spatial predator prey model with periodic forcing

http://darwin.wcupa.edu

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Predator-prey basic model

$$\frac{\partial u}{\partial t} = u(1-u) - \frac{uv}{u+h}$$

Intrinsic birth and death

Predation

$$\frac{\partial v}{\partial t} = k\frac{uv}{u+h} - mv$$

Benefit from Predation

Death

Modified model

$$\frac{\partial u}{\partial t} = [c + \lambda \sin(\omega t)]u(1-u) - \frac{uv}{u+h} + D_1 \frac{\partial^2 u}{\partial x^2}$$

Periodic forcing

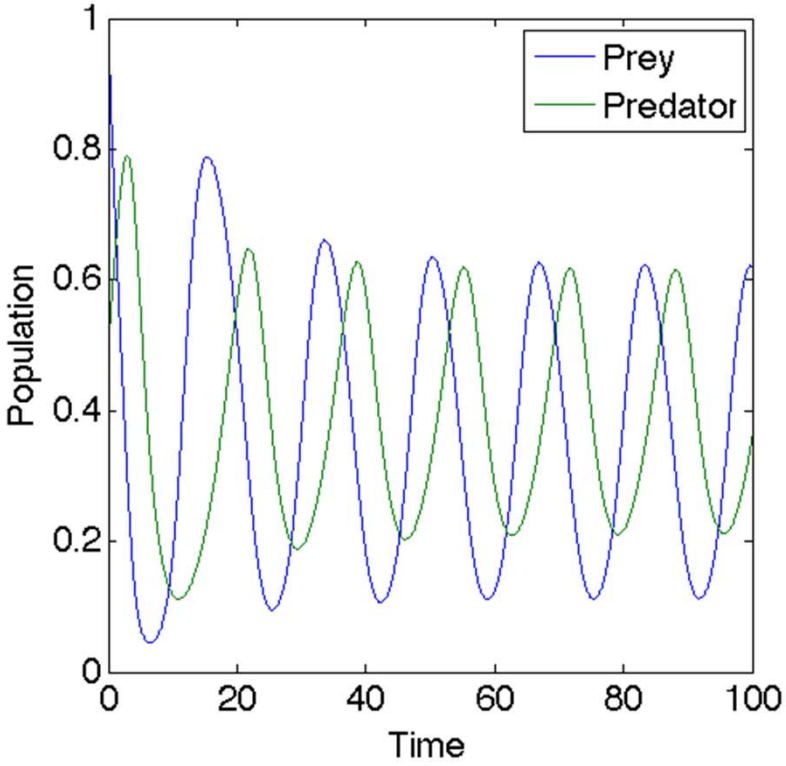
Dispersal

$$\frac{\partial v}{\partial t} = k\frac{uv}{u+h} - mv + D_2 \frac{\partial^2 v}{\partial x^2}$$

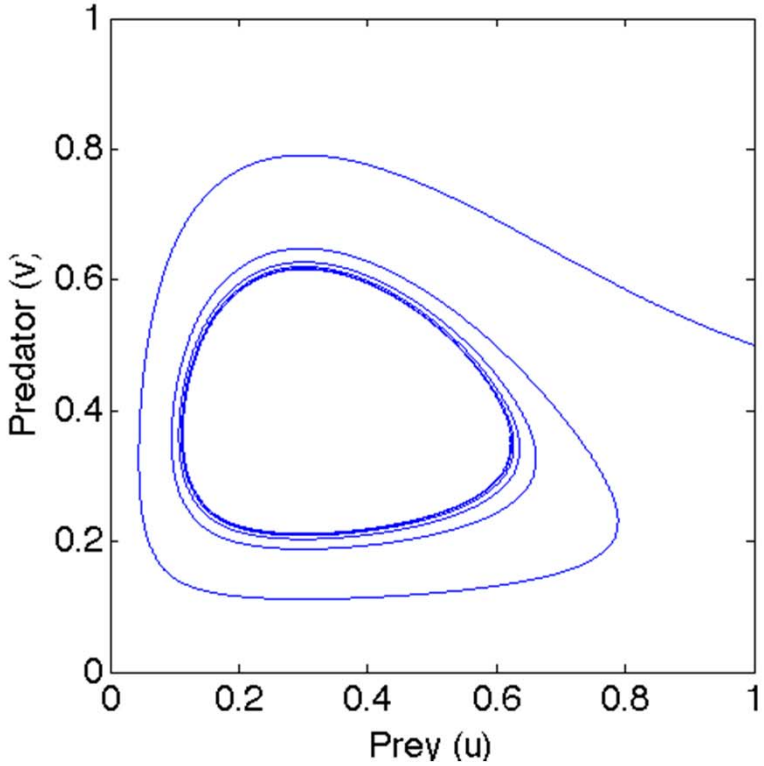
Dispersal

Case without forcing & diffusion

Temporal patterns



Phase space



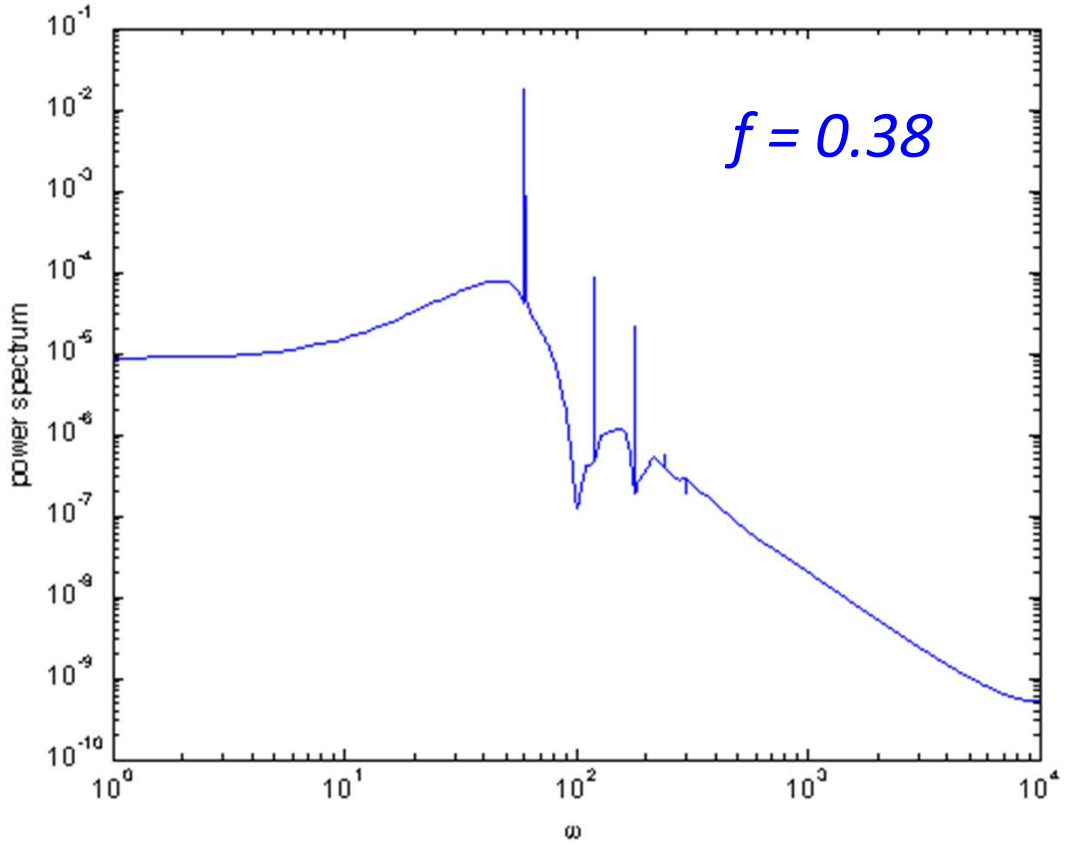
Handling time (h) = 0.3

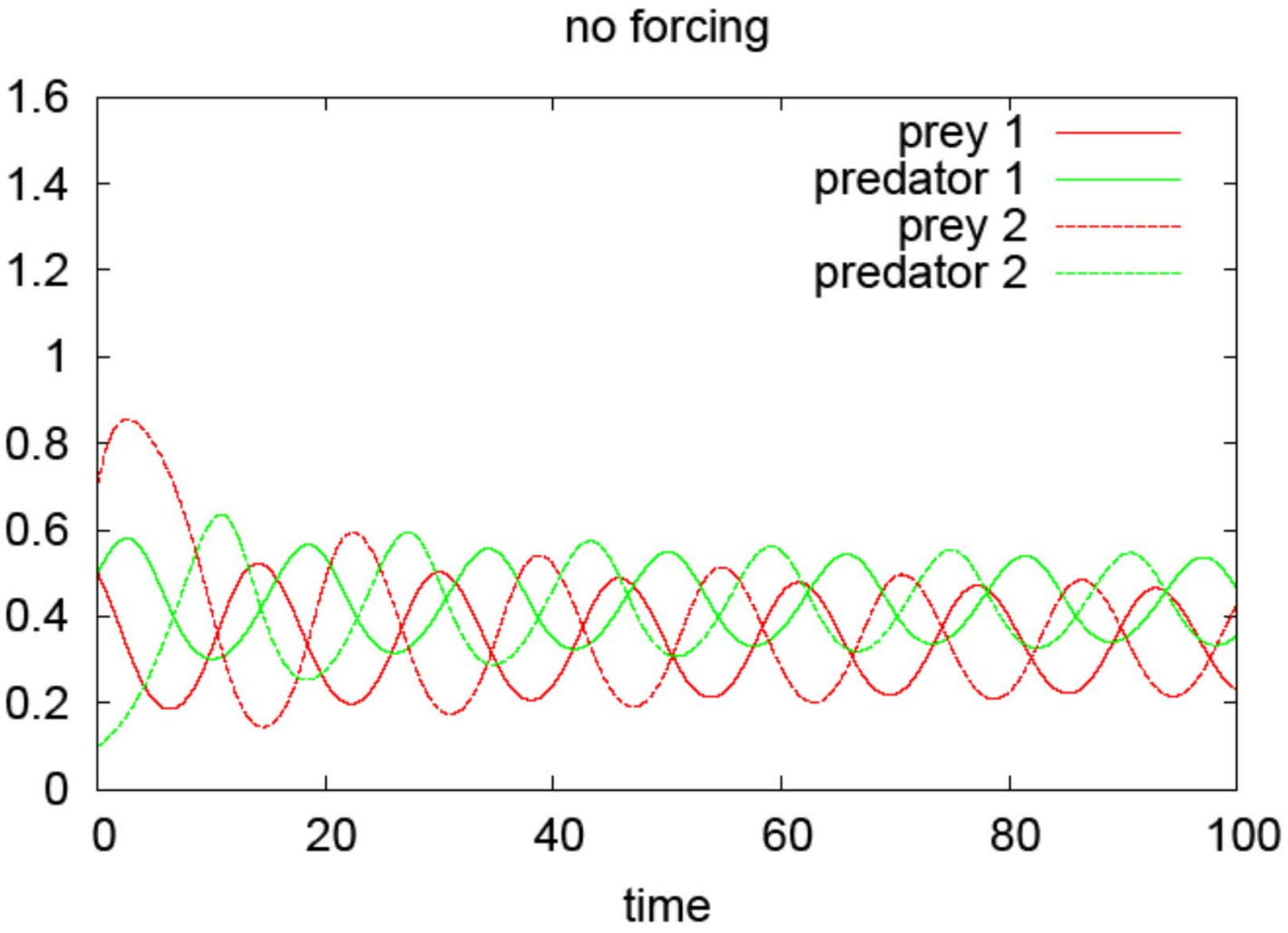
Efficiency of predator(k) = 1

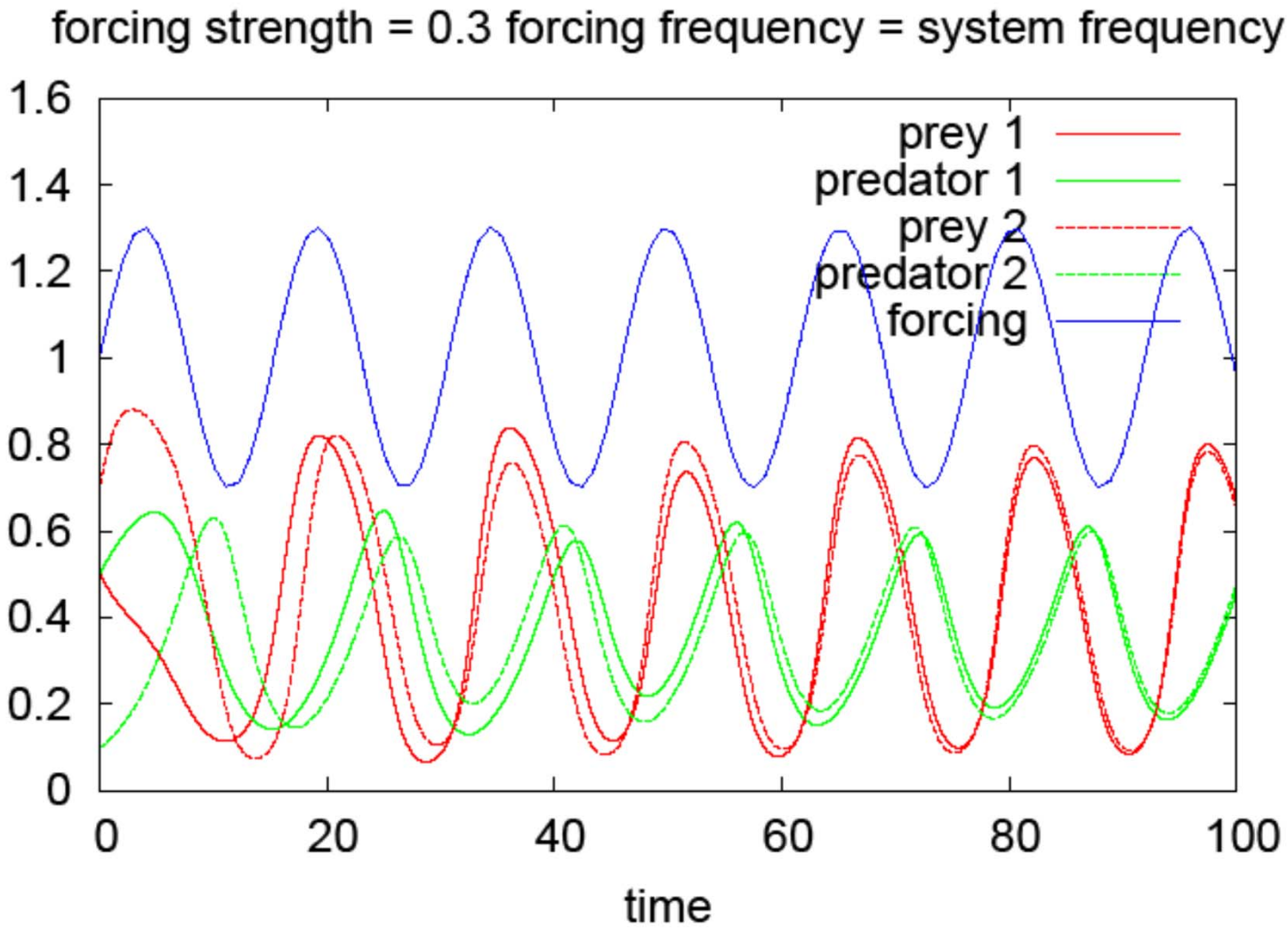
Death rate (m) = 0.5

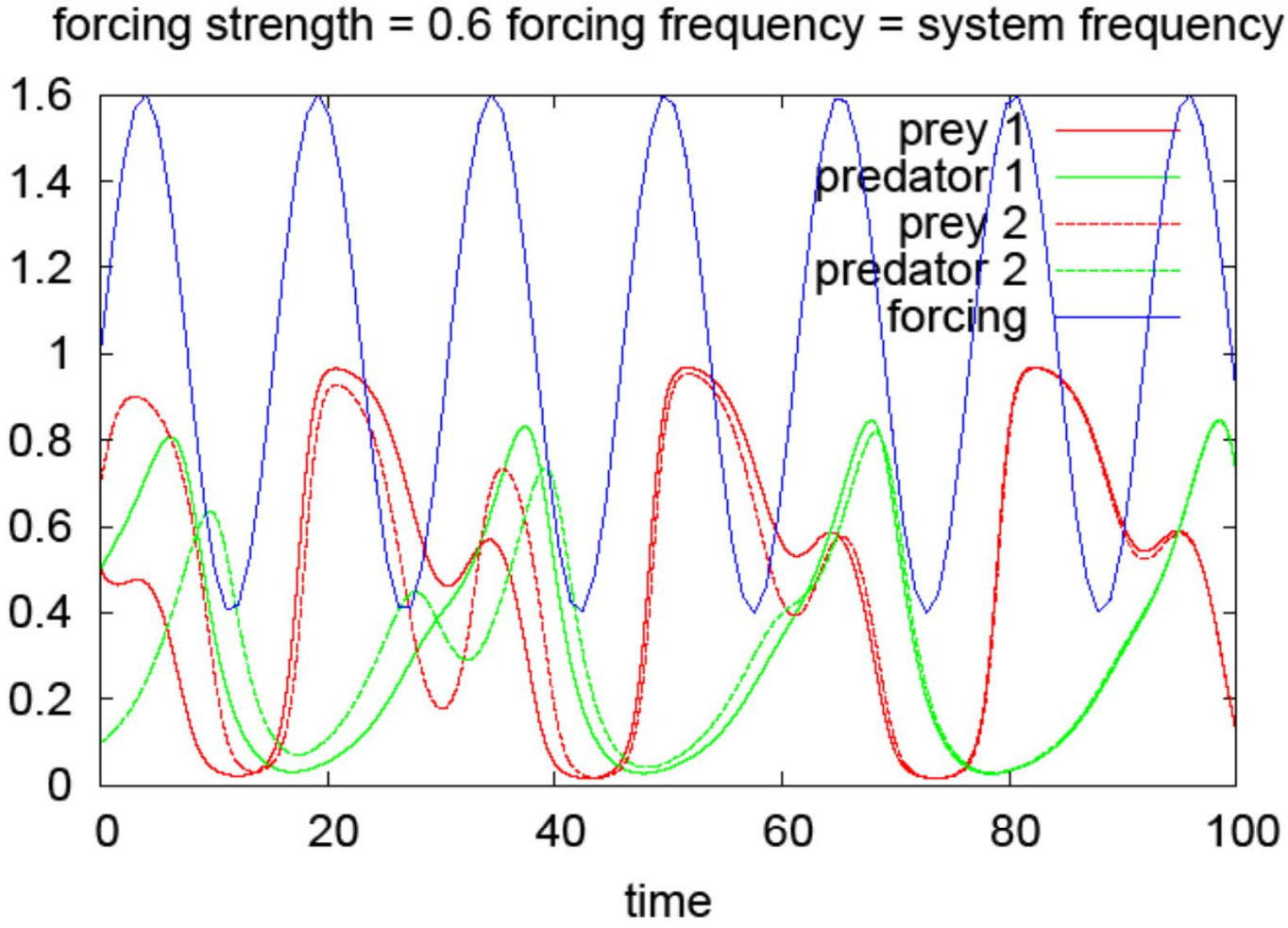
Case without forcing & diffusion

Temporal power spectrum: to find natural periodicity



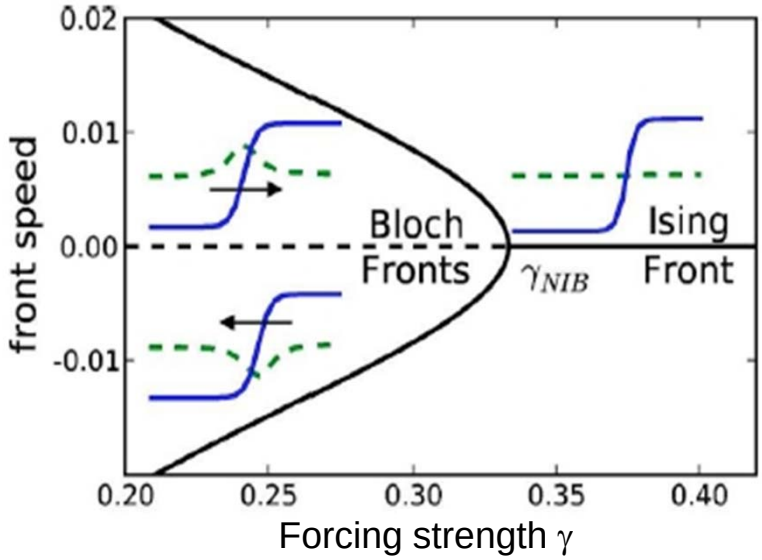

no forcing
prey 1
predator 1
prey 2
predator 2
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
time

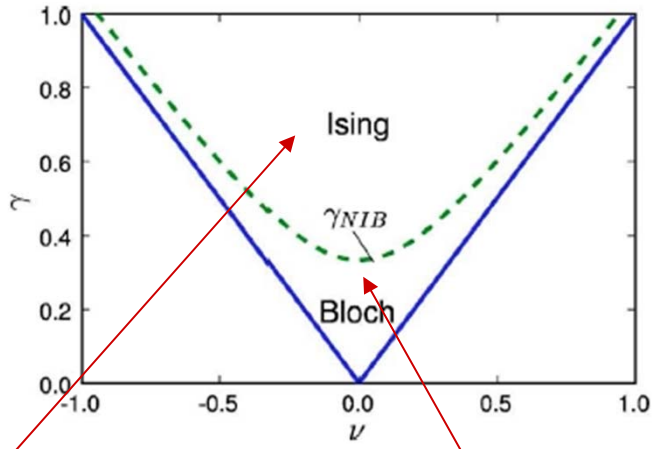

forcing strength = 0.3 forcing frequency = system frequency
prey 1
predator 1
prey 2
predator 2
forcing
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
time


forcing strength = 0.6 forcing frequency = system frequency
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
time
prey 1
predator 1
prey 2
predator 2
forcing

Temporal forcing: frequency locking – patterns

front solutions that can go through a NIB front bifurcation as the forcing strength is decreased (like in the unforced bistable FHN):

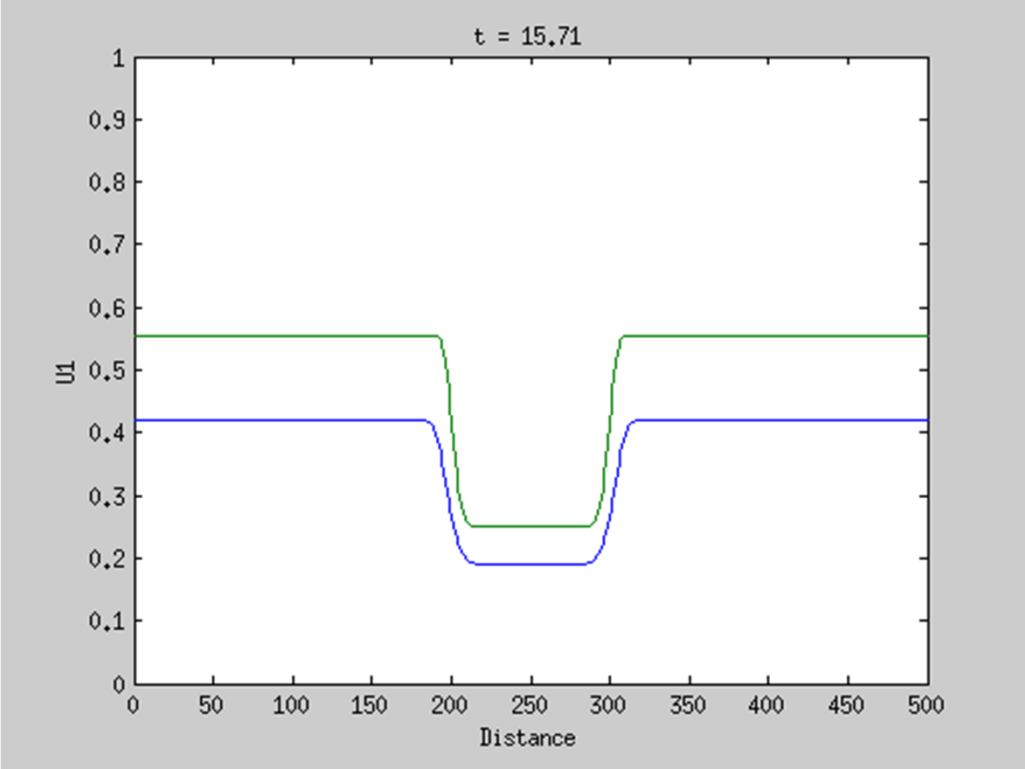




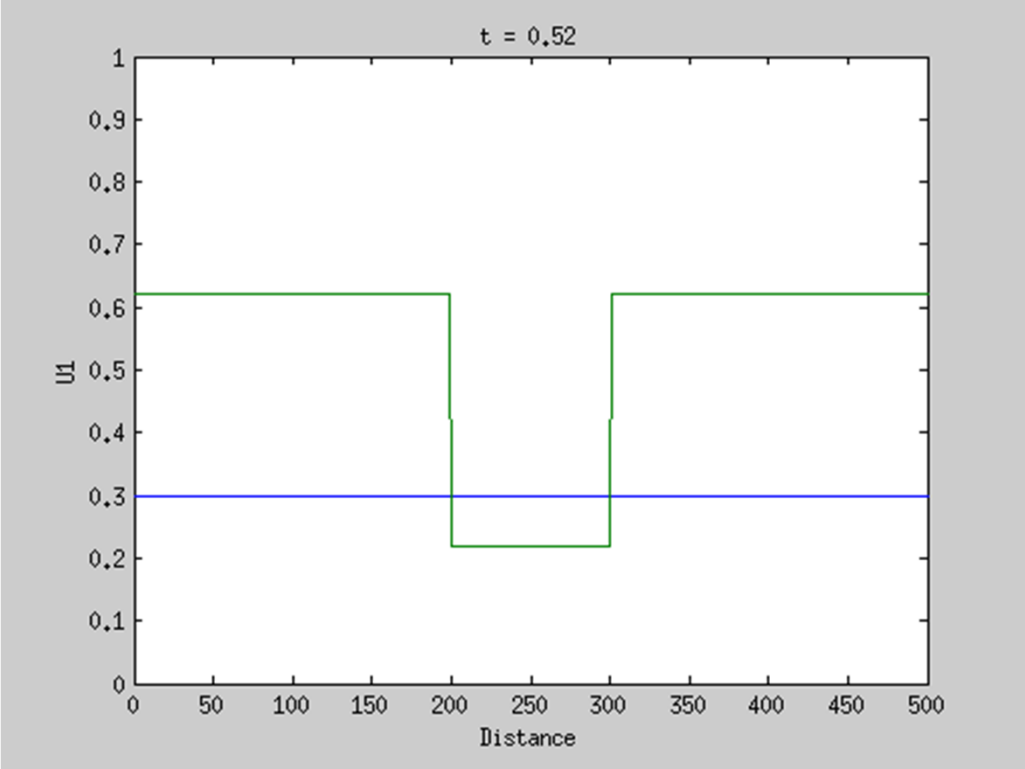
Ising: Stationary fronts and patterns

Bloch: Traveling fronts and patterns

stationary front (phase locking)
forcing freq = 2 * natural freq



no phase locking

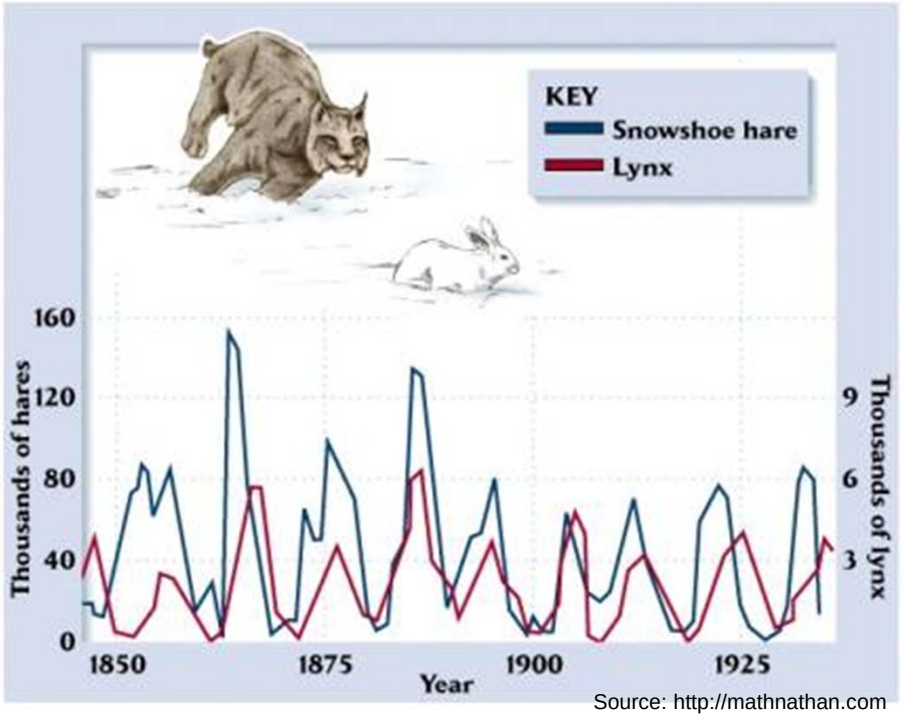


Ecological context

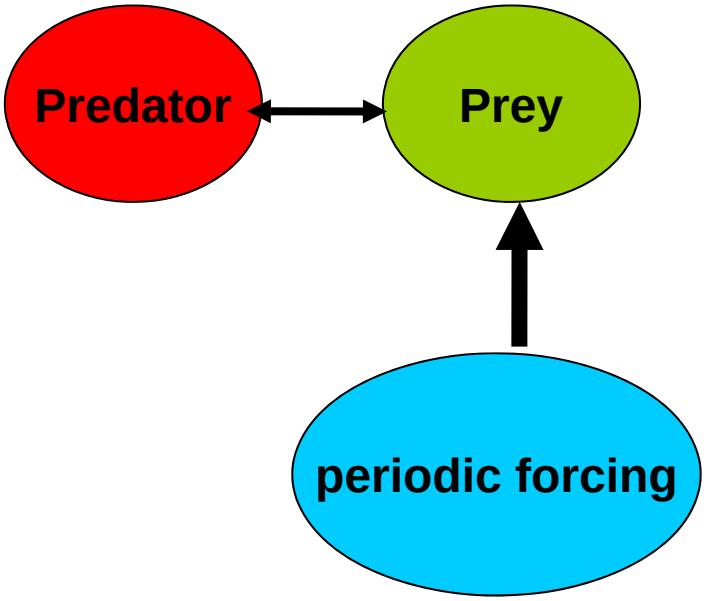
periodic forcing on prey:

- food avialability
- reproductive cycle

also possible:
- periodic forcing on handling time



Source: http://mathnathan.com



seasonal food availability and prey reproduction

	generation per year
univoltine	1
bivoltine	2
multivoltine	>3
semivoltine	0.5
parivoltine	<0.3

http://www.animal-photos.org/photo/2950.html

univoltinism

- synchronised single reproduction with climate, low rates
- food limiation

Arctic hare (*L. arcticus*) day length

Capybara (*Hydrochoerus spp.)* rainy season

multivoltinism

- reproduction all year round
- high reproduction rate
- no seasonal food limitation

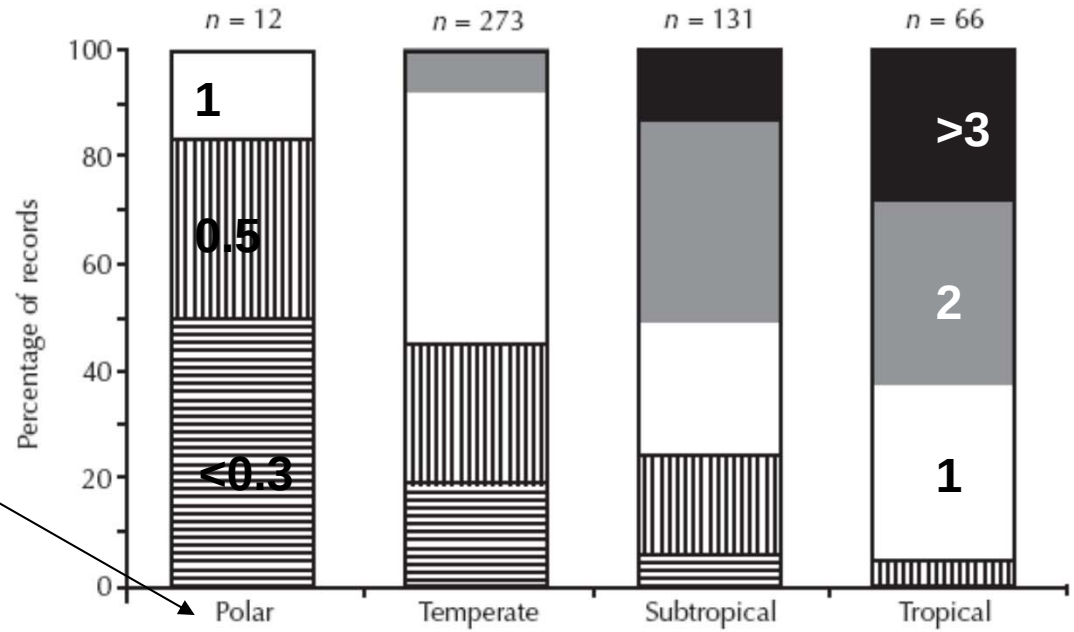
Agouti (*Dasyprocta* ssp.)

< every 3 month

biological synchrony of predator and prey

“Sleeping with the enemy” (*Kroon et al. 2008)*

Biogeography and external forcing



linked to season

climate change:

Firefly voltinism *Corbet et al. 2006*

longer summers, shorter winters an high latitude
decreasing time of snow cover
change in dry season, rainiy season

Voltinism can change with climate change *(Stoeckli et al. 2012)*

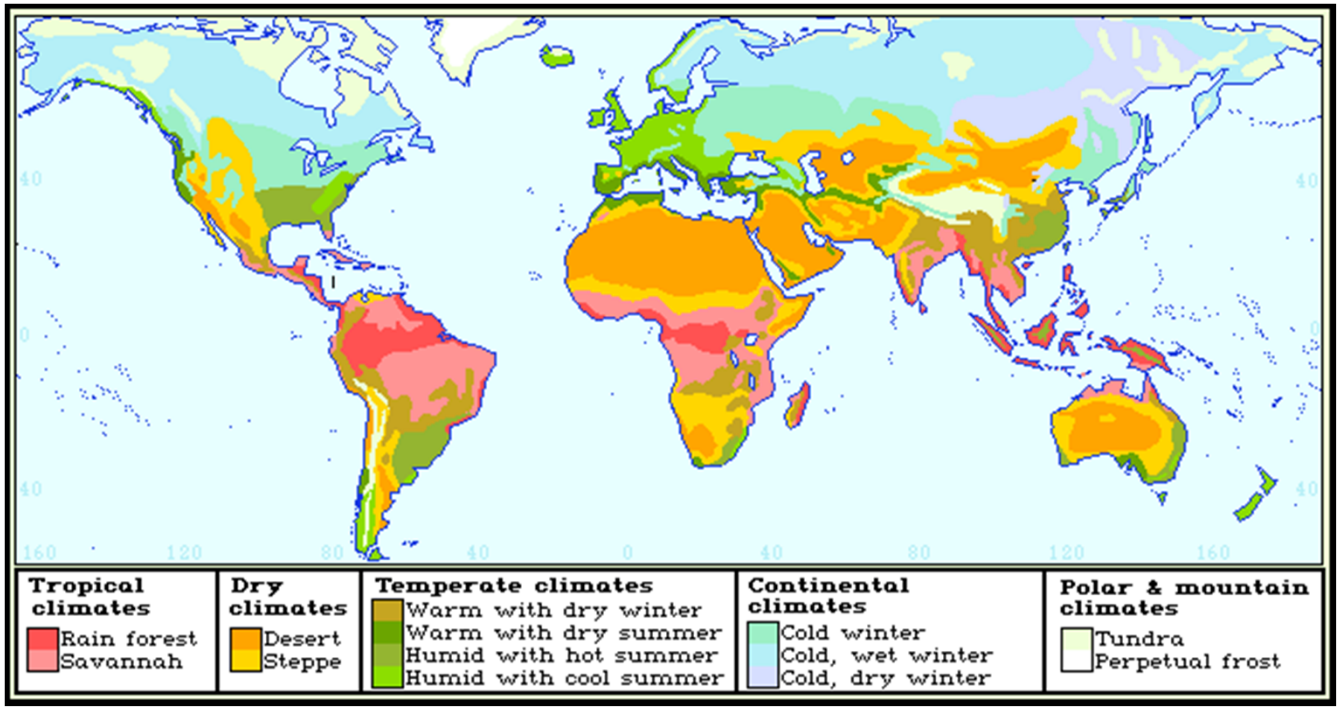
Hypothesis

weak seasonal forcing, high growht rate (e.g. tropics):

→ **traveling waves**

strong seasonal forcing, small growth rate:

→ **more stationary pattern**



http://tpittaway.tripod.com/sphinx/biog.htm

Thank you

http://www.condenaststore.com

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