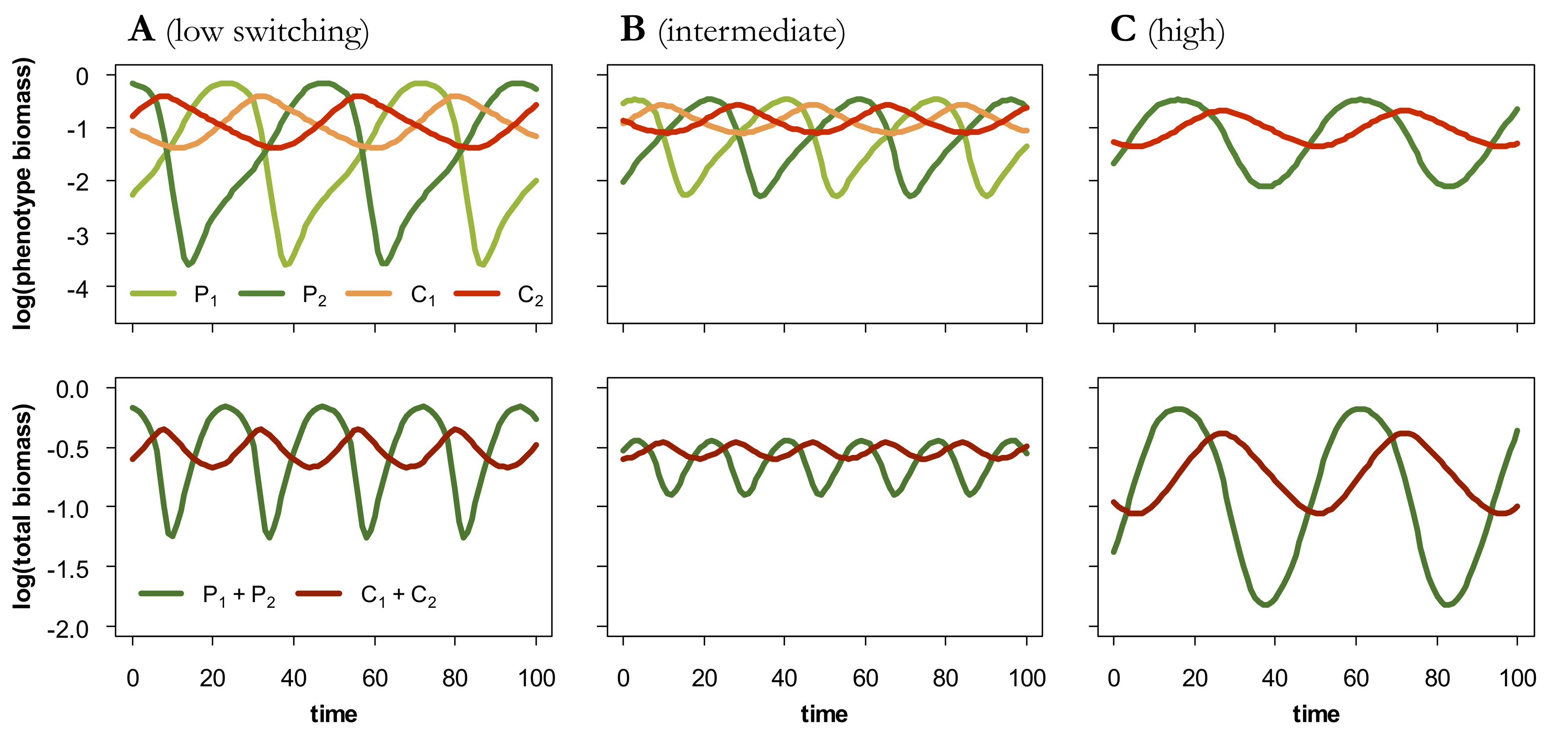
$$\frac{dP_i}{dt} = r\left(1 - \frac{P_1 + P_2}{K}\right)P_i - \frac{aC_iP_i}{1 + haP_i} - \chi_{ij}P_i + \chi_{ji}P_j$$

$$\frac{dC_i}{dt} = \frac{aC_iP_i}{1 + haP_i} - dC_i, \quad \chi_{ij} = \chi_{max}\frac{1}{1 + e^{\theta\cdot(\varphi_j - \varphi_i)}}, \quad \varphi_i = \frac{aC_i}{1 + haP_i}$$

Does plasticity stabilize?

- initially, increasing switching **stabilizes dynamics** of total prey biomass
- but high switching rate **destabilizes**



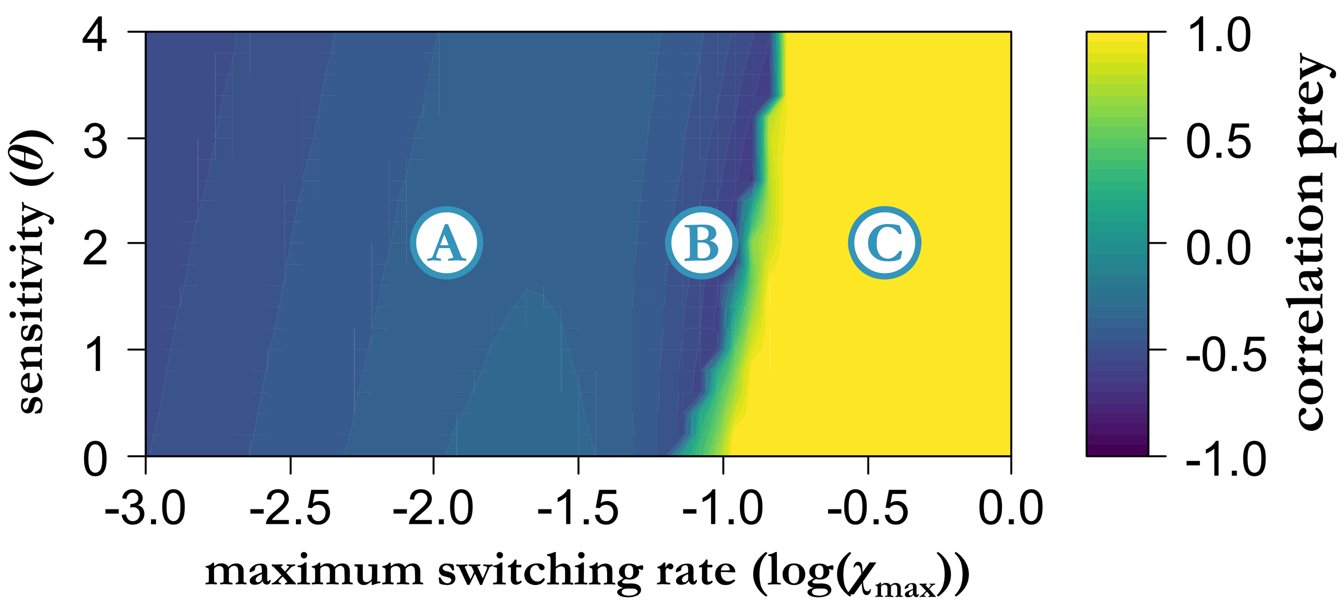


A (low switching)
- competition between prey drives **compensatory dynamics**
- fluctuations in total biomass are **dampened**

B (intermediate)
- increased exchange dampens prey phenotype oscillations
- **stabilizes** dynamics even further

C (high)
- high switching **synchronizes** prey (and predators)
- **destabilizes** dynamics of total prey and predator biomass

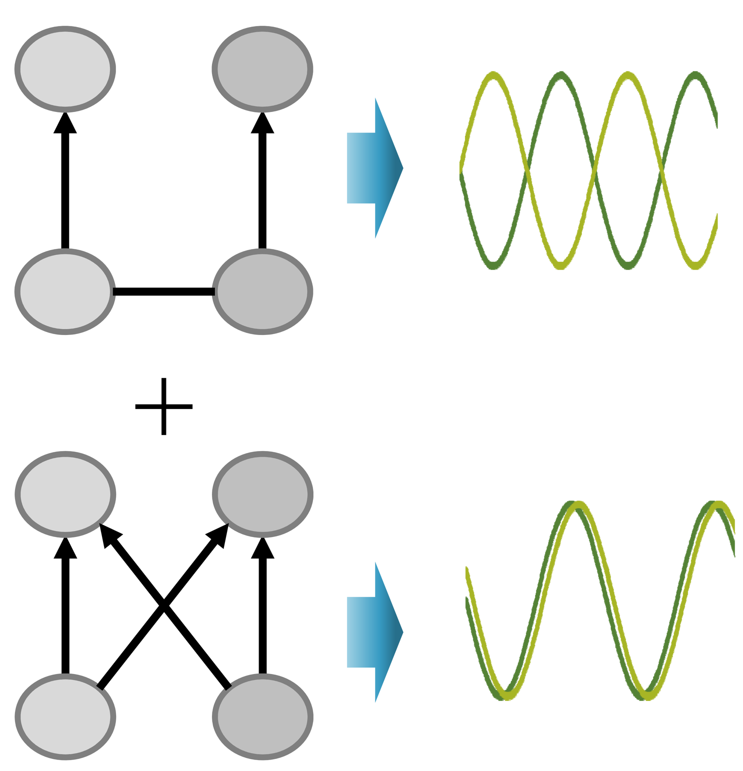
- calculated **correlation** between prey phenotypes
- shift from compensatory to synchronized dynamics with high plasticity
- synchronization causes higher community-level variability[5-6]



Conclusions

- pattern of stability is reversed in a two-predator system: instead of stabilizing, inducible defenses destabilize dynamics
- this pattern is entirely driven by switching-induced synchronization, and independent of mechanisms regulating switching
- destabilization is a result of **incompatible defense**, rather than the presence of two predators in itself

Why does plasticity synchronize?



- no switching
- competition between prey: compensatory dynamics

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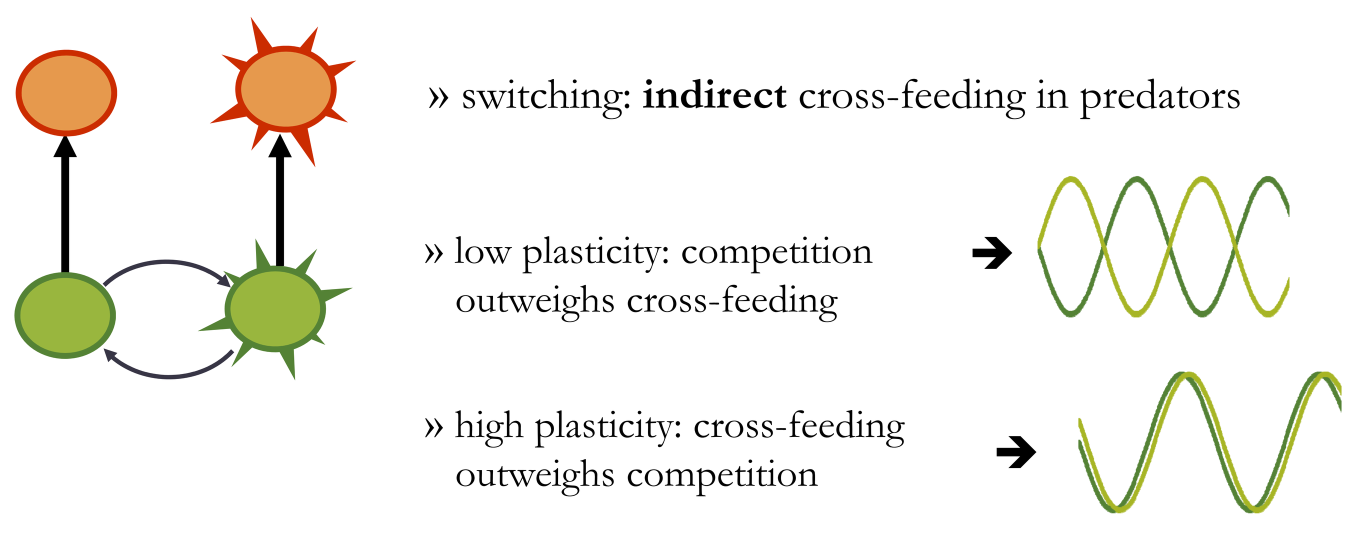
- no switching
- cross-feeding in predators: synchronized dynamics



- switching: **indirect** cross-feeding in predators
- low plasticity: competition outweighs cross-feeding ➔
- high plasticity: cross-feeding outweighs competition ➔

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References

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