(A bit) Earlier or later is always better

Phenological shifts in consumer-resource interactions

Tomás Revilla[1]

[1]Centre for Biodiversity Theory and Modelling
Station d'Ecologie Expérimentale du CNRS à Moulis

Outline

Outline

Phenology

1: a branch of science dealing with the relations between climate and periodic biological phenomena (as bird migration or plant flowering)

2: periodic biological phenomena that are correlated with climatic conditions

It is important because:

- Plays an important role at many scales (e.g. populations, communities) and processes (e.g. dispersal, growth, evolution)
- There is concern about the potential consequences of changes in species phenologies driven by global climate change

Effects of climate change

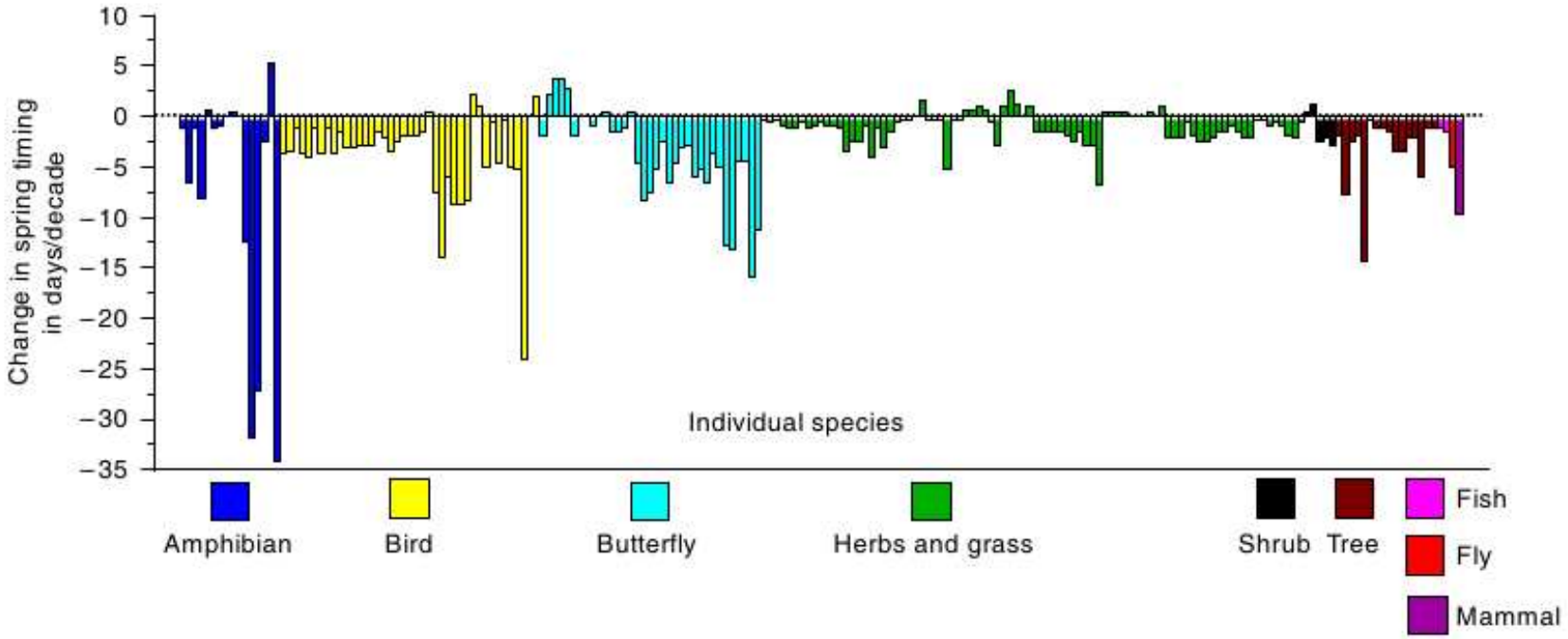

Fig. 2 Changes in timing of spring events in days decade^{-1} for individual species grouped by taxonomy or functional type for the combined dataset. Each bar represents a separate, independent species. Negative values indicate advancement (earlier phenology through time) while positive values indicate delay (later phenology through time).

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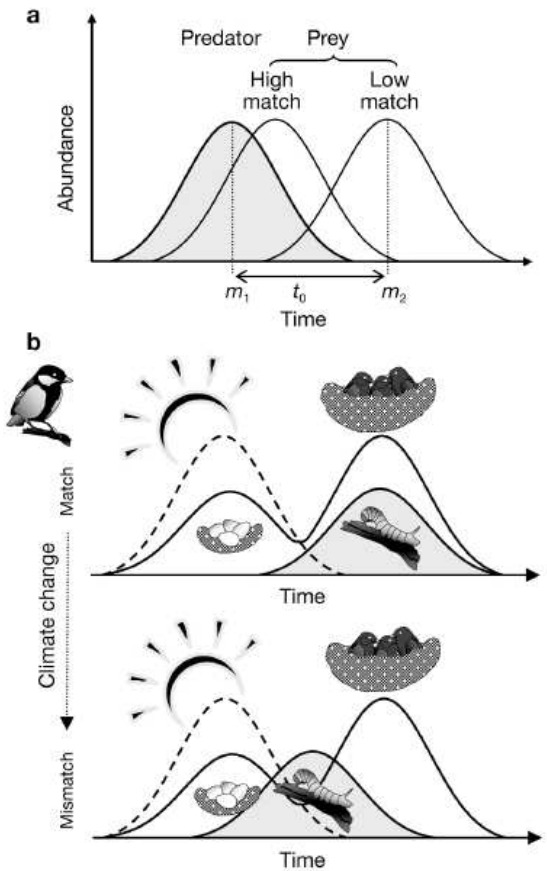
Match–Mismatch Hypothesis



Goals

- Study the effects of changes of phenology on the abundances and dynamics of consumers and resources
  - Shifts in timing (when)
  - Changes of activity periods (how long)
- Study the consequences for top-down and bottom-up regulation, consumer–resource feedbacks
- Investigate the role of foodweb structure

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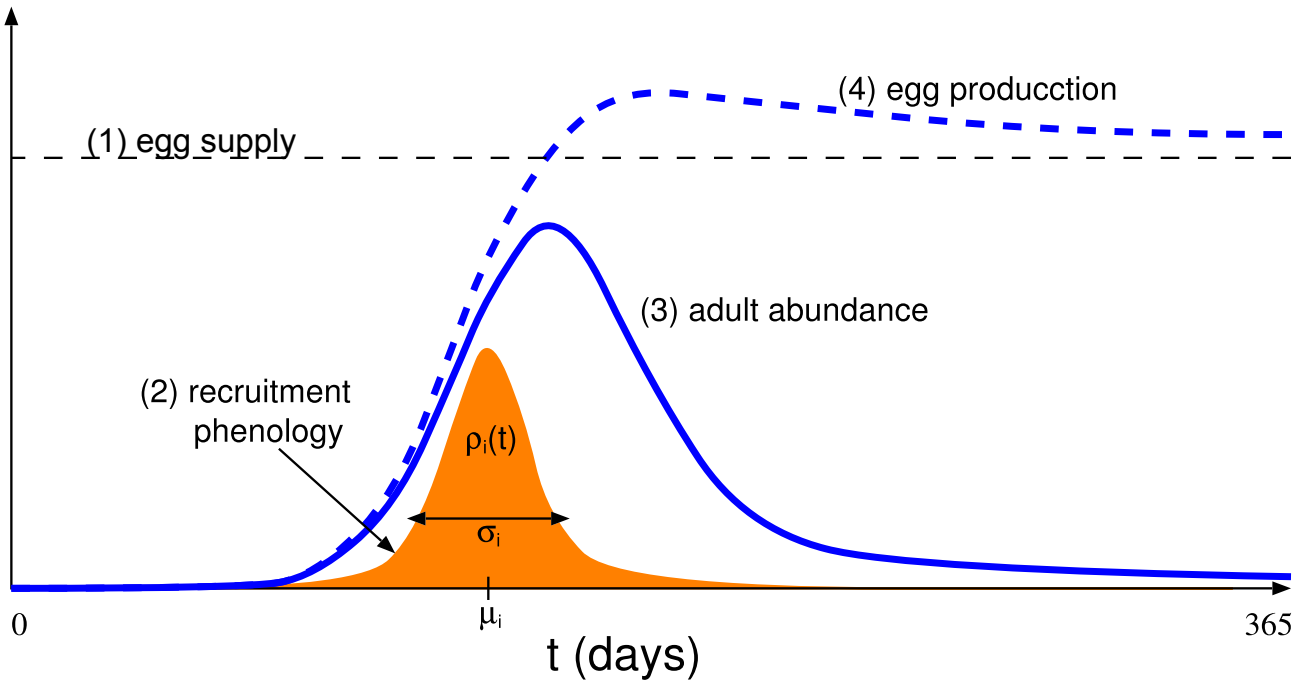
This happens every year

Adults (blue line) emerge around day μ with an s.d. σ, from seeds or eggs produced by the adults in the previous year



Dynamics of interacting adults during one year

One resource (species 1) and its consumer (species 2)

$$\frac{dN_1}{dt} = \rho_1(t)n_1 - m_1 N_1 - a_{12} N_1 N_2$$
$$\frac{dN_2}{dt} = \rho_2(t)n_2 - m_2 N_2$$

N_i biomass of adults

$\rho_i(t)$ recruitment rate at day t

n_i number of seeds or eggs

m_i mortality or decay rate

a_{ij} consumption rate of i by j

Seed/Egg production

During the same year

$$\frac{dB_1}{dt} = \frac{b_1 N_1}{1 + c_1 N_1} - d_1 B_1$$
$$\frac{dB_2}{dt} = e_2 a_{12} N_1 N_2 - d_2 B_2$$

B_i seeds or eggs

b_i, c_i resource growth rate and self-limitation coefficient

e_i consumer's conversion efficiency

d_i mortality or decay rate

Long-term dynamics

The long term dynamics, year after year, is given by

$$n_{1,\tau+1} = B_1(t = 365 | n_{1,\tau}, n_{2,\tau})$$
$$n_{2,\tau+1} = B_2(t = 365 | n_{1,\tau}, n_{2,\tau})$$

1. The number of seeds or eggs available for the next year $(\tau + 1)$ is the net number produced at the end of the present year (τ)
2. All the adults left at the end of the present year die

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Phenological match/mismatch

We study the consequences of match/mismatch as follows

1. Set species 1 recruitment at $\mu_1 = 180$ (approx. mid year)
2. Set species 2 recruitment at $\mu_2 = \mu_1 + \Delta\mu$
   amount of mismatch: $\Delta\mu = -100 : 5 : 100$ days
3. Follow the long term dynamics (seeds/eggs) for 100 to 300 years

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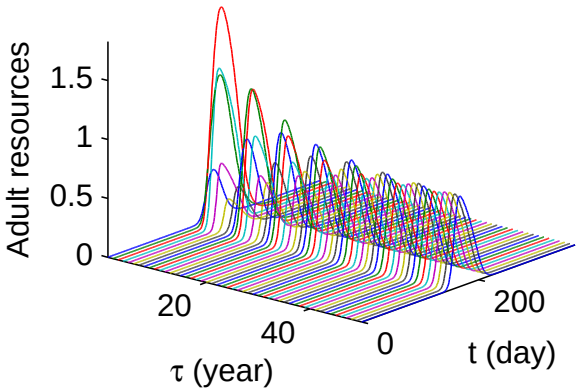
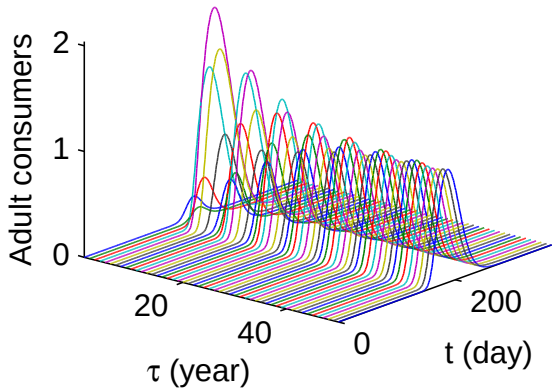
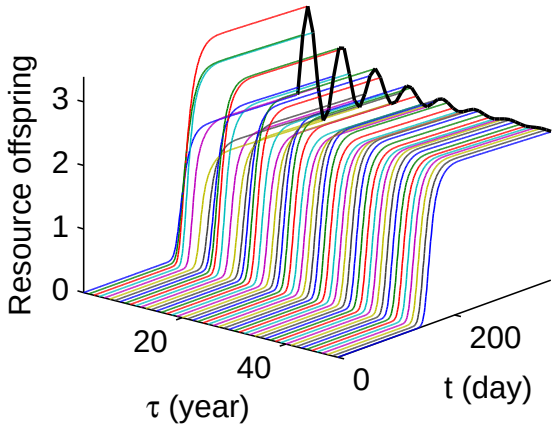
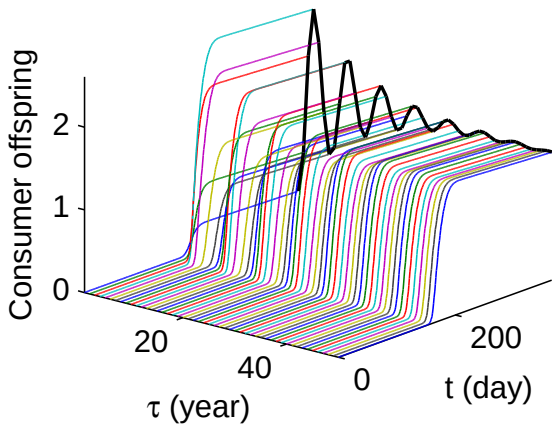
Short and long term dynamics

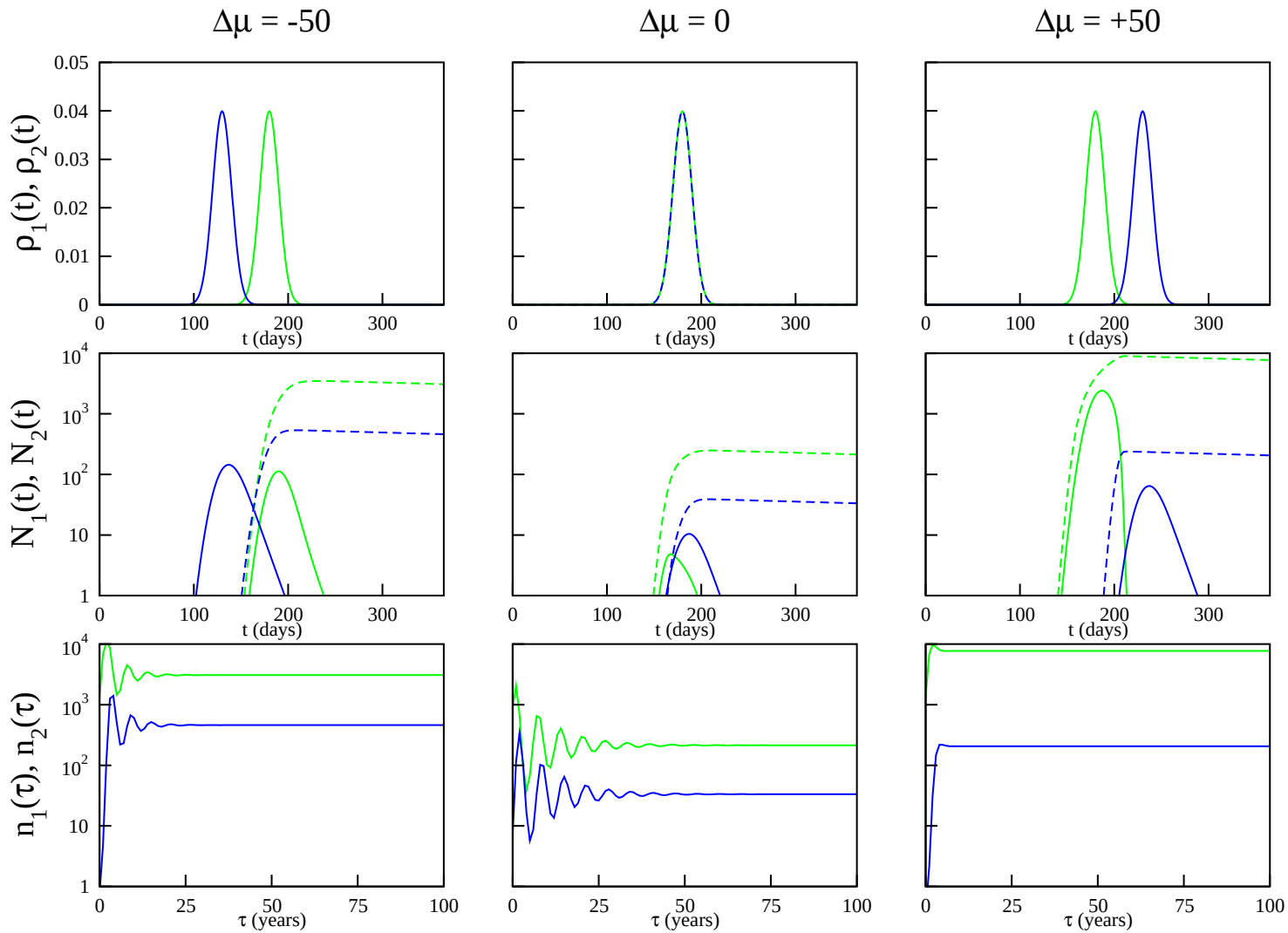




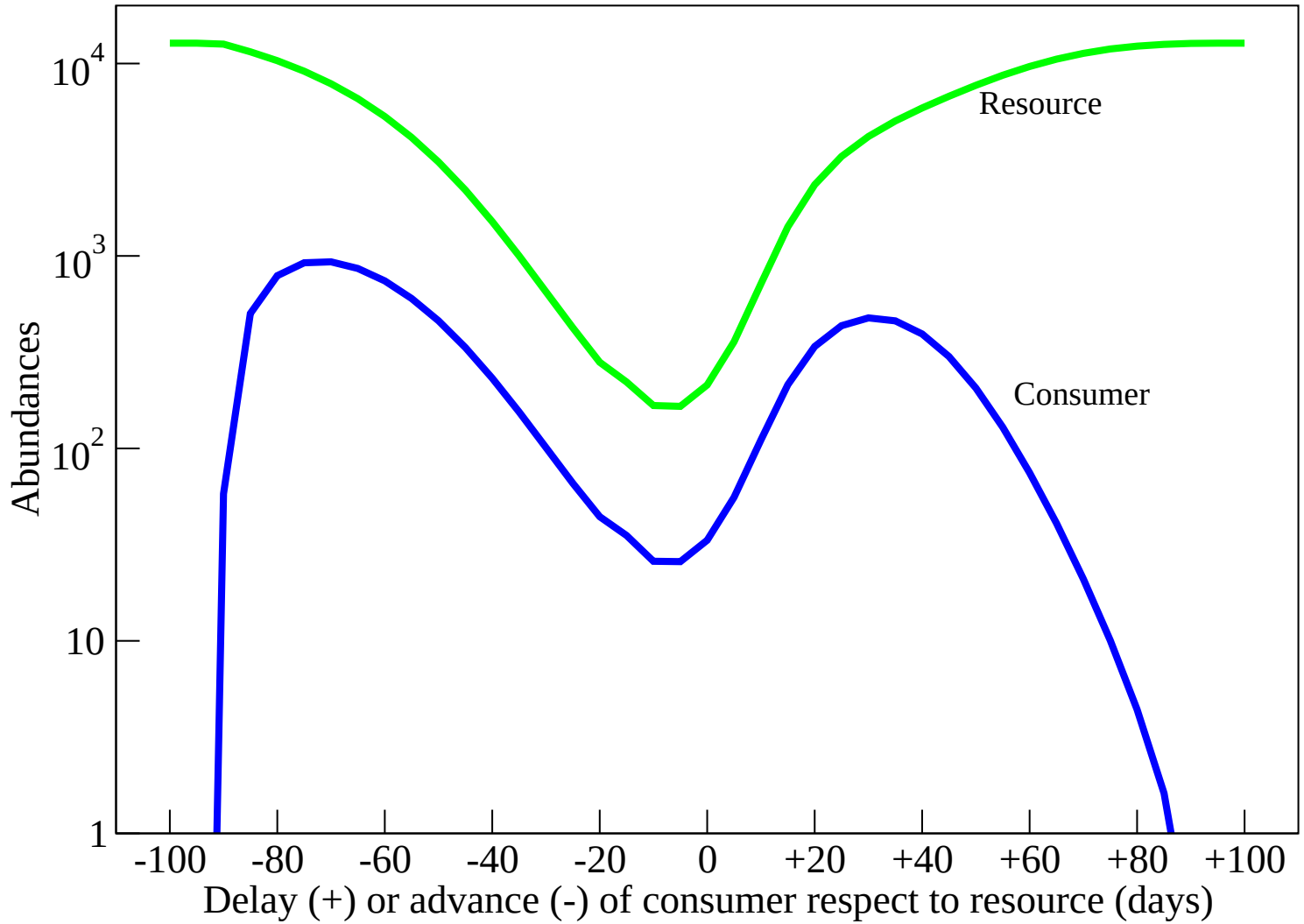




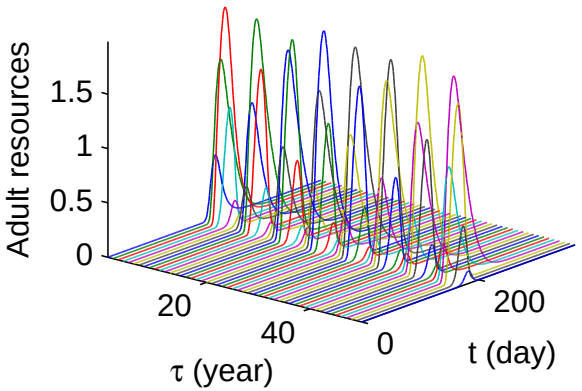
Mis

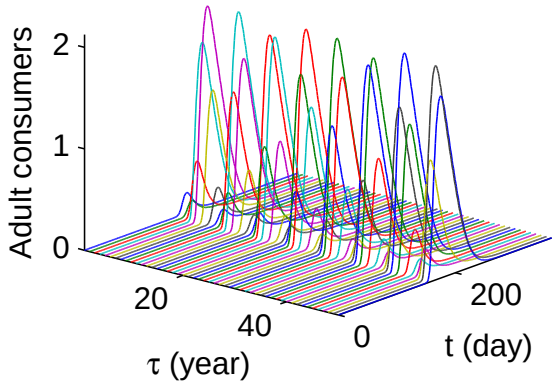


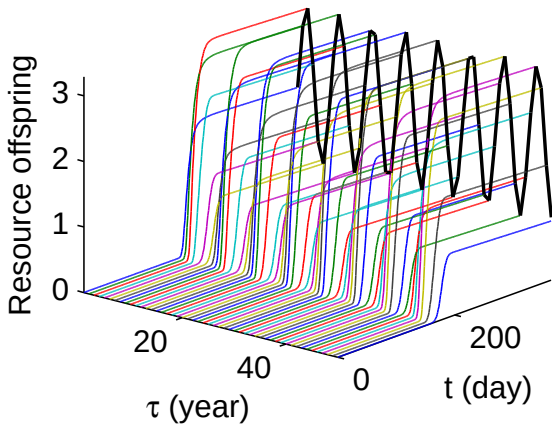
Long-term abundances (seeds/eggs)

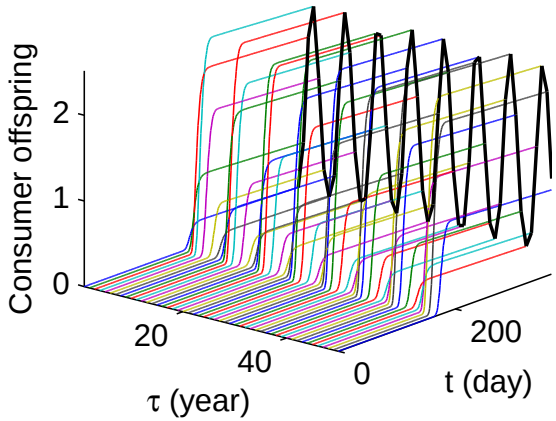


Consumer–resource oscillations







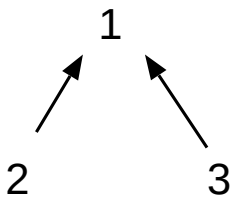


Outline

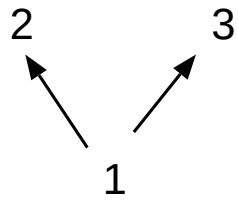
Trophic structure

We also consider three species in four *community modules*, i.e. consumer-resource arrangements

apparent competition

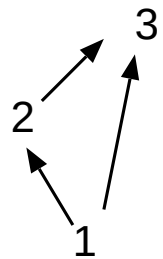


resource competition

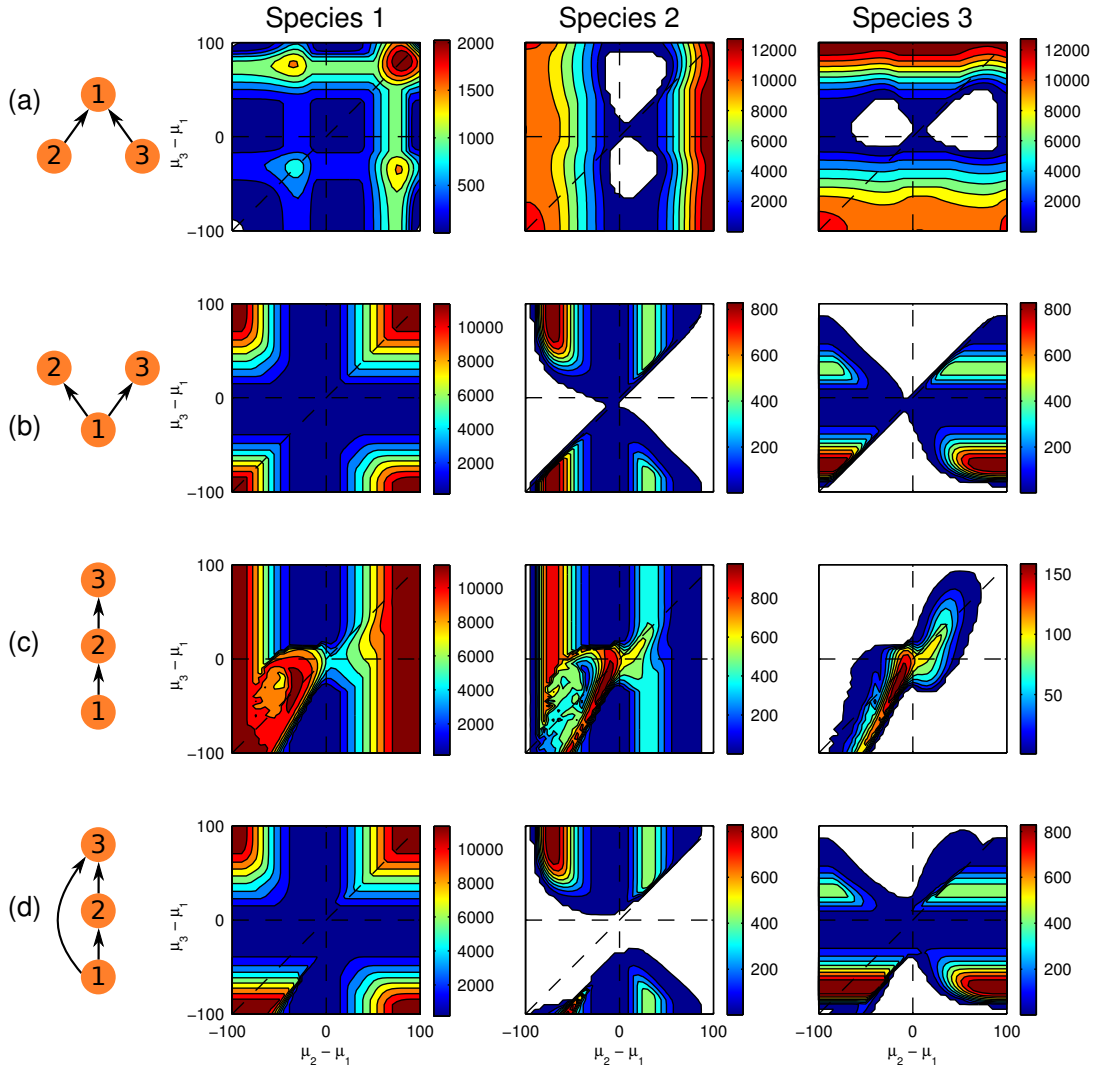


food chain

intraguild predation



Long-term abundances (seeds/eggs) and mismatch



Summary

- Consumers require temporal overlap with their resources. However, perfect matching also leads to overexploitation of resources
- Changes in the timing and the duration of the activity seasons can cause changes in long-term dynamics (stable equilibrium, cycles)
- In simple communities, the net effect of phenological mismatches is to some extent a superposition of their effects of on consumer-resource pairs

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