

The behavioral manipulation hypothesis

Life cycle of *Plagiorhynchus cylindraceus*

1. Adult female *Plagiorhynchus* lays eggs within the intestines of infected birds. The eggs are shed with feces.
2. A terrestrial isopod eats the feces of an infected bird. The eggs of *Plagiorhynchus* hatch within a few hours; they develop into a mature larva in 60-65 days.
3. The mature larvae of *Plagiorhynchus* alter isopod behavior; infected isopods leave sheltered areas and wander in the open.
4. Leaving shelter makes the isopods more conspicuous and vulnerable to predation by birds. When eaten by a bird, the mature *Plagiorhynchus* attaches to the bird's intestinal wall.

No one knows how the parasite causes these changes pill bug behavior

14-2

Influence of the Protozoan parasite *Adelina tribolii* on competition between flour beetles

In the absence of *Adelina*, *T. castaneum* outcompetes *T. confusum* most of the time. However, in the presence of *Adelina*, *T. confusum* is usually the better competitor.

Conditions	<i>T. Castaneum</i> Wins (%)	<i>T. Confusum</i> Wins (%)
No parasites	~75	~25
With parasites	~30	~70

Uninfected beetles | Infected beetles

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Temporal Dynamics of exploitation- Snowshoe Hares (Fig 14.15 Molles)

- Hares in boreal N. A. • Lynx eat mostly hares
- Eat twigs of shrubs and trees • Linked cycles?

Abundance

Year

14

Predator-Prey Cycles?

- Think and then discuss:
- Under the hypothesis that predators cause this cycle, what would you expect for the following when hare populations are **declining**?
 - Predation rate
 - Survival
 - Time spent foraging
 - Birth rate
 - Growth (weight)
 - Food availability (twigs)

Numbers in thousands

1910 1920 1930 1940 1950

Hare —
Lynx —

Figure 5.13. Cycles in the population dynamics of the snowshoe hare and its predator the Canadian lynx, redrawn by Radcliffe, 2009 from MacLulich, 2007

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Predator-Prey Cycles?

- When hare populations are declining:
 - Predators focus on hares
 - Hares spend more time foraging
 - Hares have
 - low birth rates
 - low juvenile survival
 - low growth rates (lose weight)
 - Twigs are hard to find (recover in 2-3 years)

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What causes the cycles?

- Hare-plant interactions (with predators tracking hares)?
- Predator-Hare interactions?

Time for an experiment

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Charles J. Krebs
University of
British Columbia

Experimental Plots 9@ 1km² ea.

Predator
Hare
Plants

↓

Cycles

Predator
Hare
Plants

↓

Cycles

Predator
Hare
Plants
ADD FOOD

↓

Cycles

Predator
Hare
Plants
ADD FOOD

↓

No Cycles

Conclusion: Cycles are caused by Hare-Plant interactions, and by Predator-Hare Interactions. Both, in combination, probably act in the wild.

(See Stenseth et al. 1997 [PNAS 94:5147])

Results in Field vs. Lab

- In the field
 - Coexistence of predators and prey is common
 - Predators often control prey (keep to a low level)
 - Cycles sometimes occur, sometimes don't
- In the lab
 - One or both species usually goes extinct
 - Refuges and immigration help increase stability
 - Cycles sometimes occur, sometimes don't

Review session

Tuesday April 5
2PM
Location: D404
(near biology office)

Building a Model

- Start as simple as possible
- Do we see cycles?

Lotka Volterra Predation Equations

- Prey: Exponential growth except for predation losses

Prey Population Growth Rate = Exponential Growth

- Losses to Predators

- Predators
 - Prey consumption determines growth rate
 - Without prey, predators gradually die off

Predator Population Growth Rate = Births (increase with prey abundance)

- Death Rate in Absence of Prey

Prey or Host Population Growth

Rate of prey or host population change... $\frac{dN_h}{dt} = r_h N_h - p N_h N_p$

- ...equals the exponential rate of increase by host population...
- ...minus the number of prey or hosts killed by the predator or parasite.

Host per capita rate of increase r_h Number of predators or parasites N_p Predation rate p Number of hosts N_h


Predator or Parasite Population Growth

Rate of predator or parasite population change... $\frac{dN_p}{dt} = c p N_h N_p - d_p N_p$

- ...equals the rate at which prey are converted to predator or parasite offspring...
- ...minus the number of predator or parasite deaths.

Host to predator or parasite conversion rate $c p$ Predator or parasite death rate d_p

Linked Equations

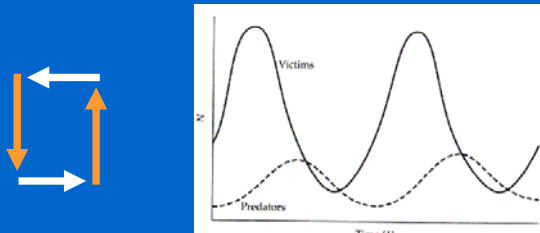


- These equations are linked - each affects the other
- Both based on exponential growth - no K
- But:
 - More predators means fewer prey
 - Fewer prey means fewer predators
 - Fewer predators means more prey
 - More prey means more predators

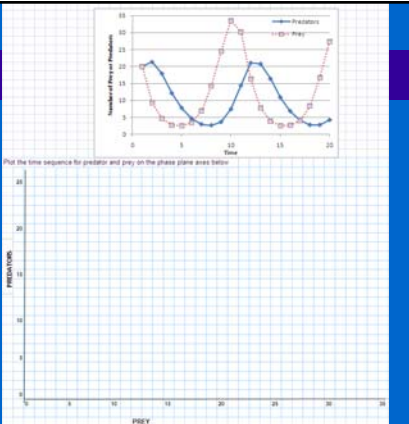
CYCLES predicted
Populations are limited by each other

Cycles

- Predator-prey interactions can "cycle" over time
- Prey are "controlled" only within certain bounds, not to some particular stable N



Phase Plane Graphs of Predator- Prey dynamics



- Use arrows to indicate direction of time
- Might explore with Populus too

Isoclines

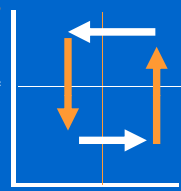
$N_{Predators} = N_P$

$N_{Hosts} = N_H$

Predators will increase when prey are above a critical density
 $N_H^* : dN_P/dt = 0$

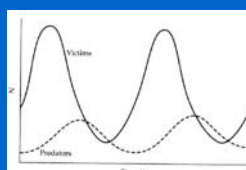
Prey will increase when predators are below a critical density
 $N_P^* : dN_H/dt = 0$

We'll ignore the equations to calculate the critical densities.



Is a predator-prey cycle 'stable'?

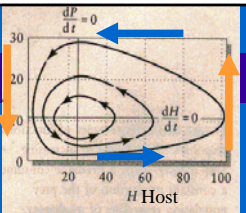
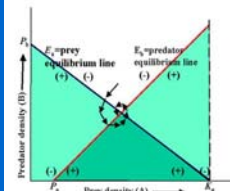
- A) Yes
- B) No
- C) It depends what you mean by 'stable'



Neutral Stability

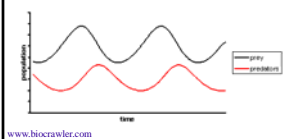
- Predator and prey abundances may oscillate
 - swing like a pendulum, never converge - 'neutrally stable'
- Starting conditions dictate size of oscillations
- Starting too far from stable point makes a crash more likely.

Adding density dependence increases self-correcting stability (spirals in)

Stability

- **Stability** of a predator-prey interaction: persistence of both prey and predator populations
- Models indicate that stability is encouraged when:
 - Prey have refuges (or prey escape/defend)
 - Density dependence occurs in either species
 - Predator switching to other prey



<http://www.amphibianinfo.com>

Assumptions of the L-V Predator-Prey Model

- Prey are only limited by predation
 - Density dependence causes damped cycles
- Predator depends on only 1 prey species
 - Eating > 1 species can either stabilize or destabilize the interaction
- Each predator can consume infinite prey
- No immigration, no age or genetic structure