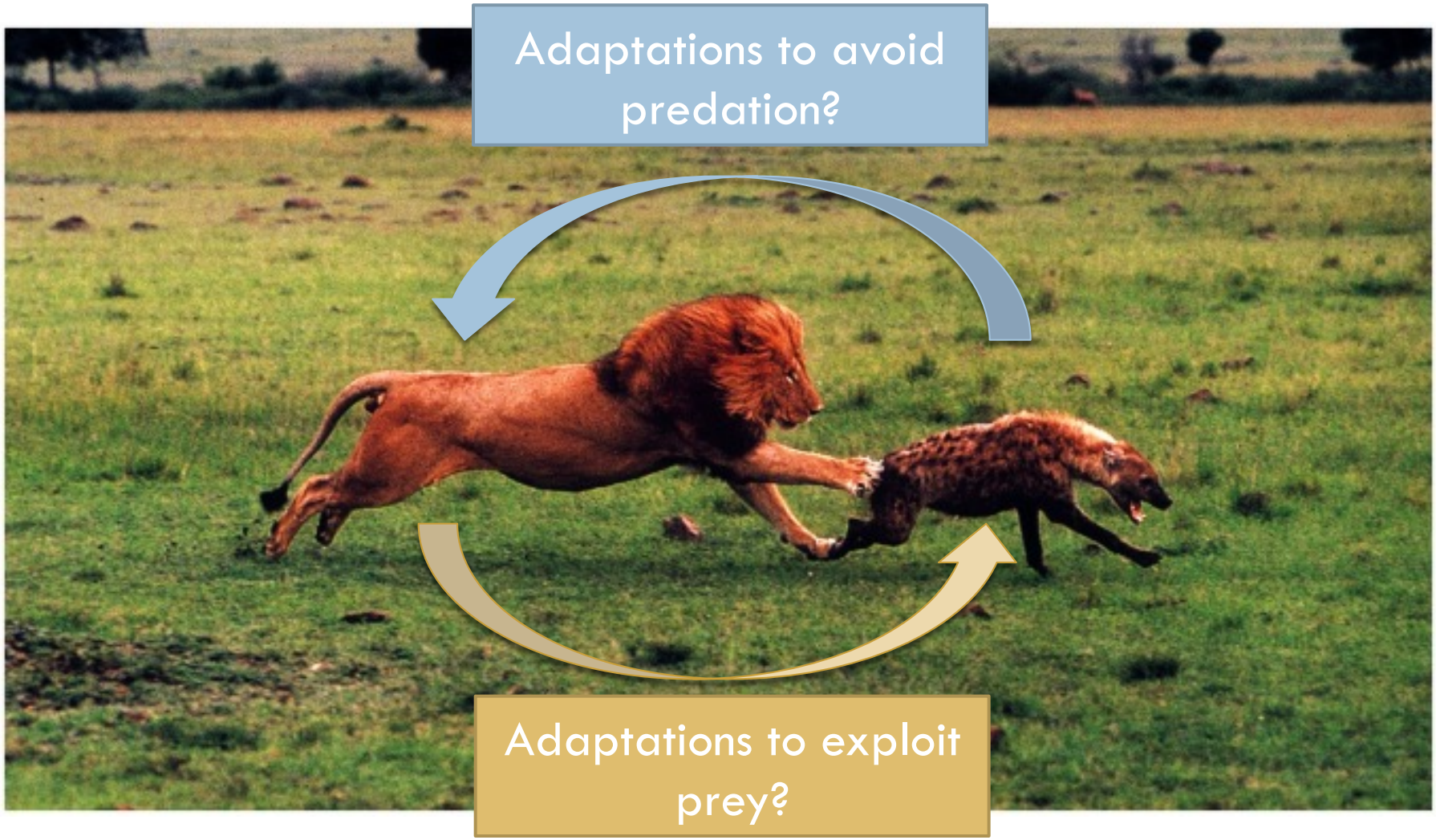
Announcements

- Exam 1 – handed back at end of lecture today
  - see me or TA's for questions or errors

Morphology (physical defense), chemical, crypsis, mimicry, behaviour



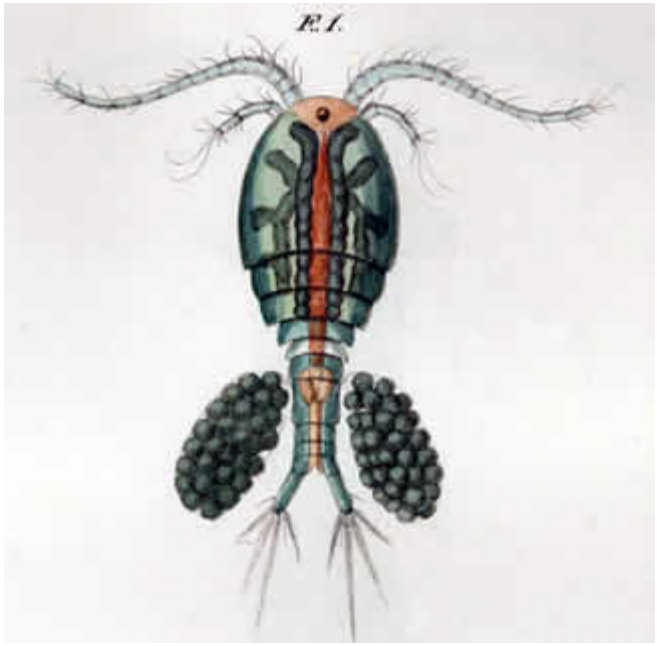
Morphology (jaws, claws, dentition, digestion), behaviour

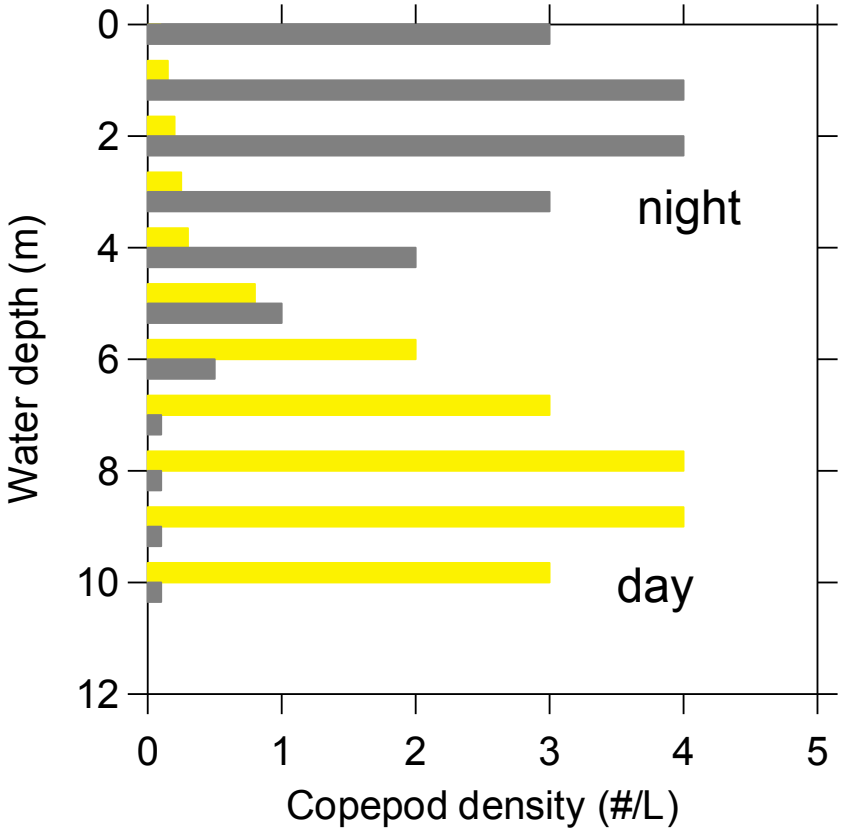
Prey have adaptations for escaping their predators

Example 5. Behavior

Copepod migration in lakes and the ocean

"Diel Vertical Migration"

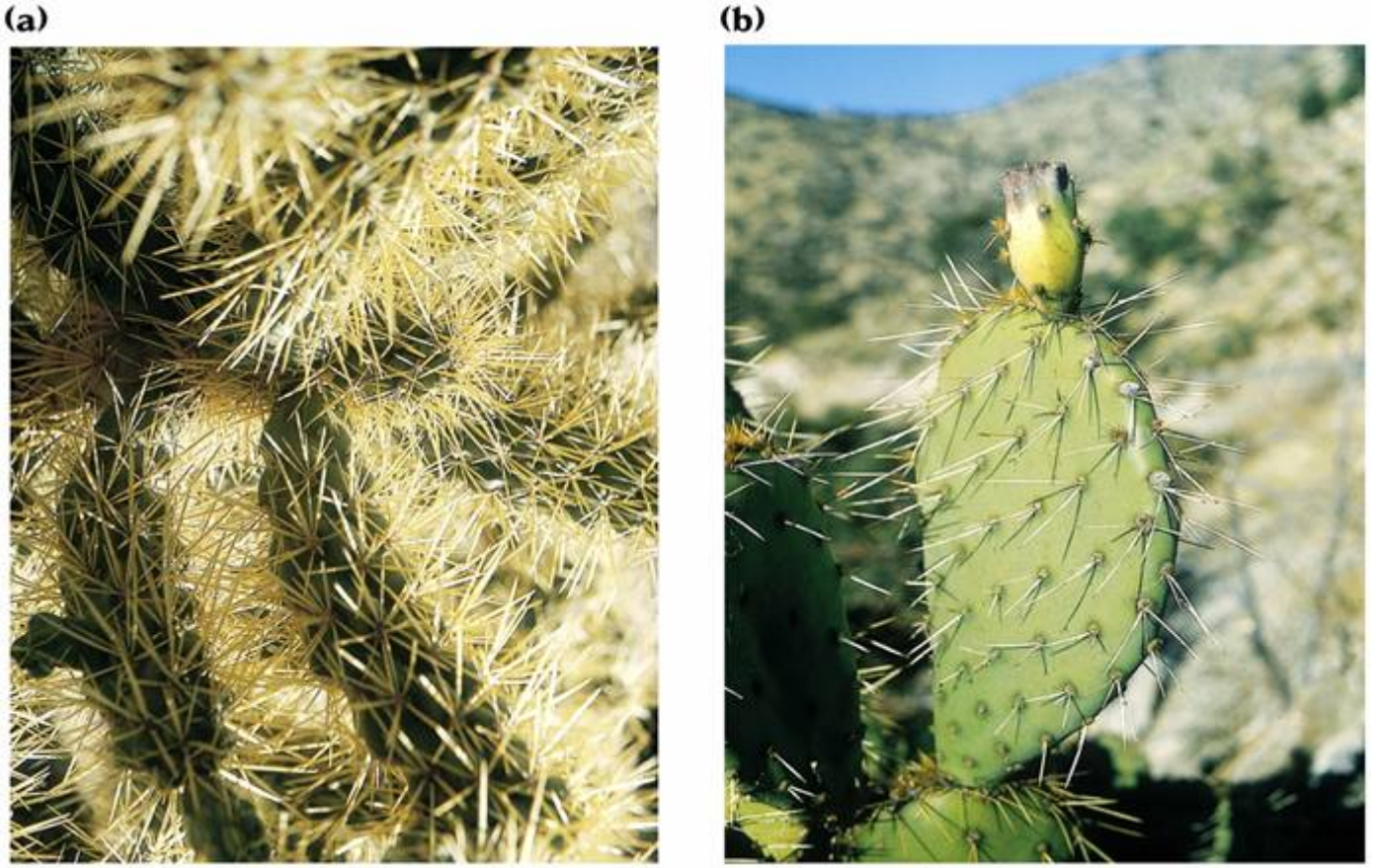




Why is the world green?

Plant defenses against Herbivory

Structural



Plant defenses against Herbivory

Chemical affects the palatability and digestibility of plants

1. Generalized inhibition: oak leaves vs. lettuce leaves
- tannins reduce availability of plant proteins to consumers, inhibit digestion
- poor growth of moth larvae (caterpillars)

2. Secondary compounds: by-products of plant metabolism, not used interfere with specific animal metabolism pathways, physiology, palatability

Many plant products used by humans are based on secondary compounds (e.g., nicotine, caffeine, cocaine, capsacin, …)

Plant defenses against Herbivory

Chemical

Secondary compounds: by-products of plant metabolism, not used interfere with specific animal metabolism pathways, physiology, palatability

Alkaloid	Plant	Part	Uses
Quinine	Cinchona officinalis (Cinchona)	Bark	Antimalarial drug
Nicotine	Nicotiana tobacum (Tobacco)	Leaves	Insecticide
Morphine, Cocaine	Papaver somniferum (Opium)	Fruit	Pain killer
Reserpine	Rauwolfia serpentina (Snake bite)	Root	Medicine for snake bite
Caffeine	Coffea Arabica (Coffee plant)	Seed	Central nervous system stimulant
Nimbin	Azadirachta indica (Neem)	Seeds, Barks, Leaves	Antiseptic
Scopolamine	Datura stramonium	Fruit, flower	Sedative
Pyrethroids	Chrysanthemum	Flower	Insecticides

Plant defenses against Herbivory

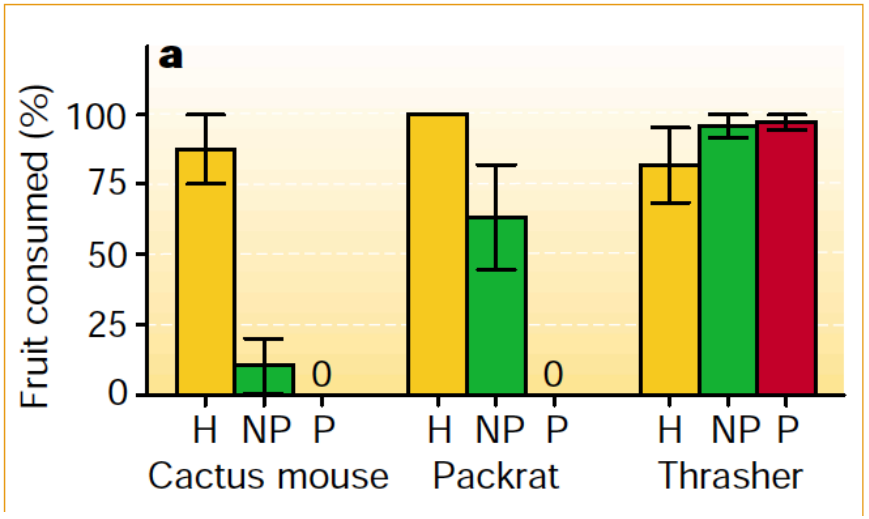
Chemical: Why are chilies hot??

Good herbivore??

Bad herbivore?

Tewksbury and Nabhan (2001) *Nature*

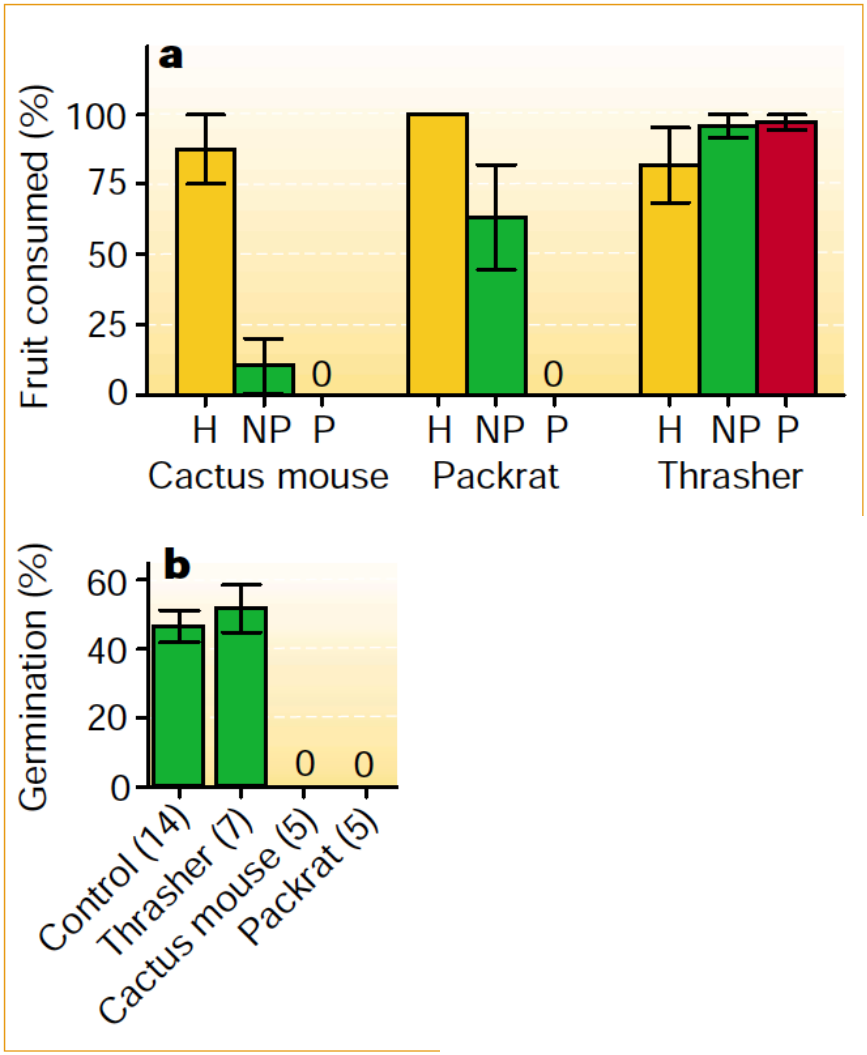
Plant defenses against Herbivory



H = hackberry (not hot)
NP = chilies (not hot)
P=chilies (HOT)

Tewksbury and Nabhan (2001) *Nature*

Plant defenses against Herbivory



H = hackberry (not hot)
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Tewksbury and Nabhan (2001) *Nature*

Plant defenses against Herbivory

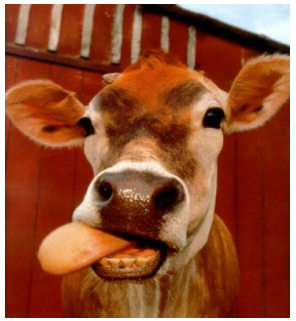
Are defenses ON at all times?

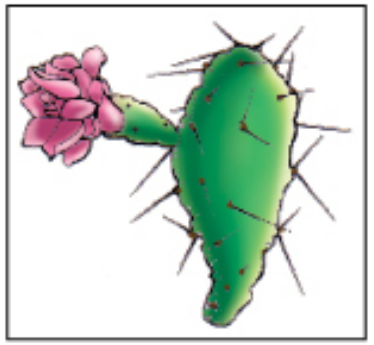
1. **Constitutive defenses** – always at high levels (e.g., oak leaves)

2. **Induced defenses** – turned ‘on’ by herbivore damage

Plant defenses against Herbivory

Are defenses ON at all times?





Induced defenses

Example 2. Willow trees & Moose

Mechanical damage to apical meristems (+ saliva) stimulate higher leaf growth

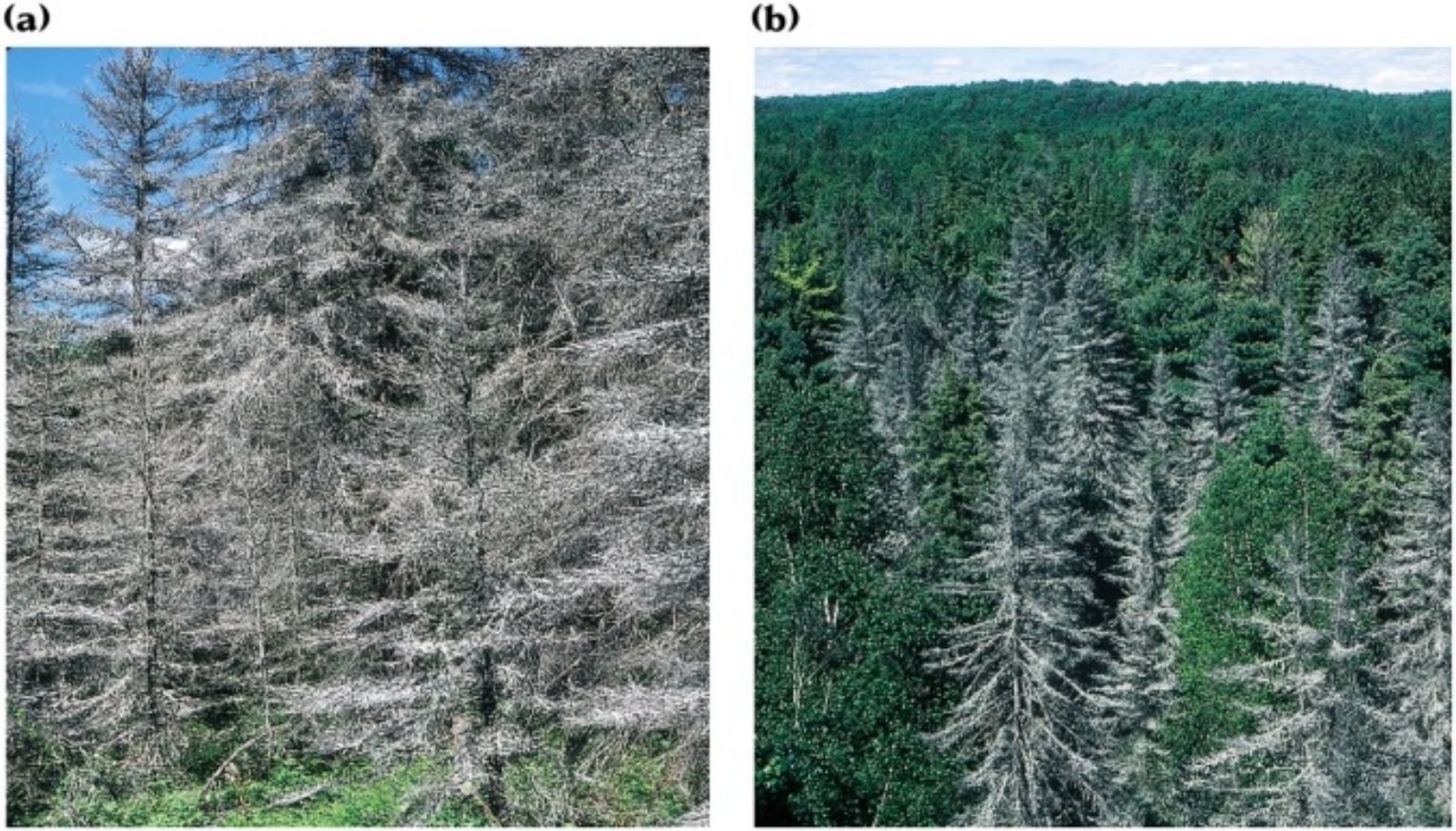
Can herbivores control plant populations?

Can herbivores control plant populations?

Fenceline at Potholes in Eastern Washington

Can herbivores control plant populations?

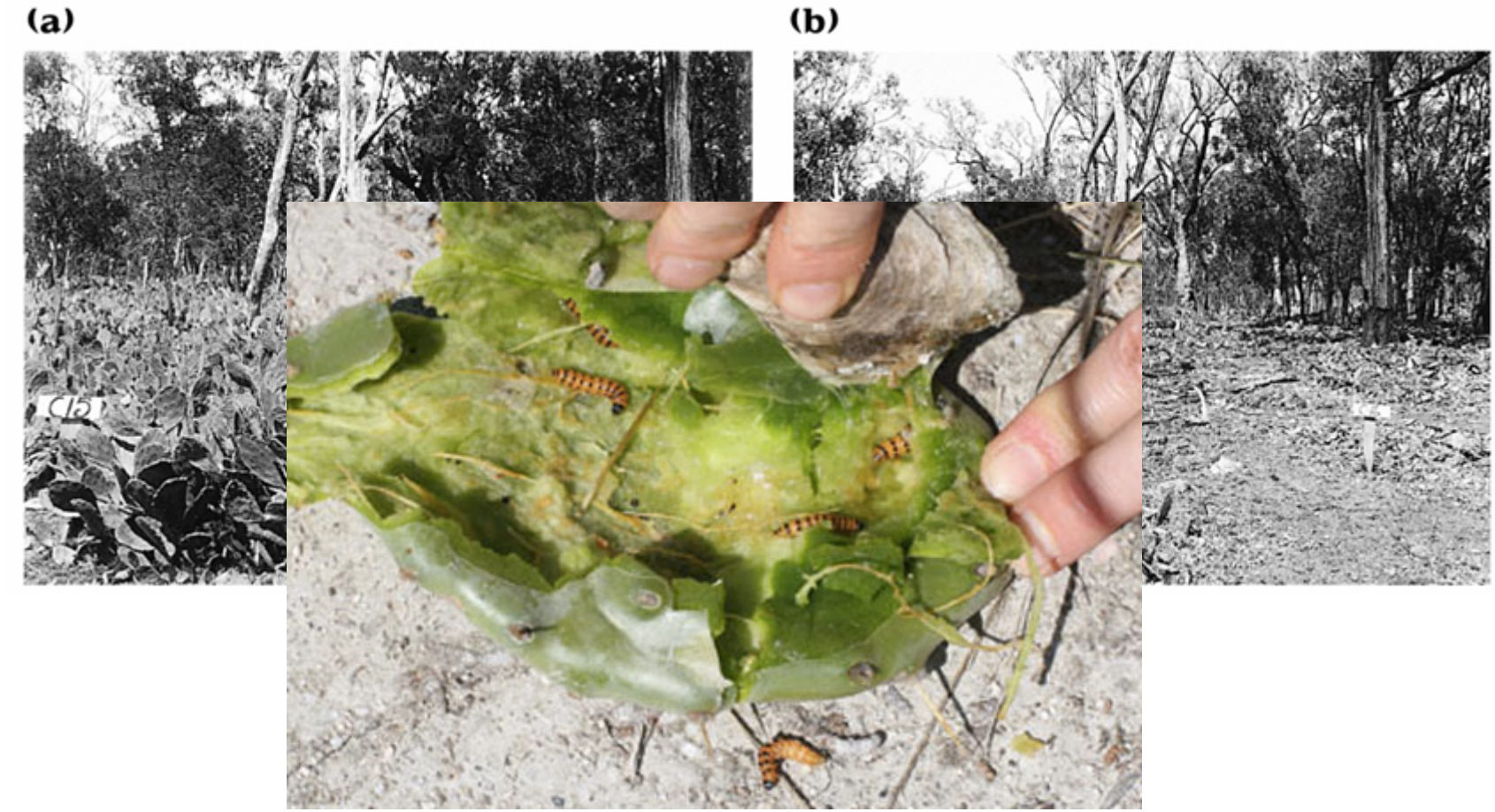
Spruce budwork outbreaks in the boreal forest



Algonquin Provincial Park, Ontario

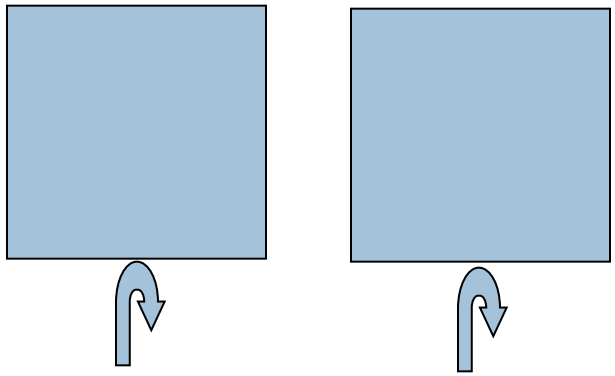
Can herbivores control plant populations?

Invasion of Australia by the prickly pear cactus (*Opuntia*),
later controlled by introduction of the cactus moth

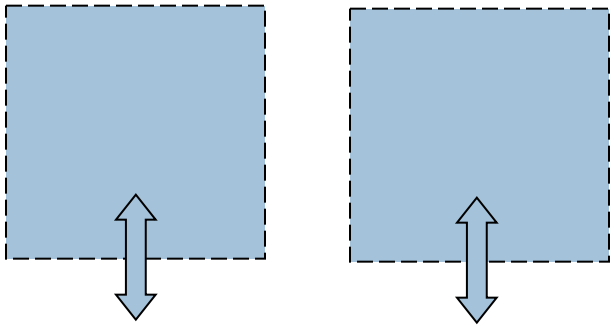


Exclosure experiments used to quantify effects of herbivores on plant communities

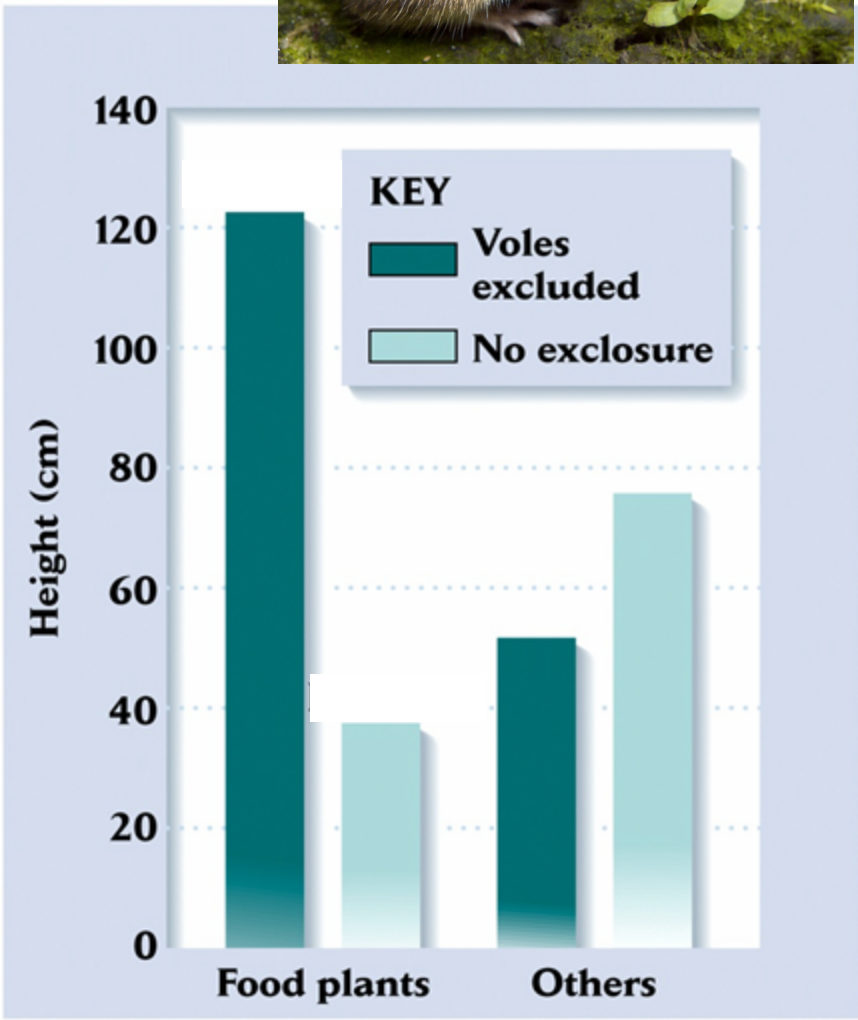
Exclosure (fence)



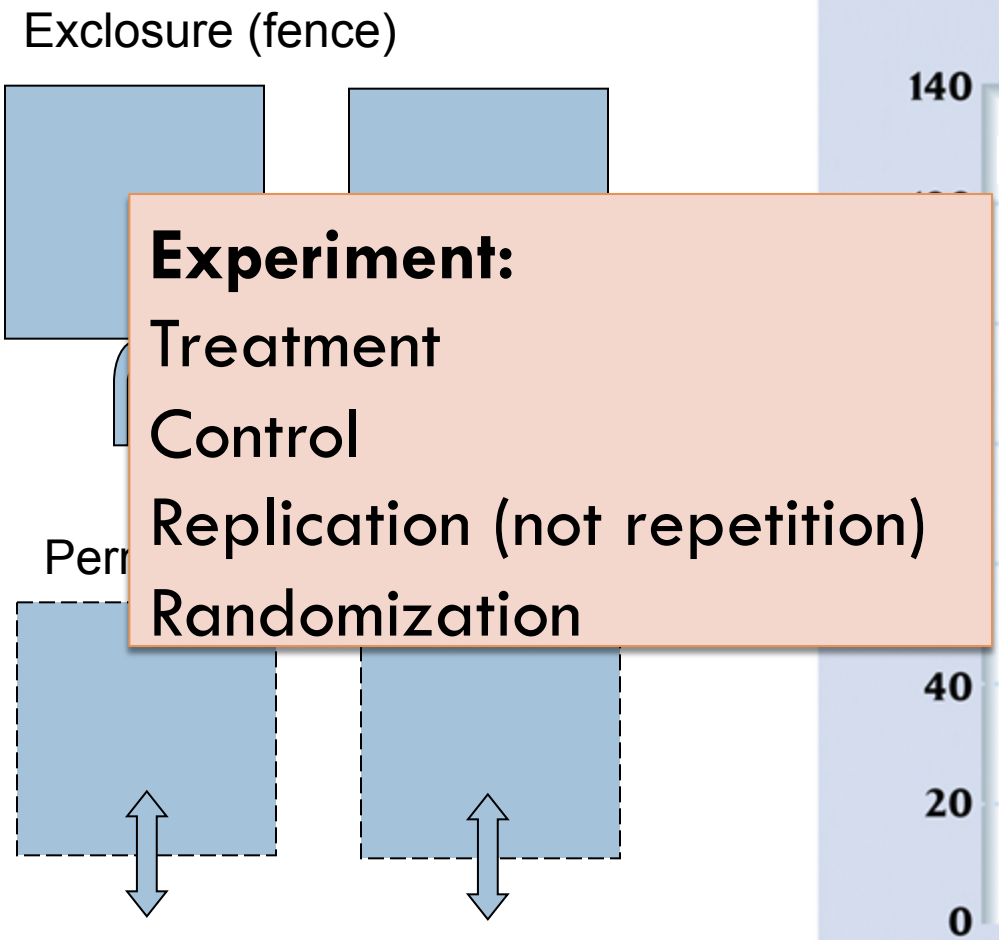
Permeable fence (control)



*2 years later →



Exclosure experiments used to quantify effects of herbivores on plant communities



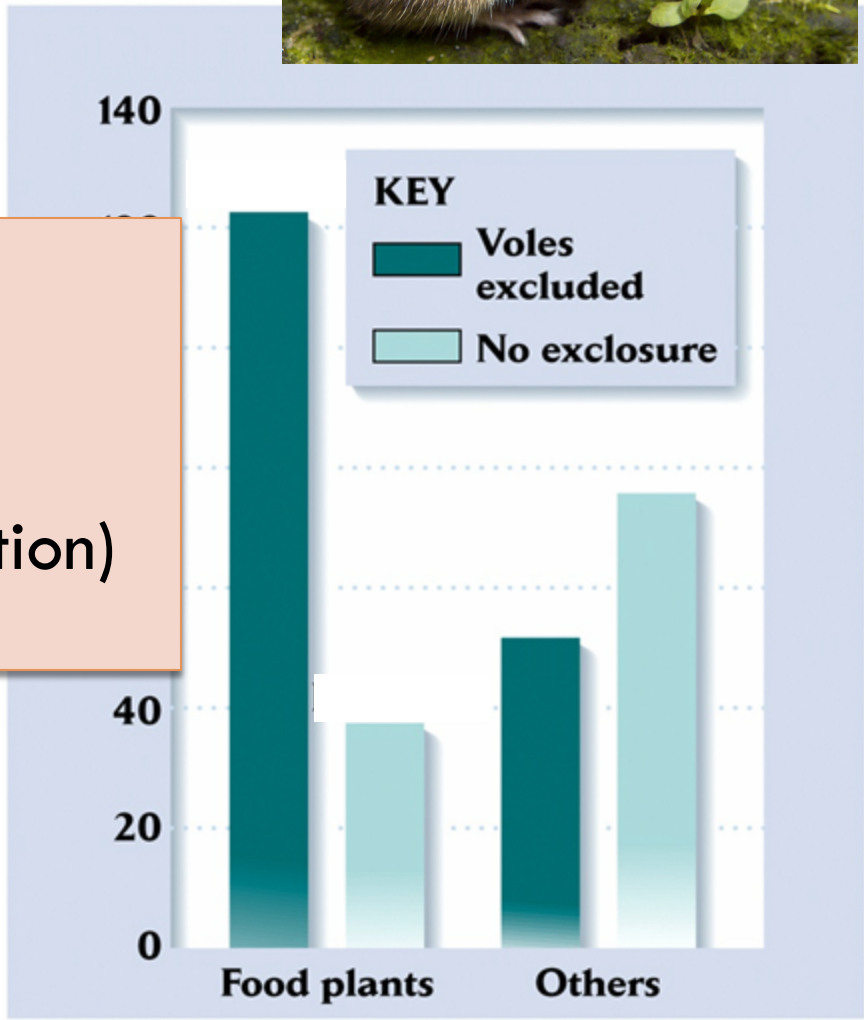
Experiment:

Treatment

Control

Replication (not repetition)

Randomization



What does a predator chose to prey upon?

How far will a predator go to capture a prey?

Optimal foraging theory provides a formal framework with which to make predictions about foraging behavior of predators

Optimal foraging theory in a nutshell (diet selection)

- All consumers are adapted to feed on certain types of prey

- All prey have certain Benefits and Costs associated with feeding on them

  Benefits: energy, nutrients

  Costs: energy to digest, handling time, travel time, danger, etc.

- Profitability of prey can be ranked in terms of their **relative cost : benefit ratio**

Predictions from optimal foraging theory (diet selection)

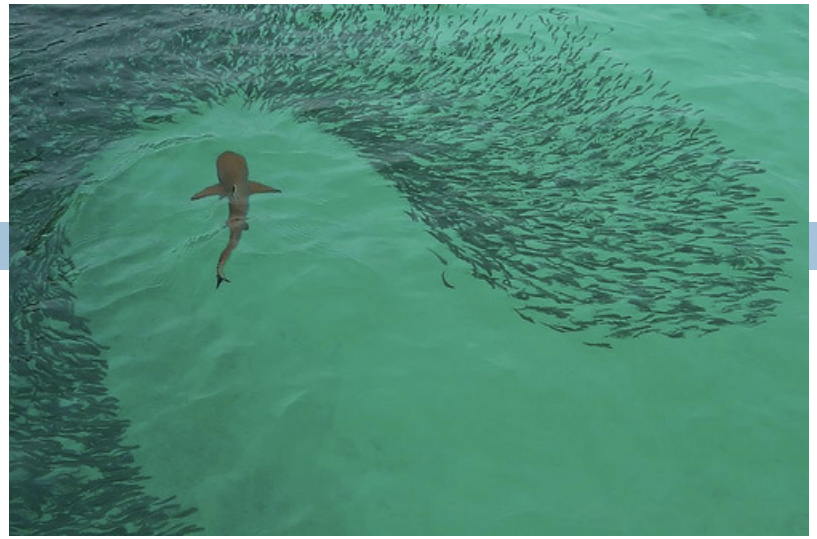
- When preferred prey are abundant, predator diets are dominated by the most profitable prey

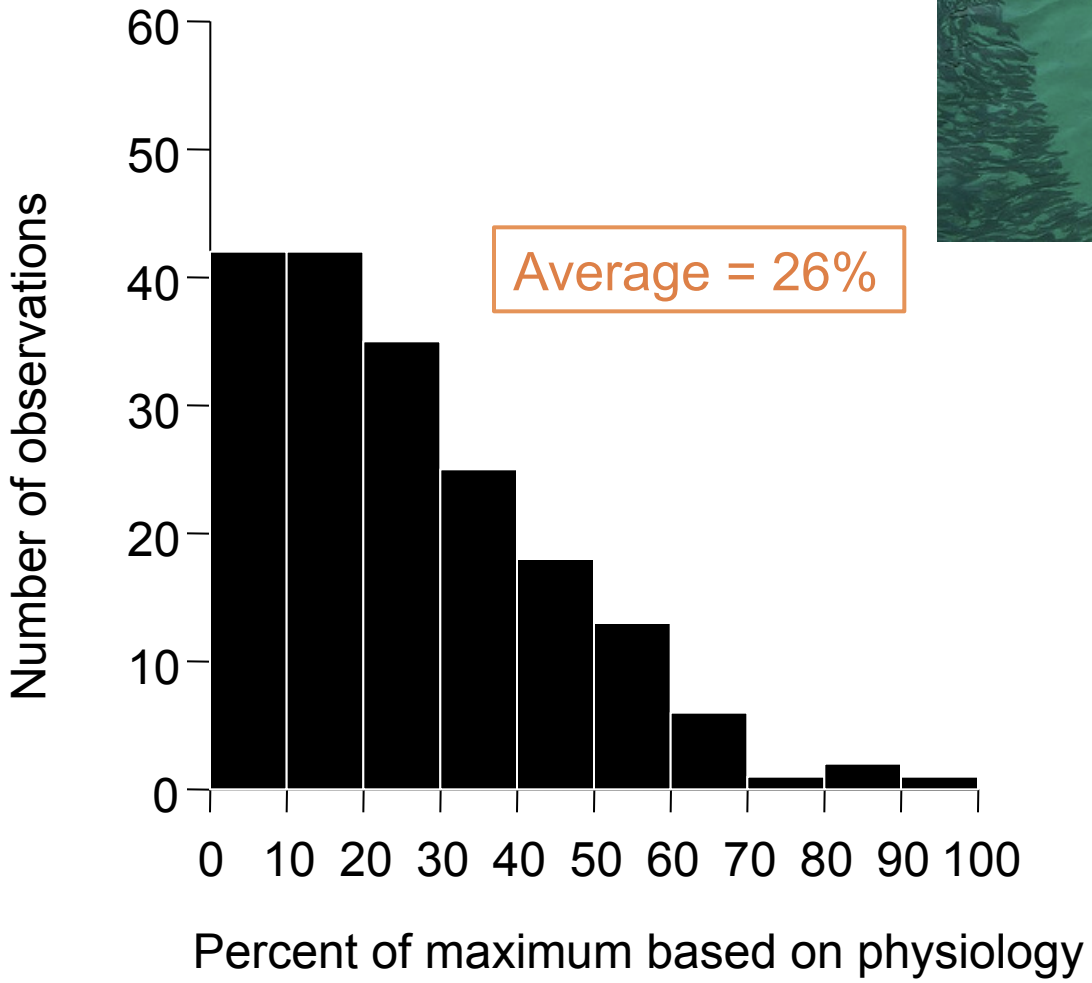
- As preferred prey become scarce, predators begin to include less profitable prey in their diets

- Therefore, diets are more diverse at low prey densities

- Optimal versus opportunistic feeding? (e.g., fishes, wolves)

Fish growth rates in nature



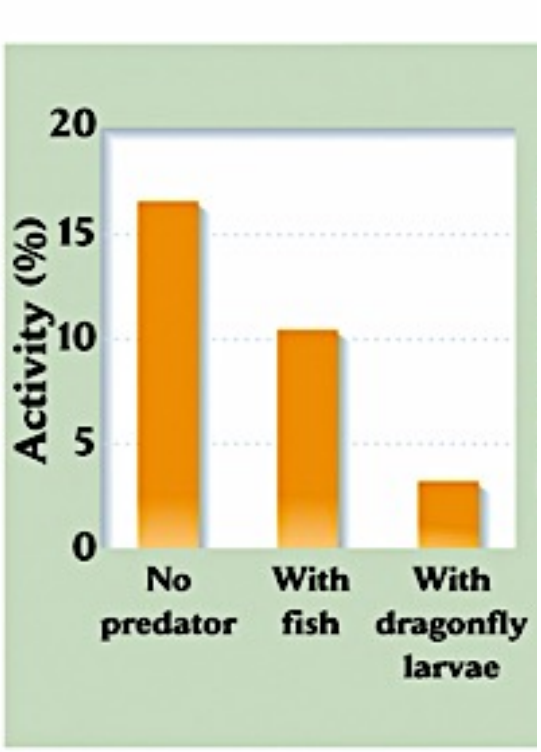


Significance of this?

Schindler et al., unpublished data

Risk sensitive foraging

Example 1: Tadpoles as prey, fish and dragonfly larvae as predators



Risk sensitive foraging

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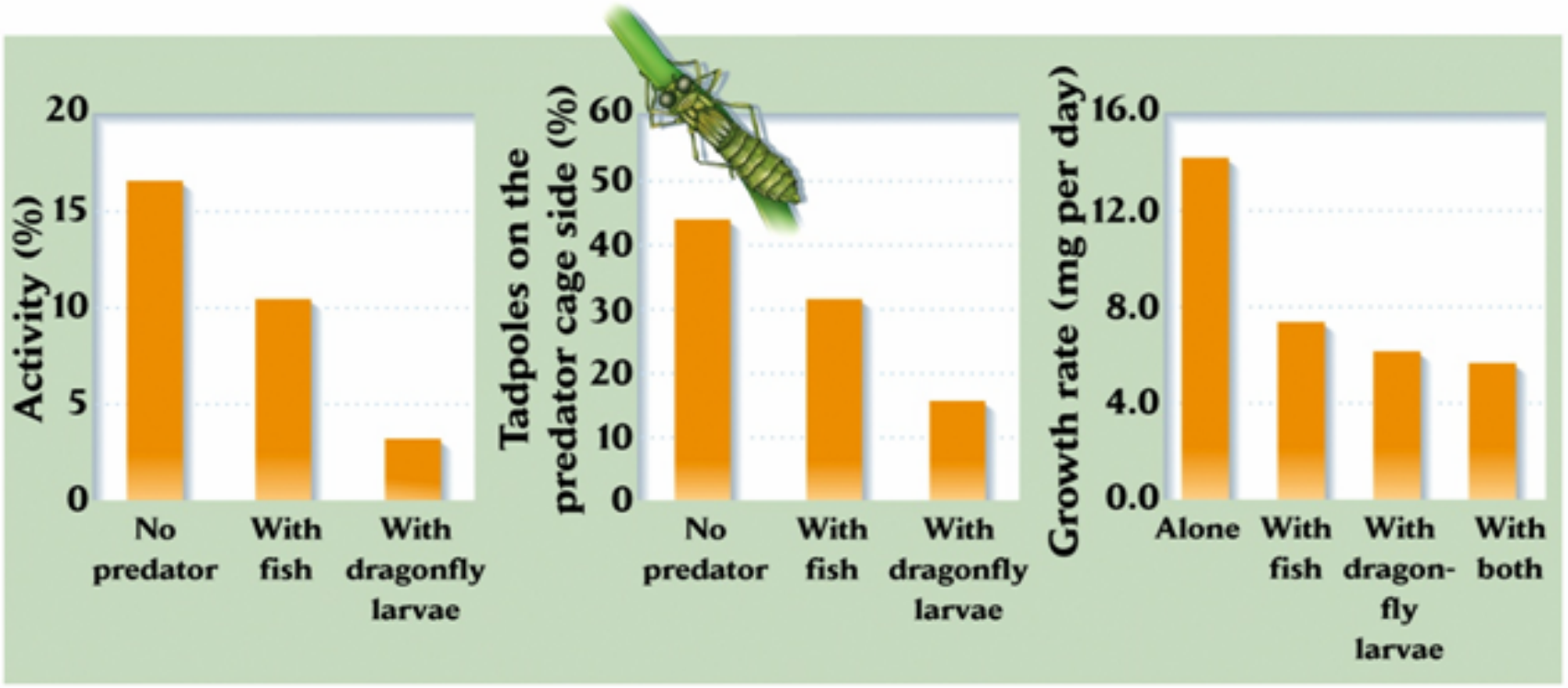
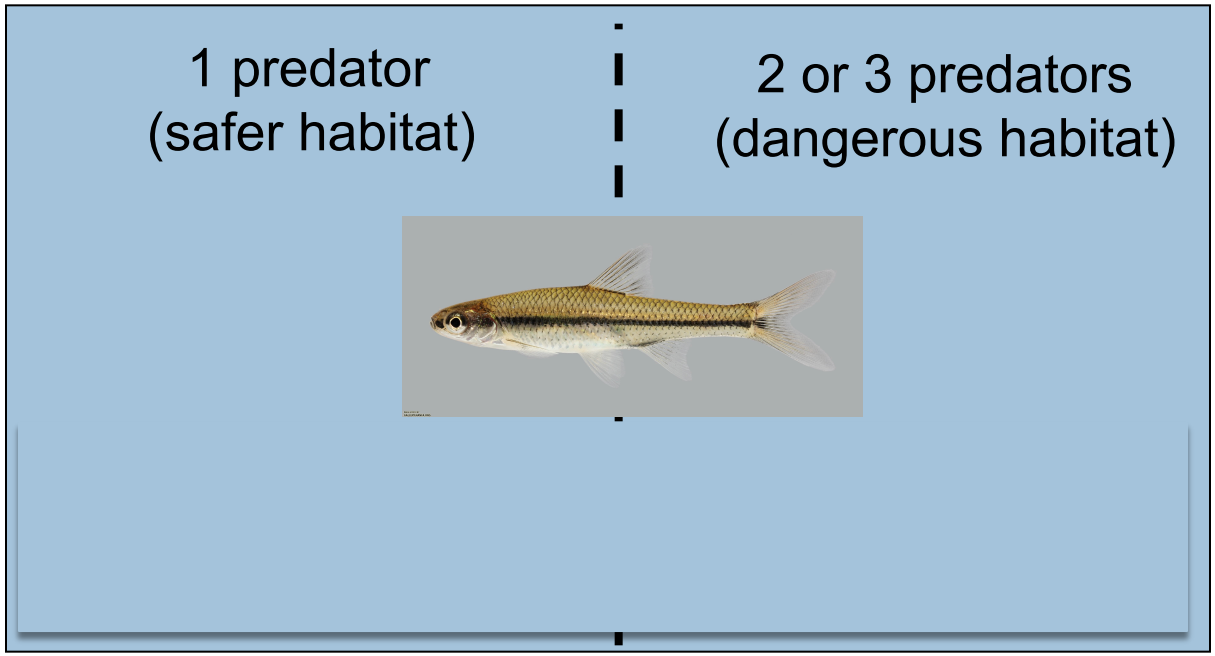


Risk sensitive foraging

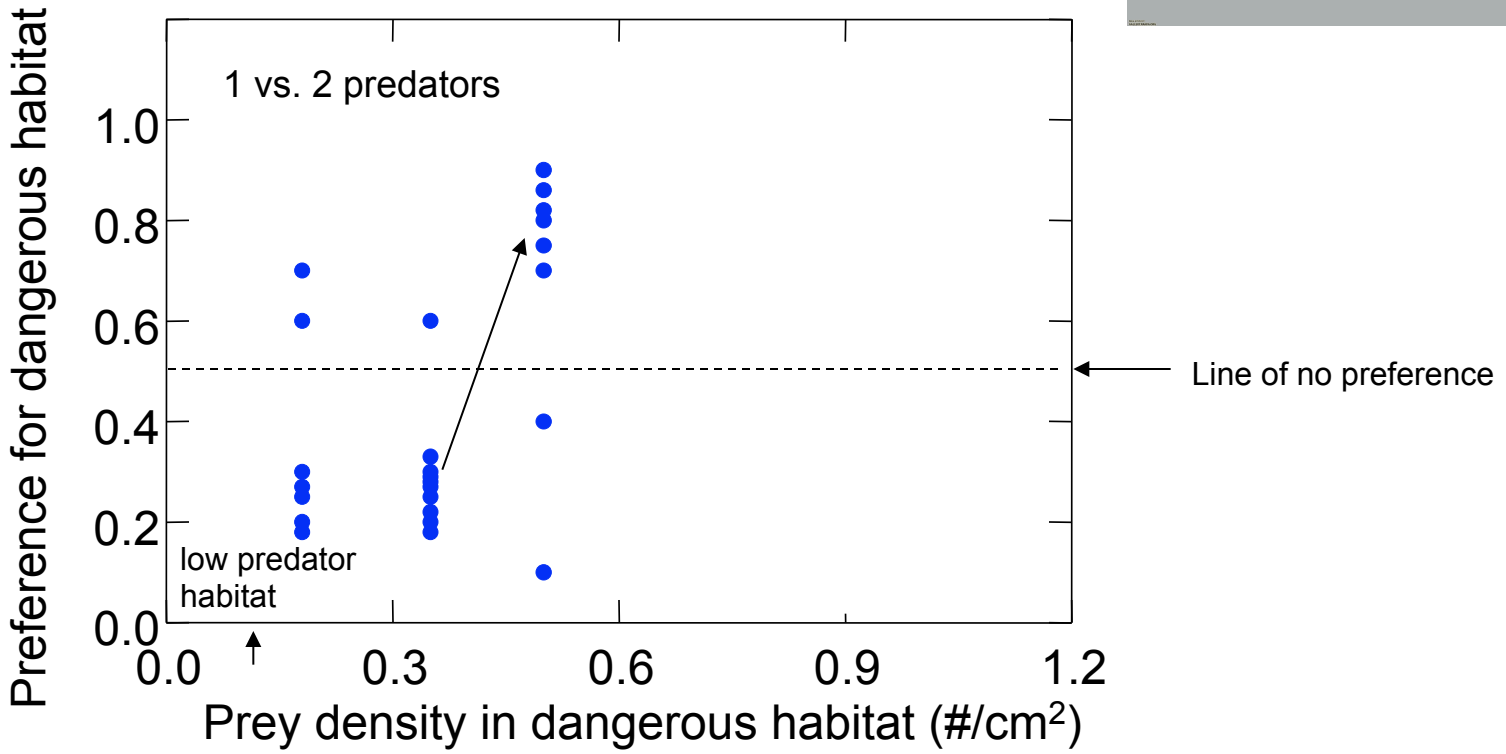
Example 2: Minnows foraging in safe and risky habits
(Gilliam and Fraser, 1987)



How much more profitable does the dangerous habitat have to be to attract the minnows?

Risk sensitive foraging

Example 2: Minnows foraging in safe and risky habits (Gilliam and Fraser, 1987)



Risk sensitive foraging

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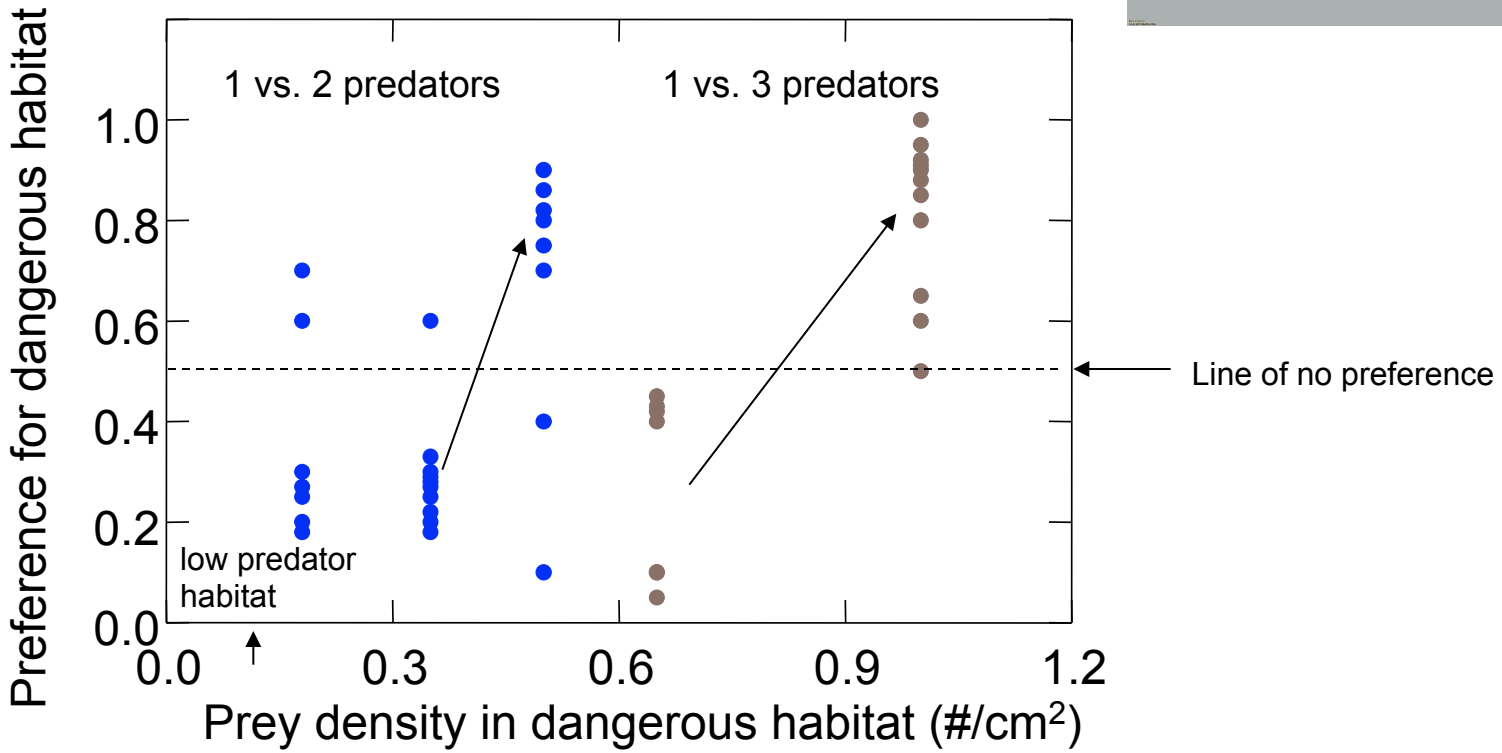
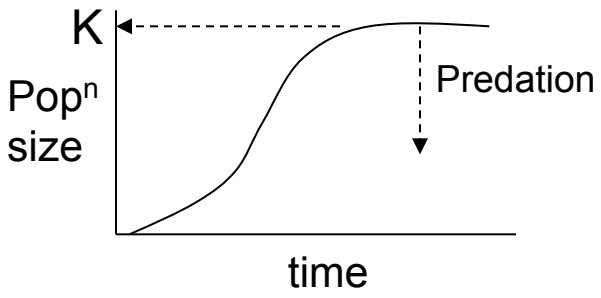


Dynamics of Predation

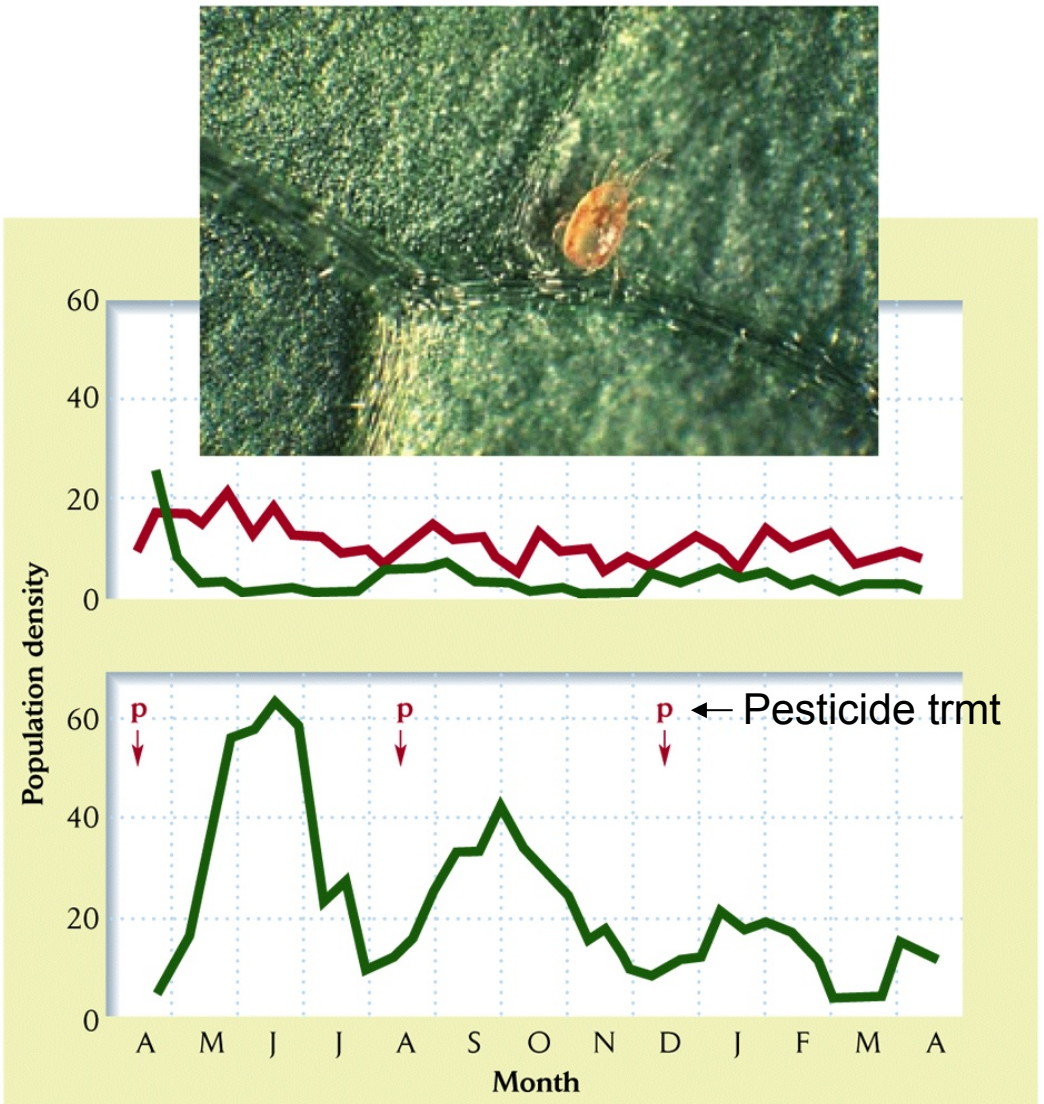
1) Can predators reduce prey densities below carrying capacity?

2) Do predator-prey interactions cause populations to oscillate?

Consumers can limit their resources



Mites on strawberries



Dynamics of Predation

1) Can predators reduce prey densities below carrying capacity?

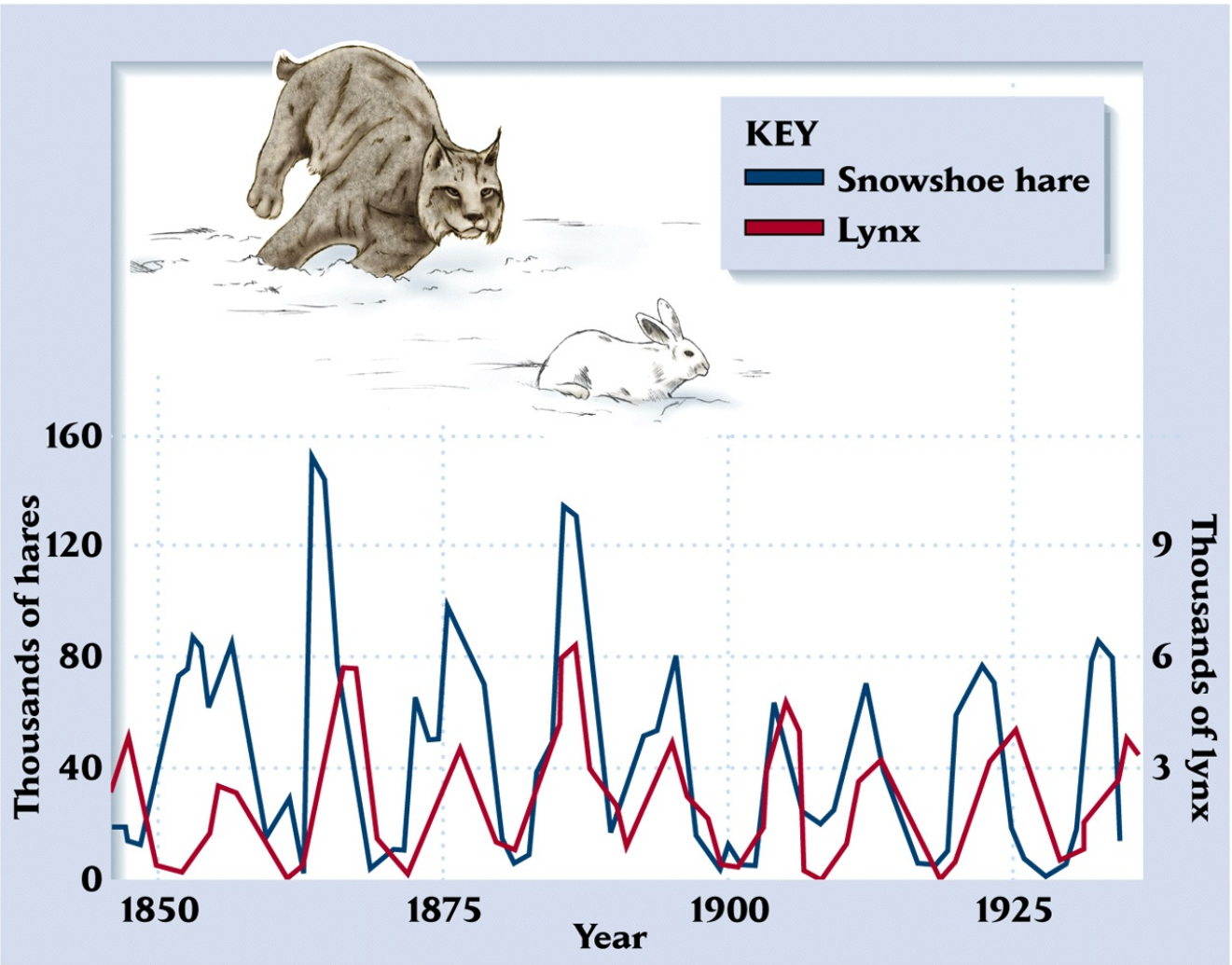
2) Do predator-prey interactions cause populations to oscillate?

Predators and prey sometimes cycle

(b)

Predators and prey sometimes cycle

Predators and prey sometimes cycle



Charles Elton

What kind of study is this?

Predator-prey systems can be modeled with simple math

R is p**R**ey pop^n

P is **P**redator pop^n

$$dR/dt = rR - cRP$$

Growth of prey population

(*r* is growth rate)

Loss to predator population

(*c* is capture efficiency)

Predator-prey systems can be modeled with simple math

R is p<u>R</u>ey pop^{n}

P is <u>P</u>redator pop^{n}

$$dP/dt = acRP - dP$$

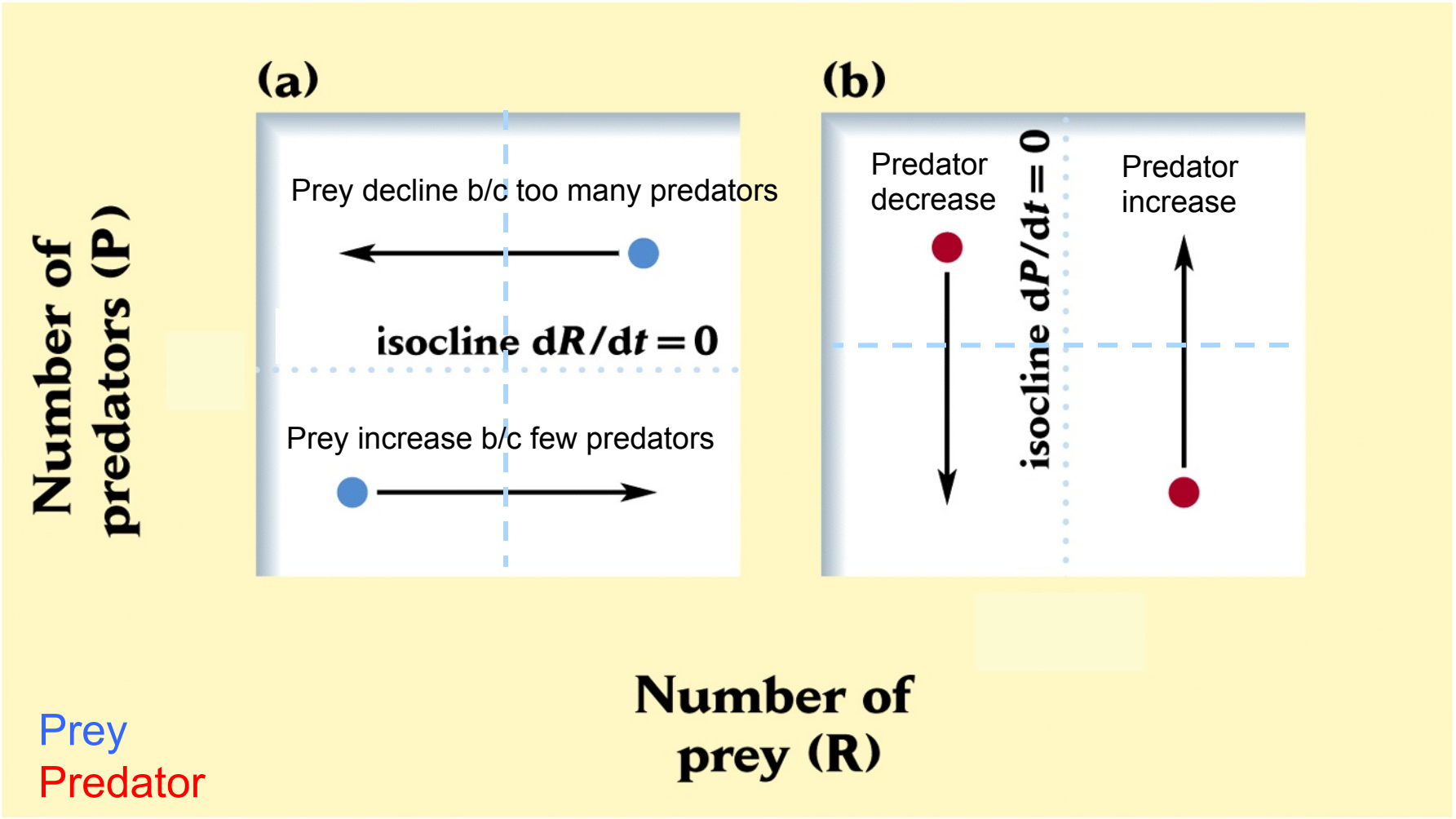
Conversion of prey to predators

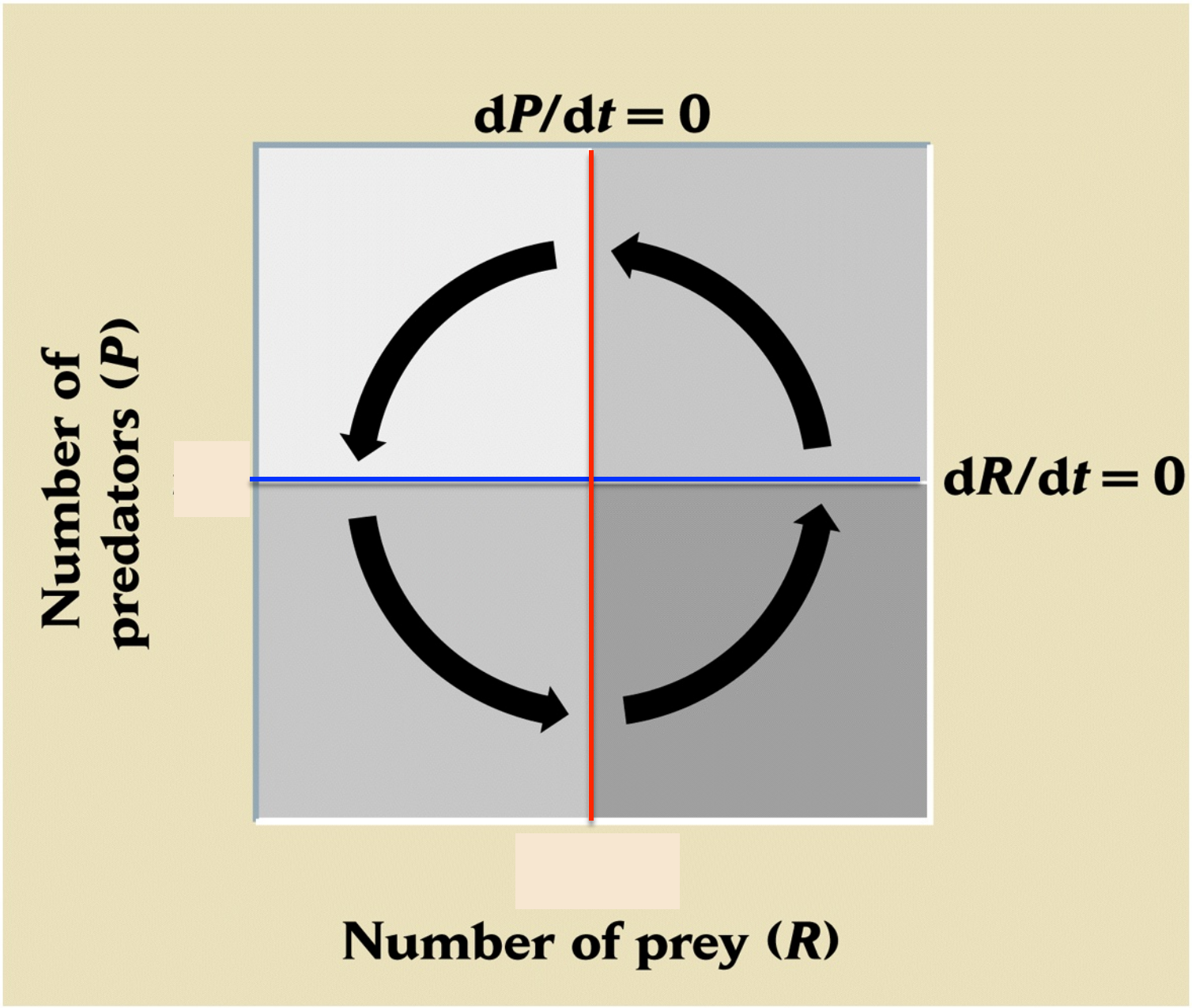
(*a* is conversion efficiency)

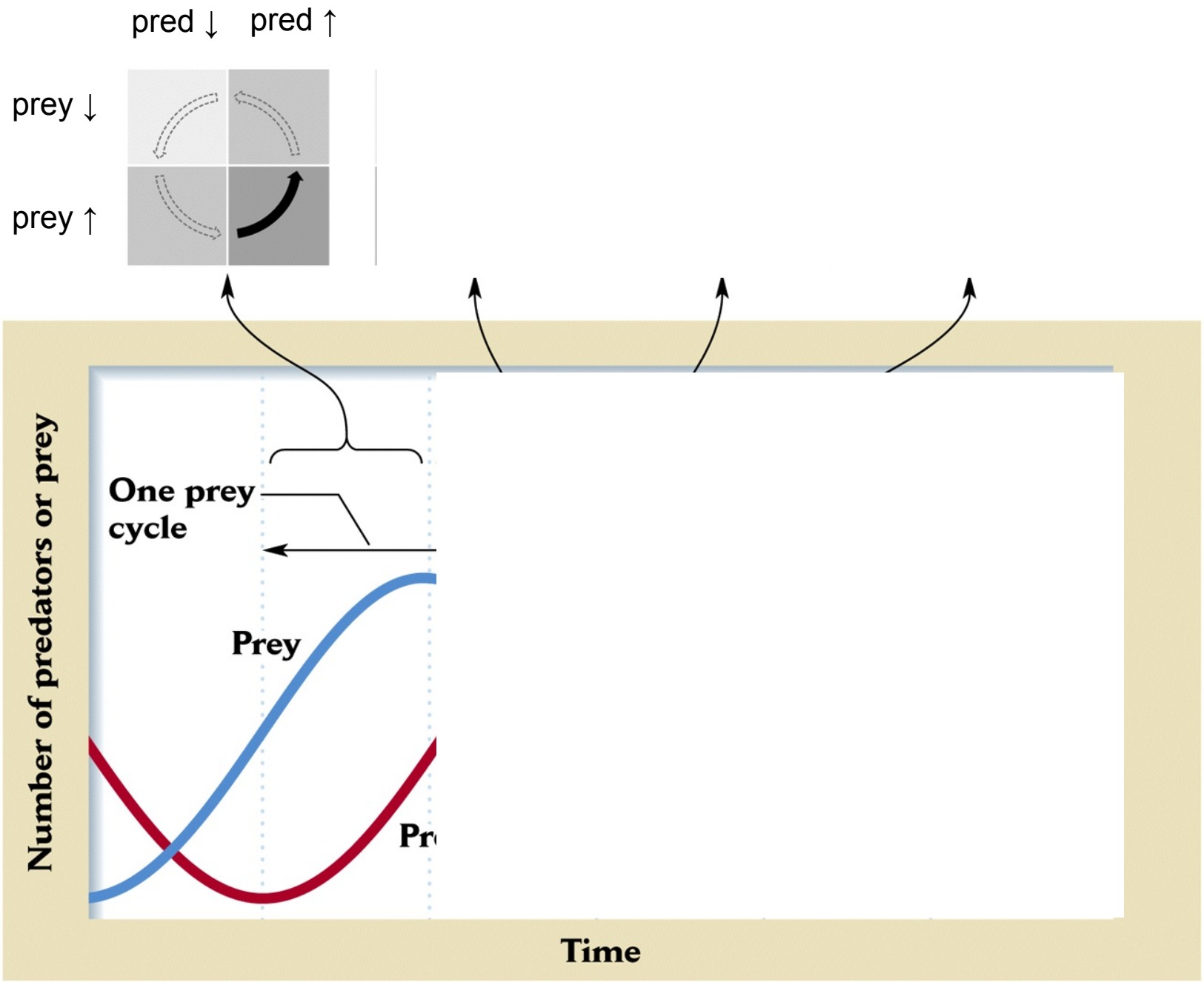
Death in predator population

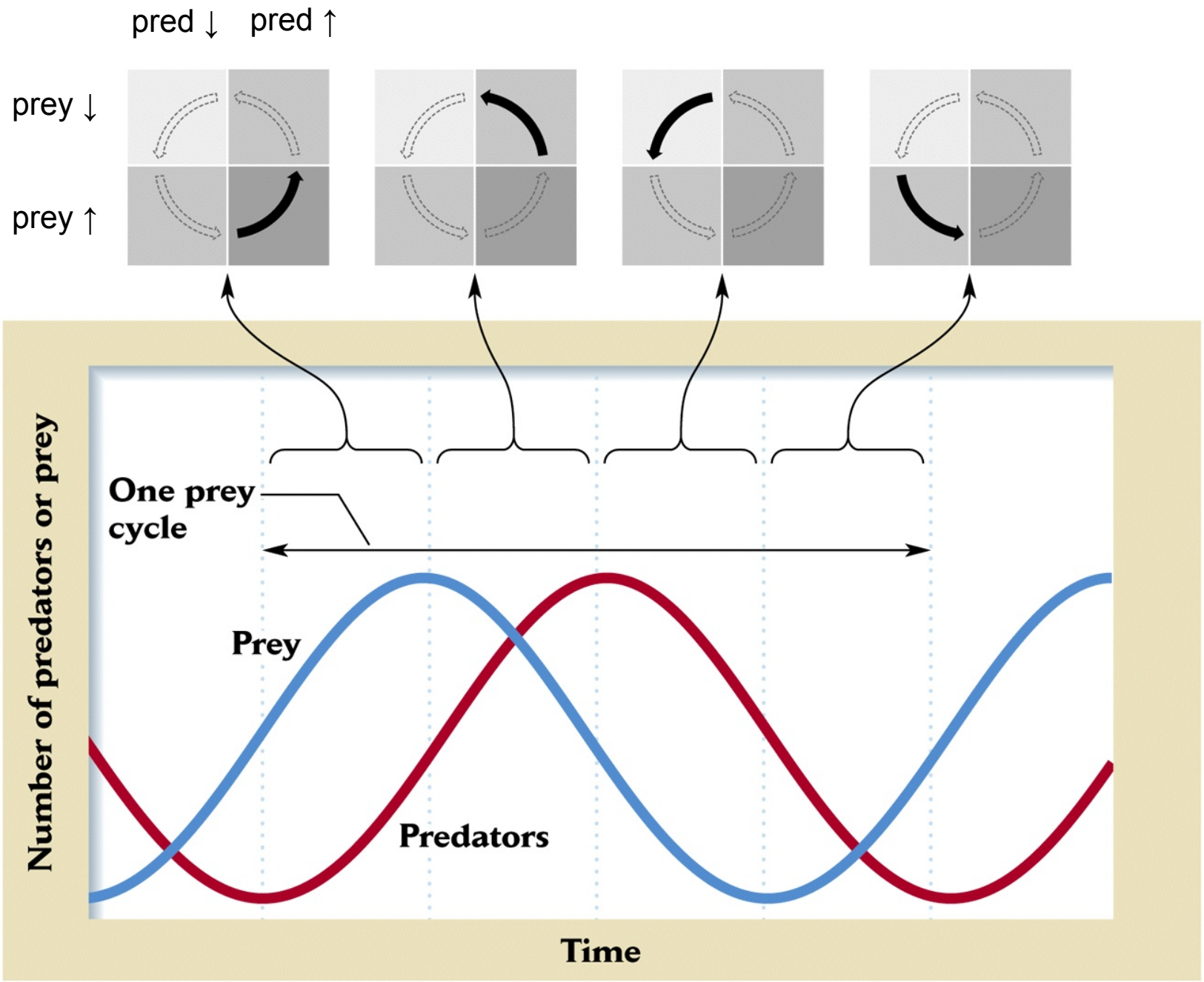
(*d* is death rate)

Lotka-Volterra predator-prey model at equilibrium

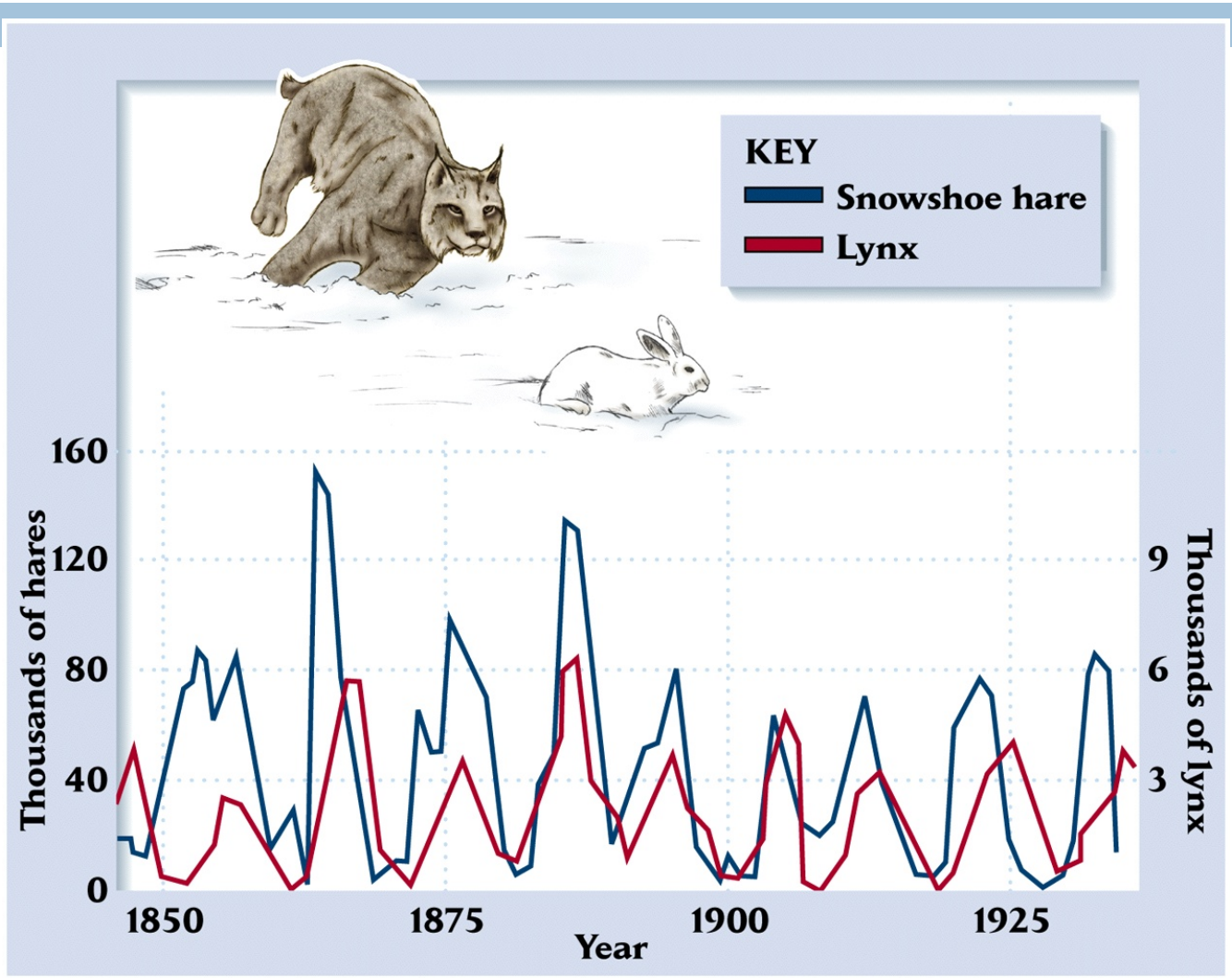



dP/dt = 0
Number of predators (P)
dR/dt = 0
Number of prey (R)


pred ↓
pred ↑
prey ↓
prey ↑
One prey cycle
Prey
Pr
Number of predators or prey
Time


pred ↓
pred ↑
prey ↓
prey ↑
One prey cycle
Prey
Predators
Number of predators or prey
Time

Predators and prey sometimes cycle



Predator-prey systems can be modeled with simple math

R is p<u>R</u>ey pop^n

P is <u>P</u>redator pop^n

$$dR/dt = rR - cRP$$

Growth of prey population

(*r* is growth rate)

Loss to predator population

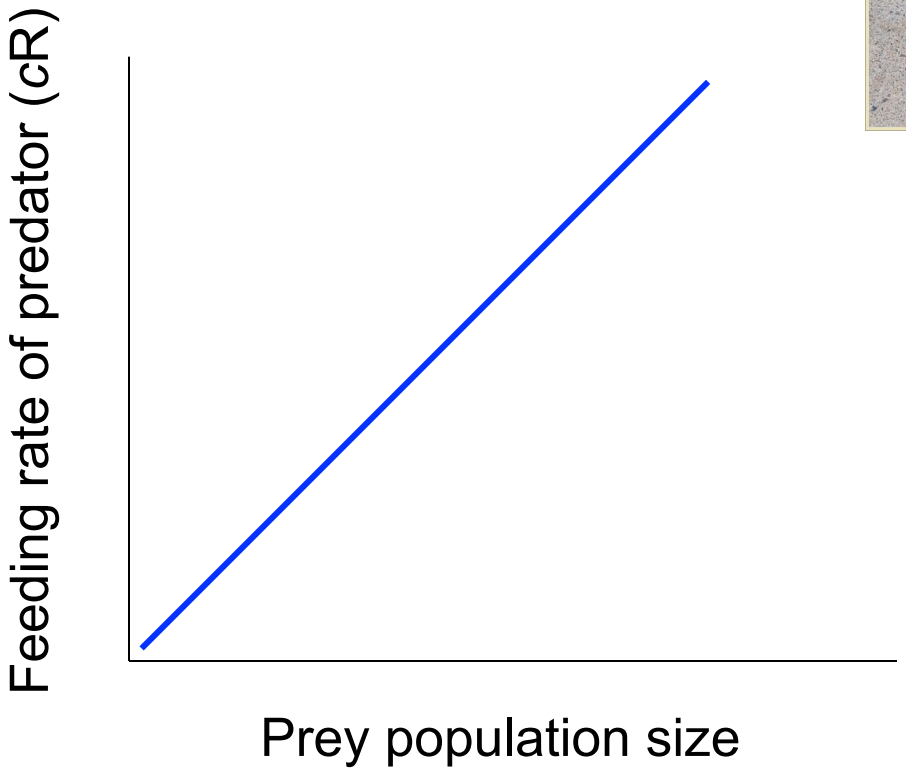
(*c* is capture efficiency)

What does it mean that *c* is a fixed number?

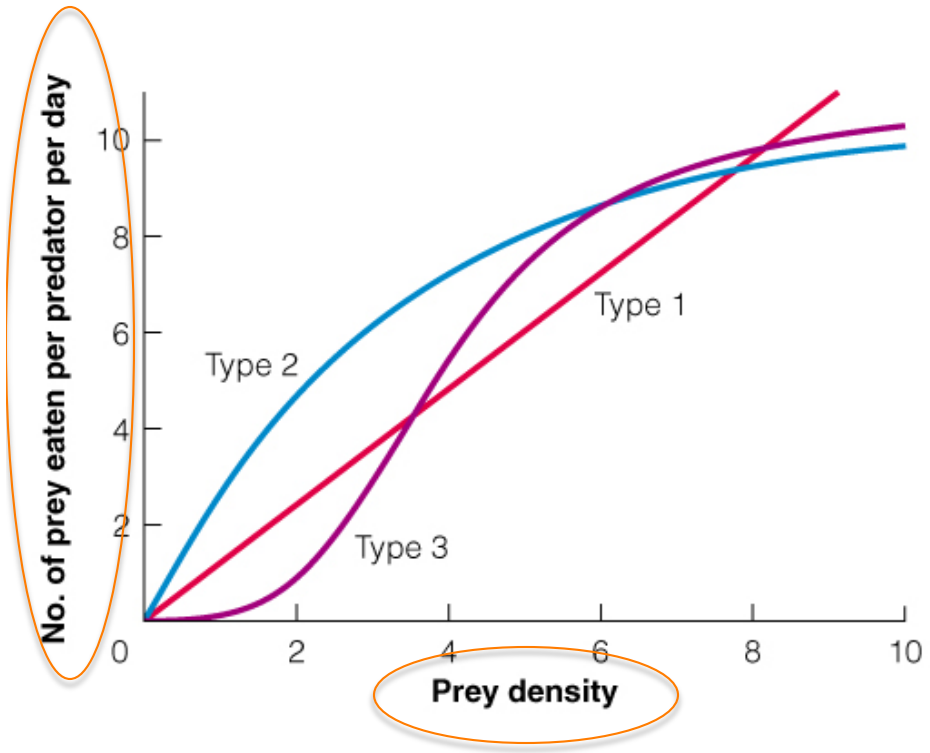
Predator functional response

Loss to predator population = *c*RP

Why is the y-axis a RATE?



3 forms of the Predator Functional Response



Type I :

linear increase with increasing prey
assumed by Lotka-Volterra
Uncommon in nature, why?

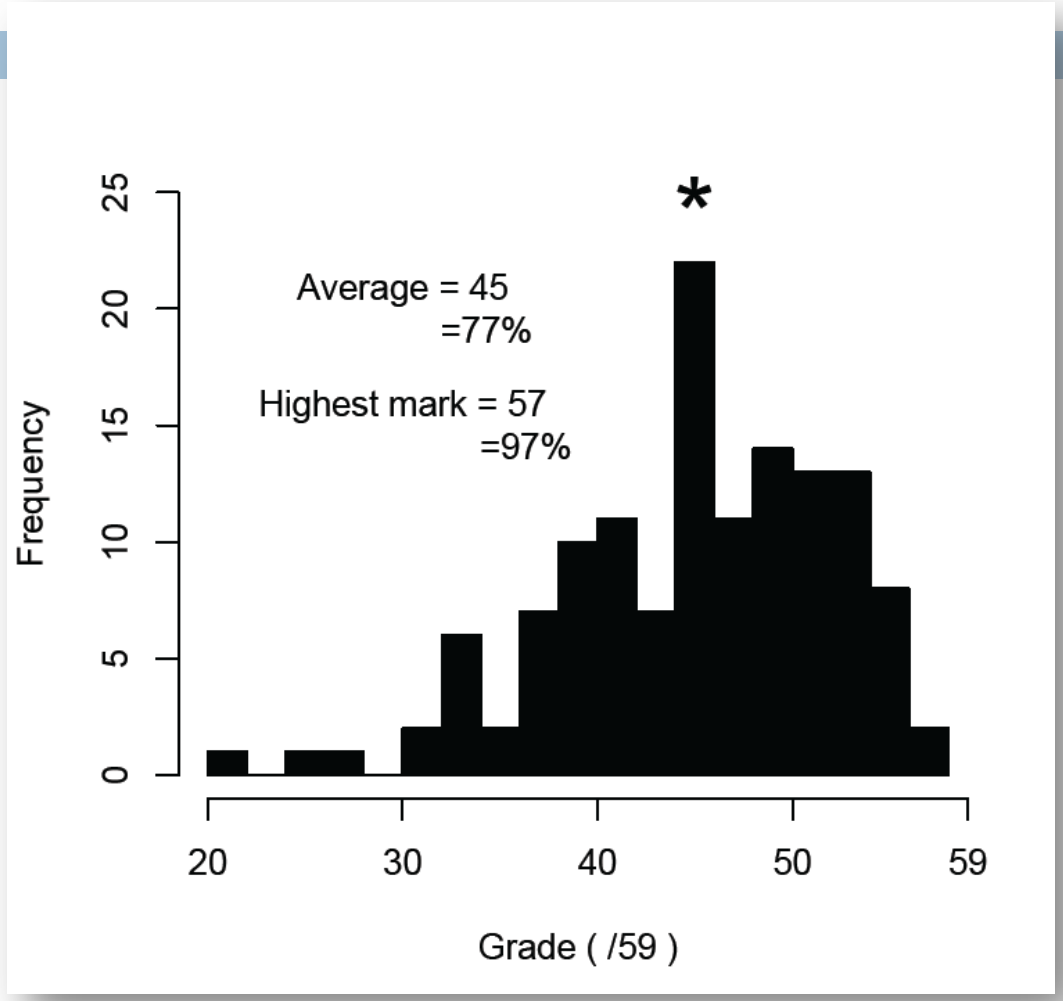
Type II:

predator consumption saturates
Limited by handling time and digestion (satiation)

Type III:

accelerating phase at low densities
saturation at high densities
Prey switching/hiding places at low densities & satiation at high densities

Exam 1:



Mean: 45 out of 59 (77%, ~B-)