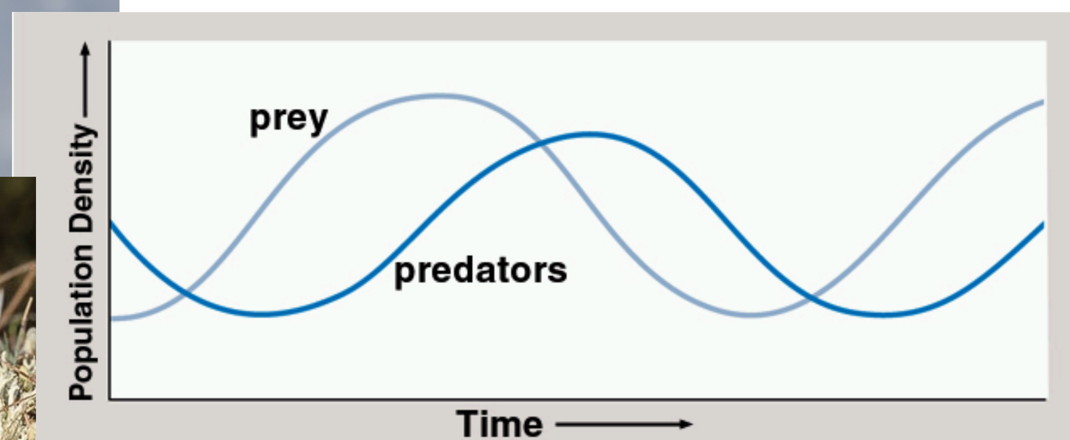
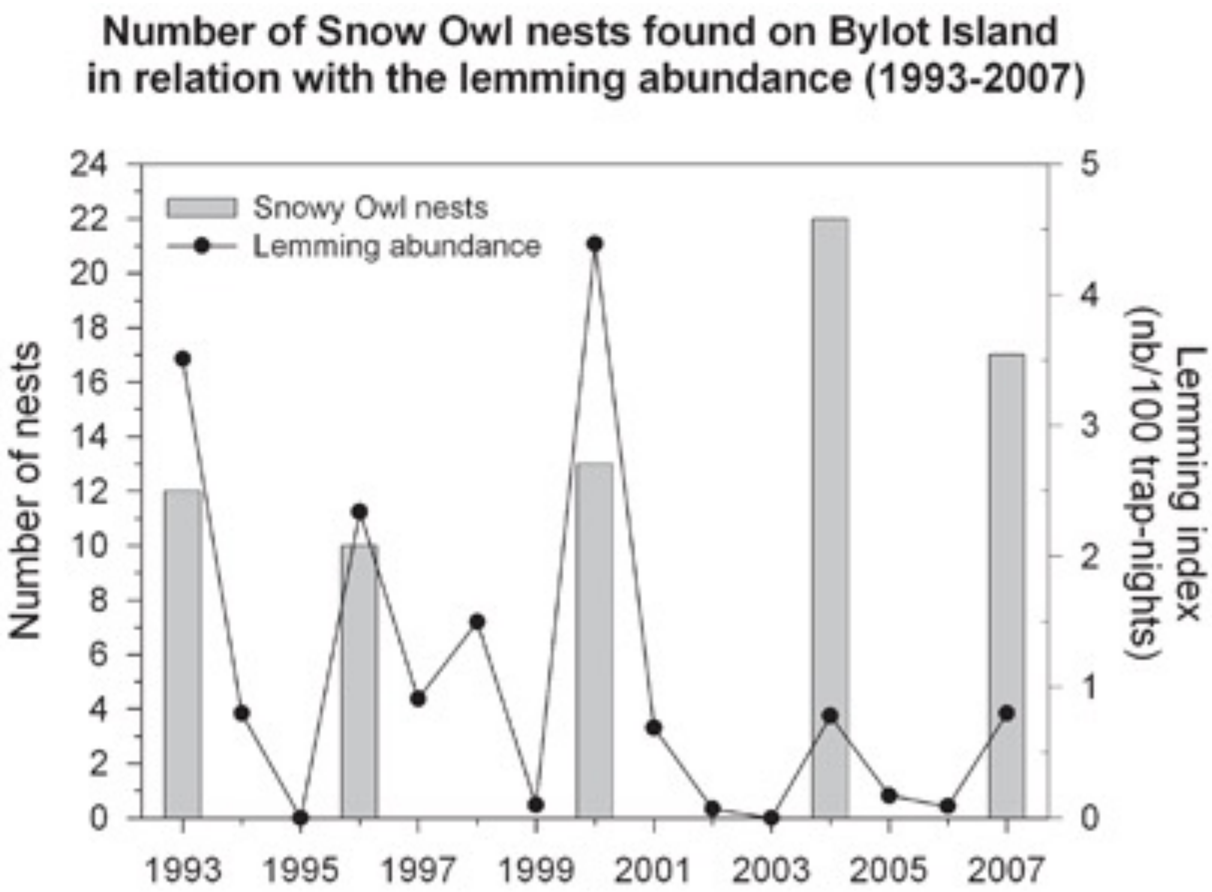
# Predators, prey, stability, cycles, feedback and coexistence



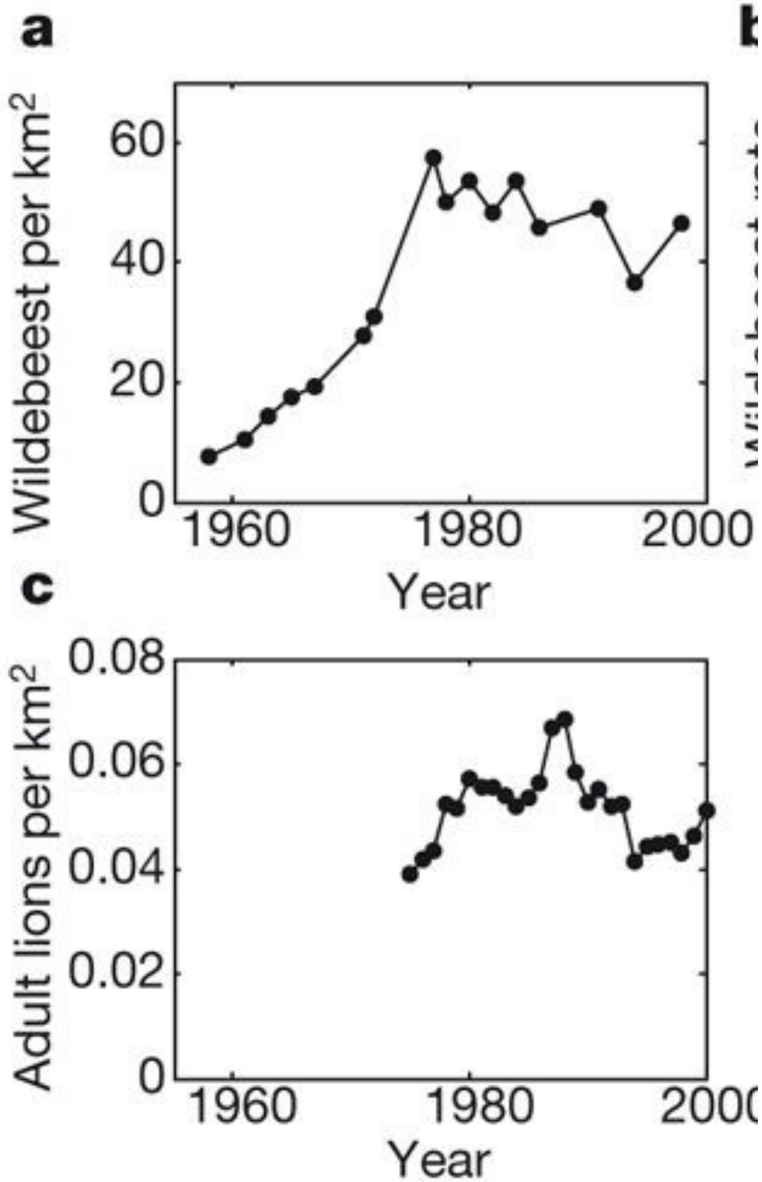
# Predator prey dynamics





Could cycles could be an outcome of simple interactions between one predator species and one prey species?

# Predator prey dynamics




What stabilizes predator-prey dynamics?

TODAY

Three functional responses

Three models

Selective predators

Selective predation and community structure

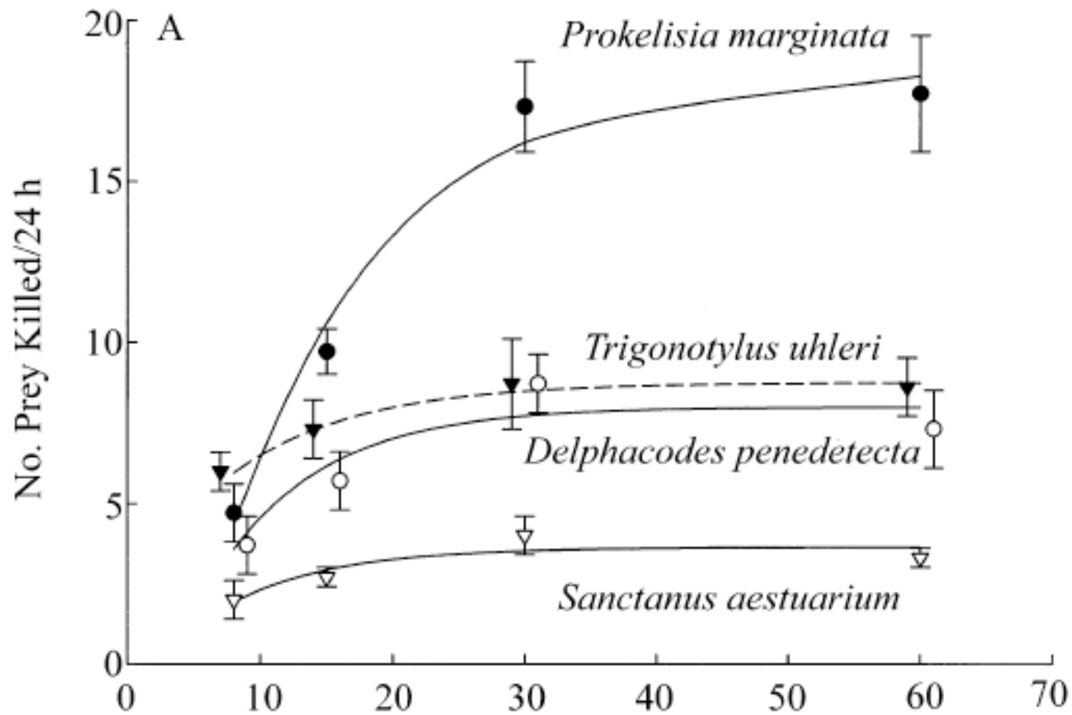
Consumptive and non-consumptive effects

# How do individual predators respond to variation in prey density ?

Pardosa - sapfeeder interactions

Expt in a mesocosm (7.5x30cm jar)

- 4 species of sapfeeder at four densities
- 1 wolf spider/jar

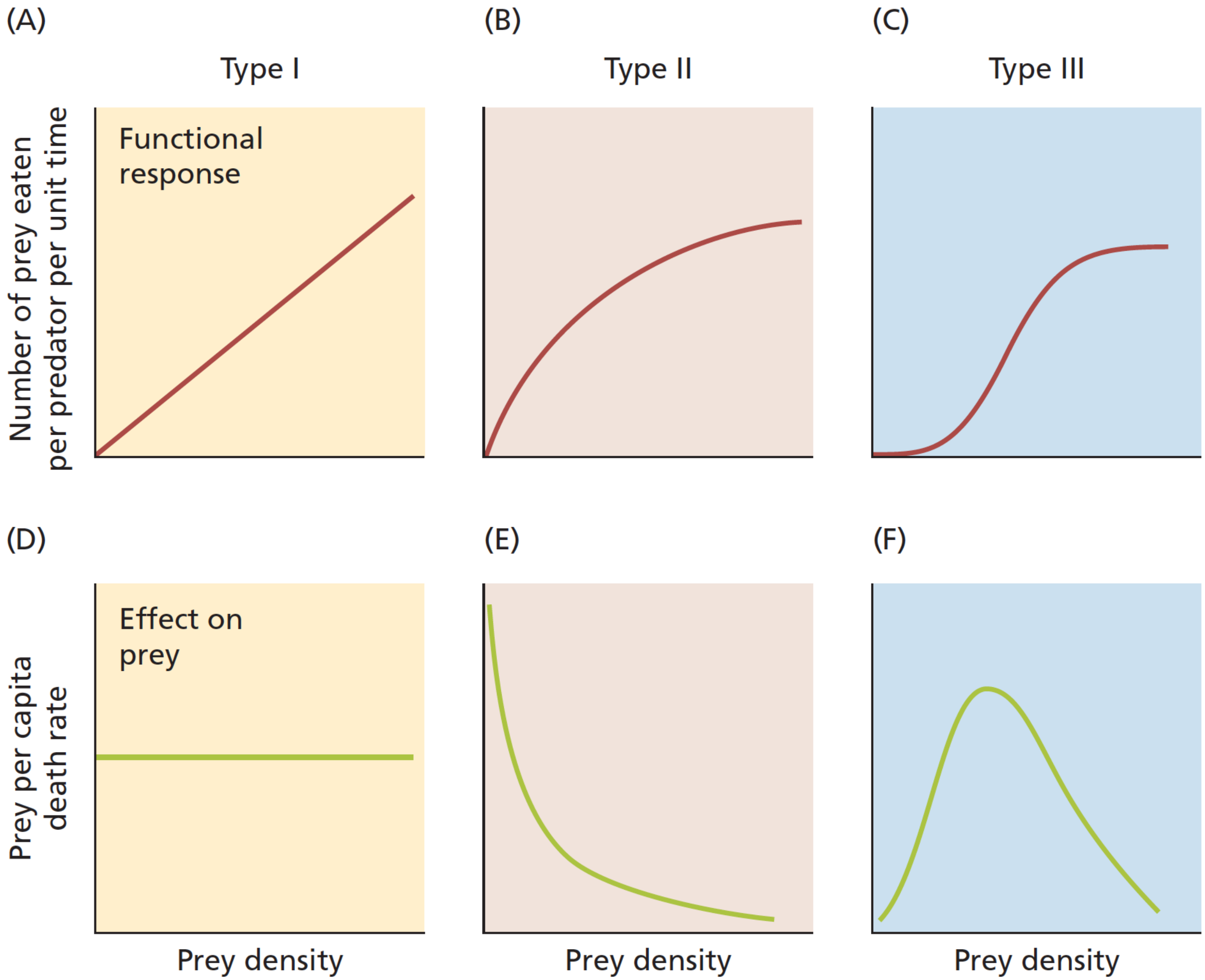



Prey density No/cage

# Three functional responses

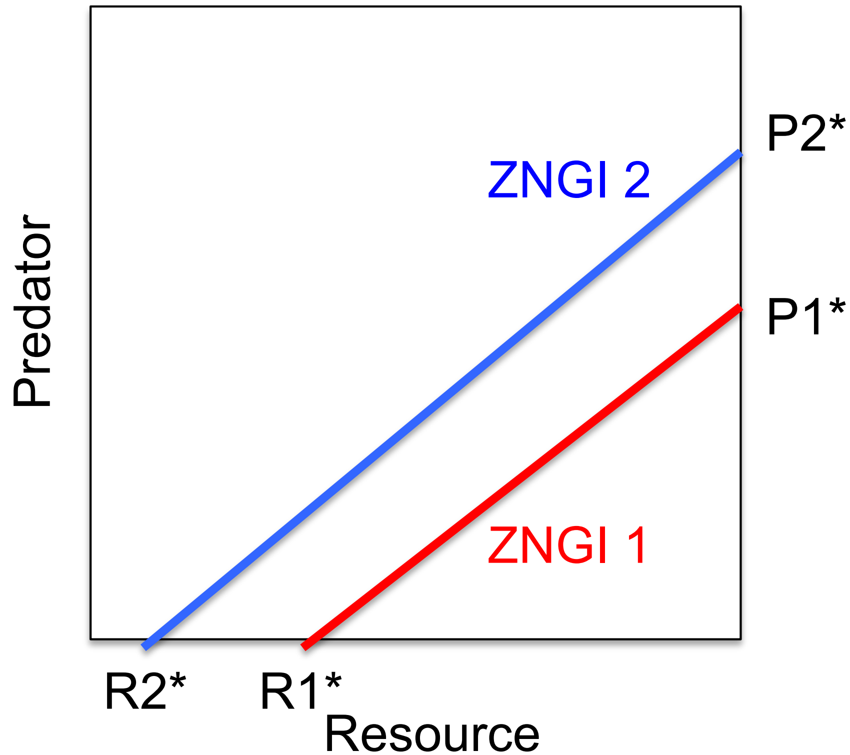

Specialist predator

Generalist predator

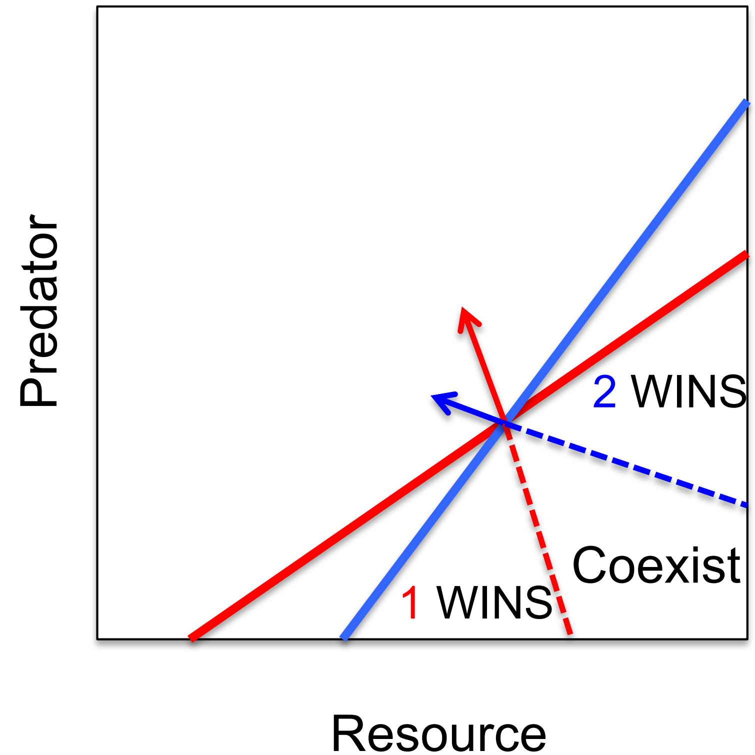


**Niche models**
for two prey species, a shared predator and a shared resource

**replace R* with P***



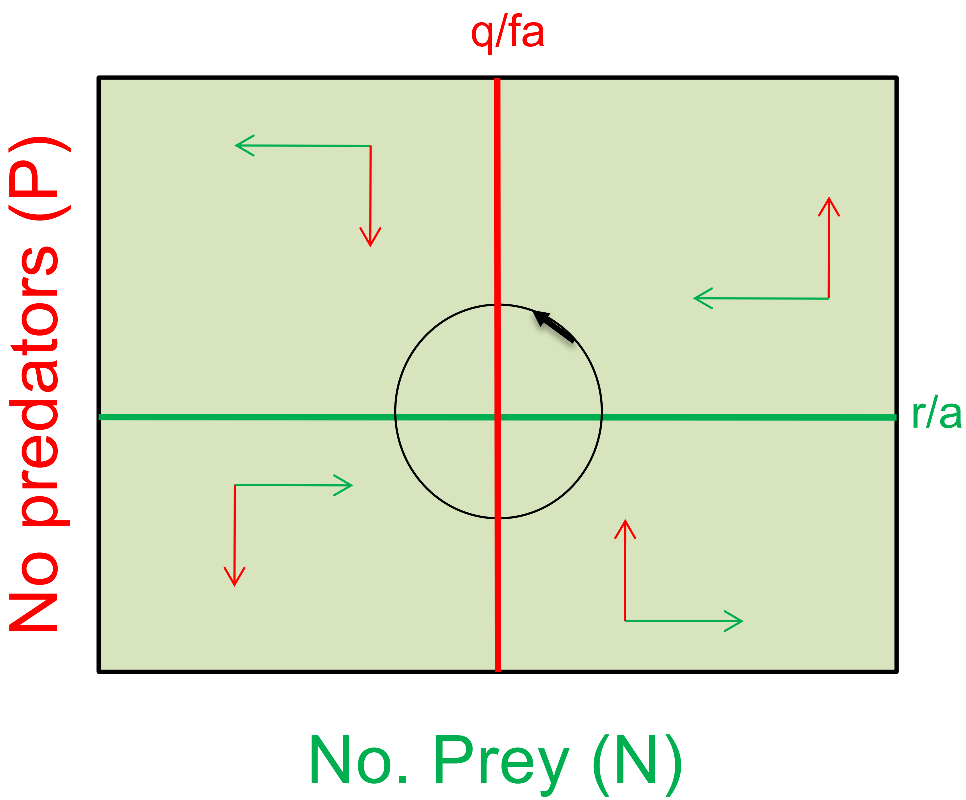

**Species 2 wins**

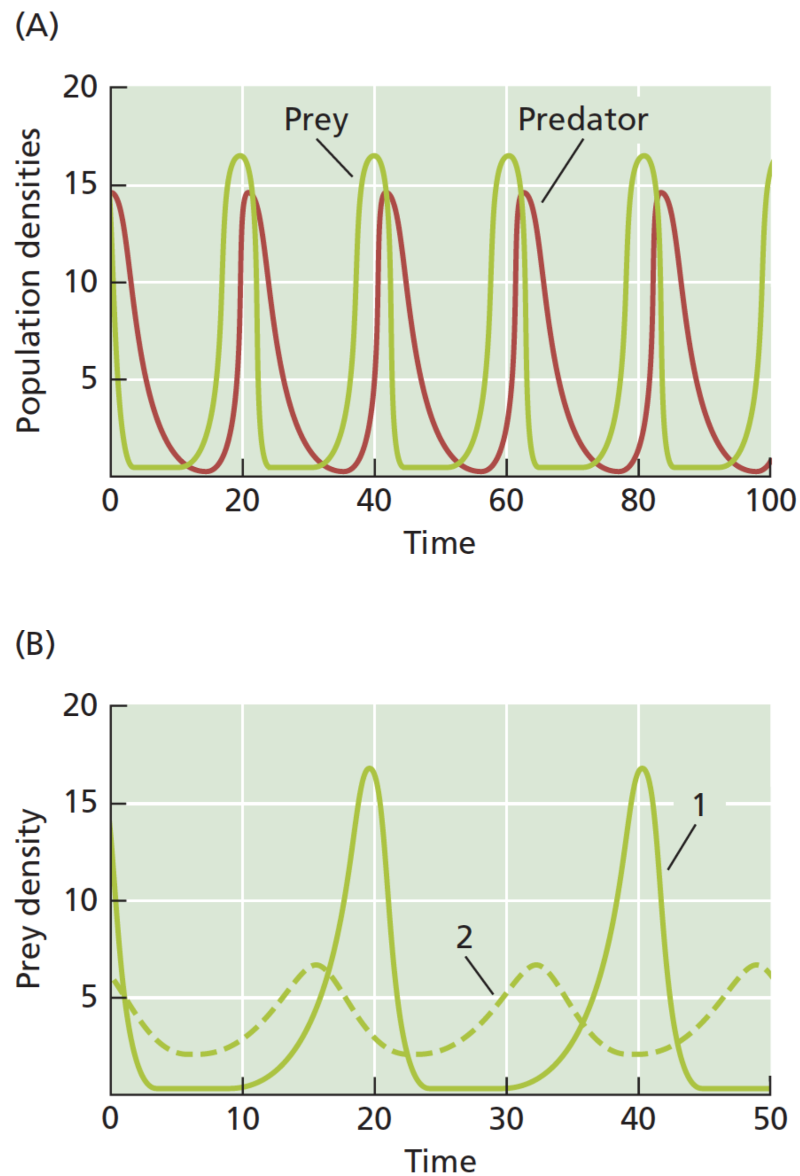



**Coexistence**
can occur if better defended species (higher P*) is the weaker resource competitor (higher R*)

# Lotka-Volterra model

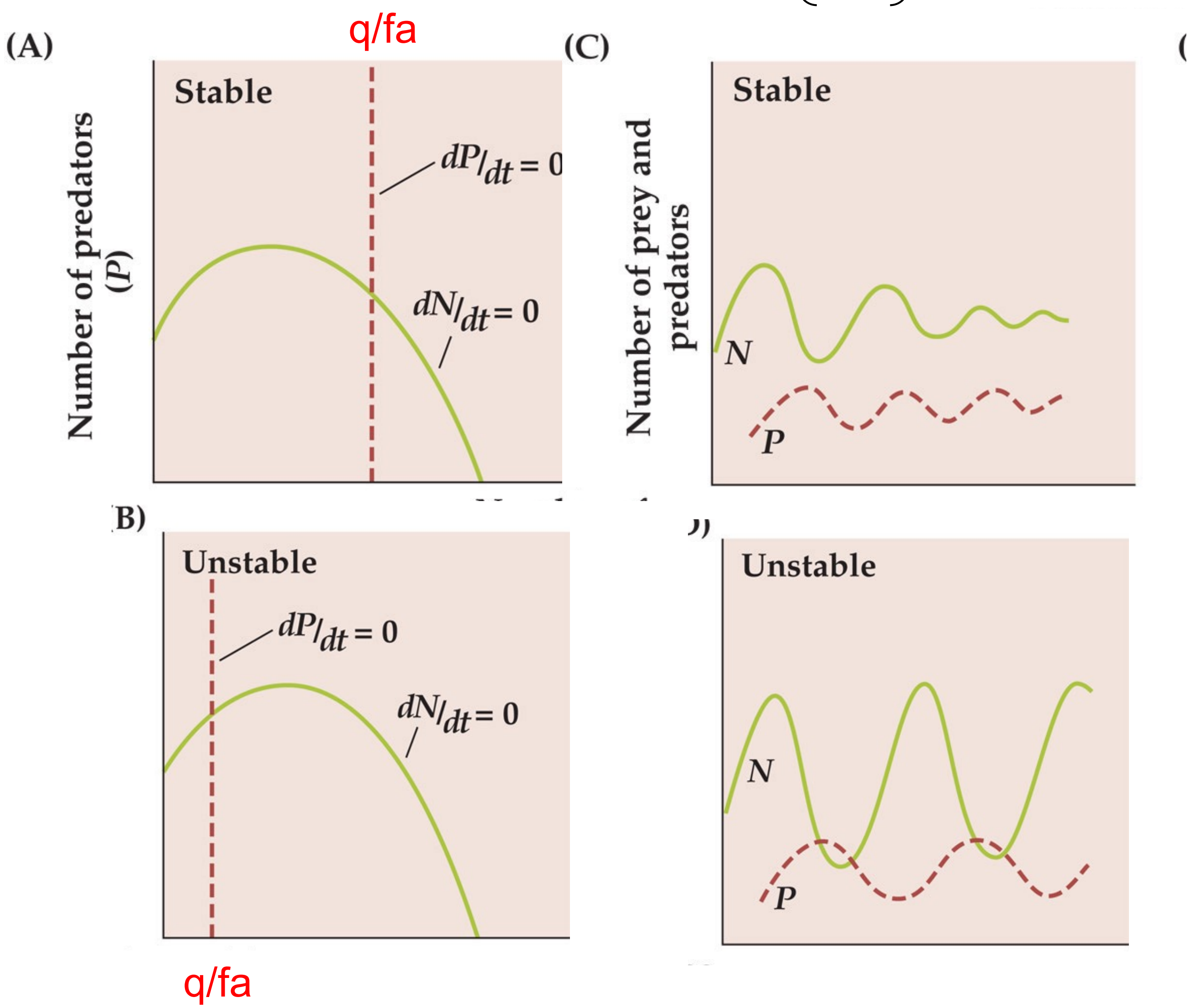
$$\frac{dN}{dt} = rN - aPN \qquad \frac{dP}{dt} = faPN - qP$$



# Rosenzweig-MacArthur model

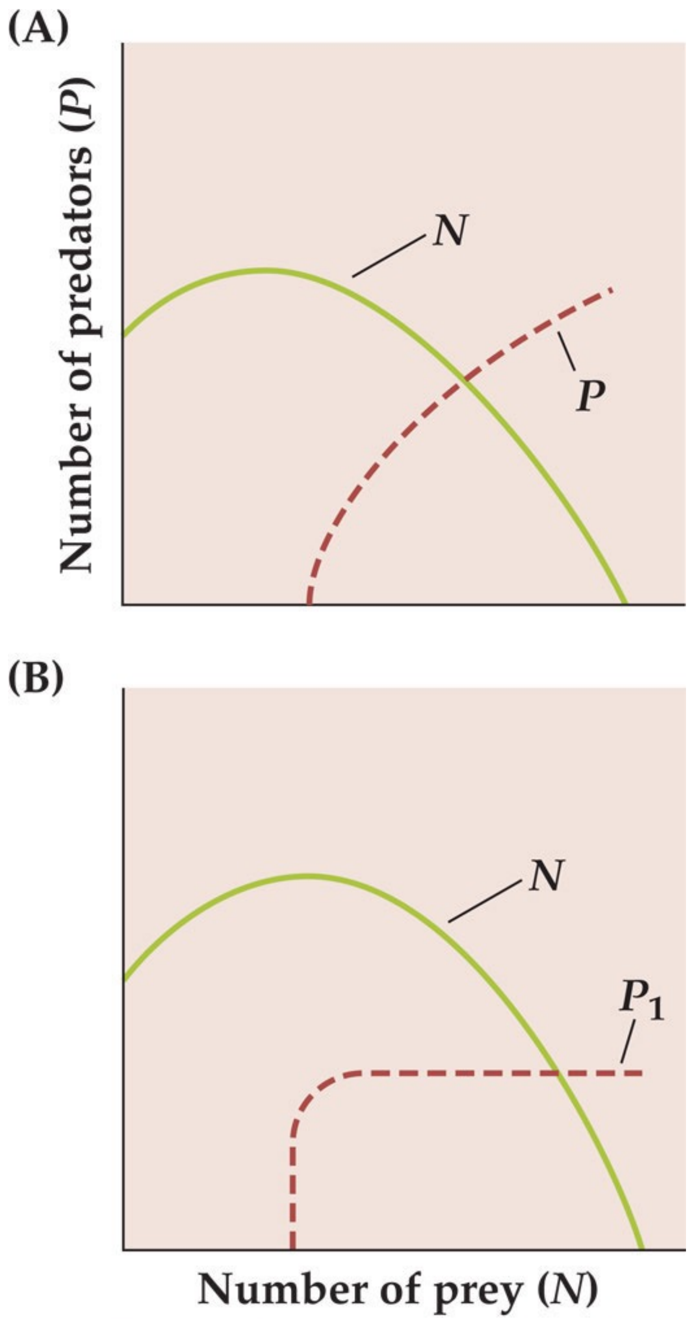
$$\frac{dN}{dt} = rN\left(1-\frac{N}{K}\right) - \frac{aNP}{1+ahN} \qquad \frac{dP}{dt} = \frac{faPN}{1+ahN} - qP$$




inefficient predator
(q/fa to the right)
produce a stable equilibrium

efficient predator
(q/fa to the left)
produce a limit cycle or
extinction of one/both
populations

# Predator self limitation model




COMMUNITY ECOLOGY, Figure 5.11



Predators compete over same prey item (=interference)

or are limited by a second resource eg a territory, nest site, den

Predator density dependence stabilizes predator-prey dynamics

**Modifications to the Lotka-Volterra model show**

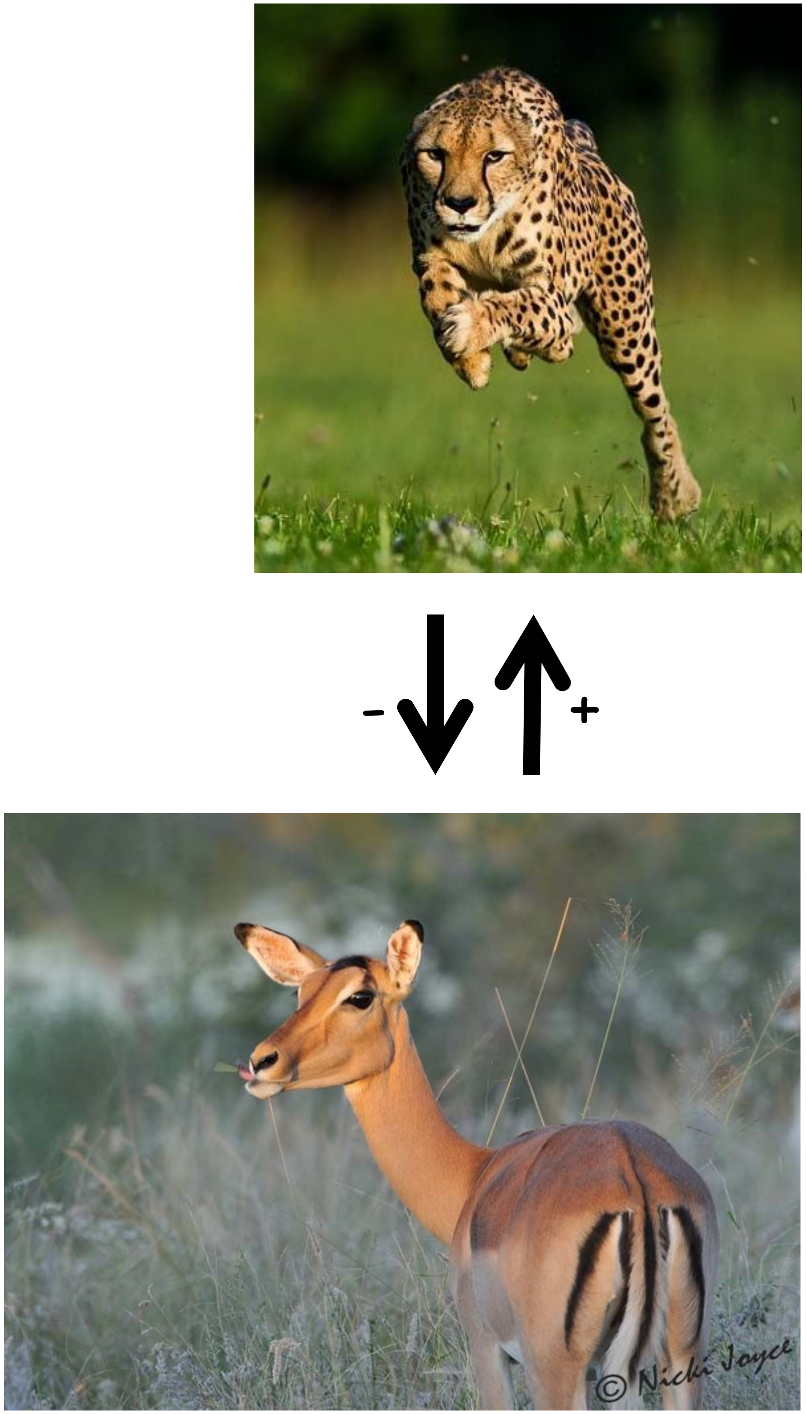
- incorporating a carrying capacity acts to stabilize the system

- incorporating a more realistic functional response stabilizes the system

- predator- prey systems are more likely to be stable when the predator is relatively inefficient

- the addition of resources that increase K can destabilize a system

- interference or competition among predators for limiting resources will stabilize the system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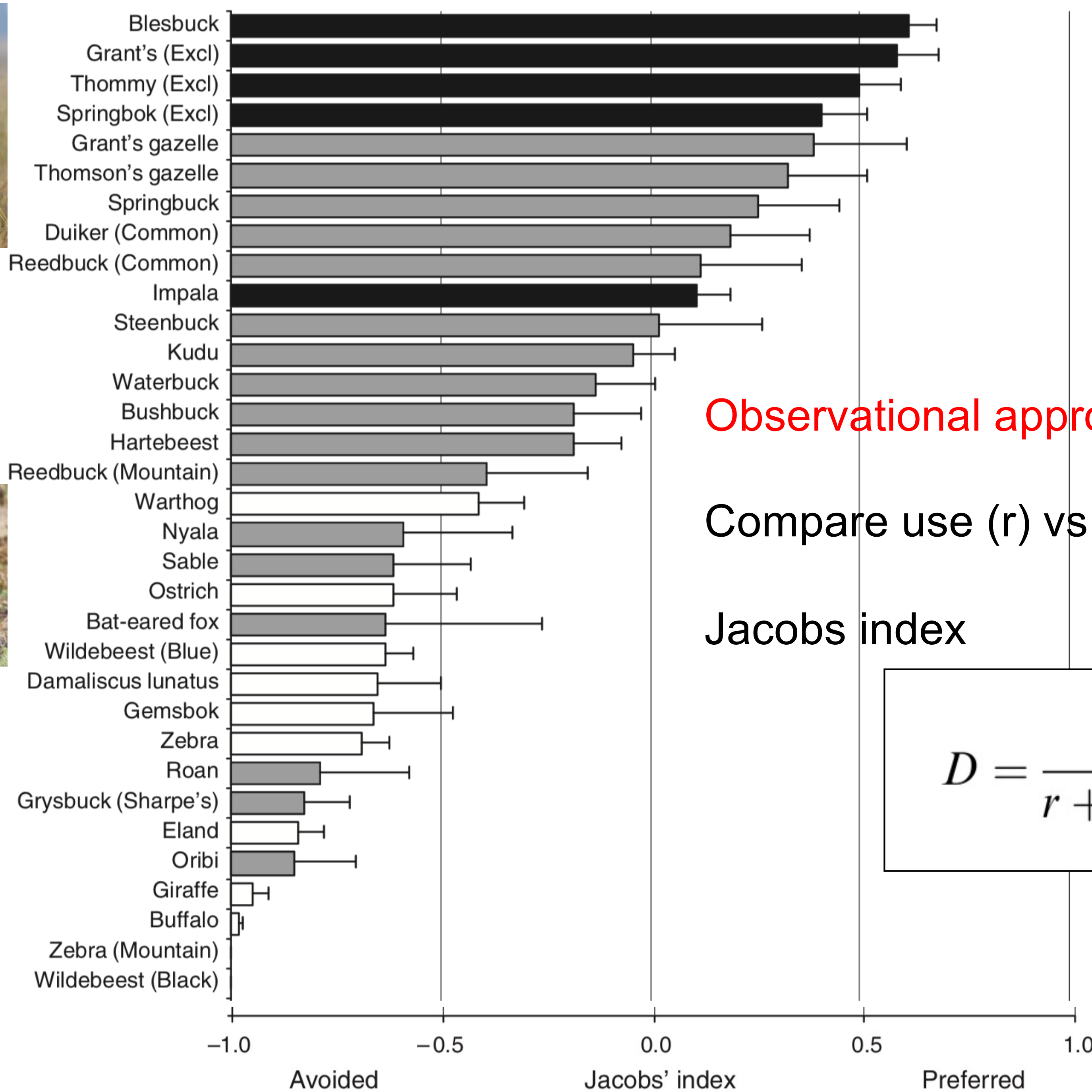
# Predators are selective - eg cheetah Hayward et al. 2006 J Zool




Observational approach

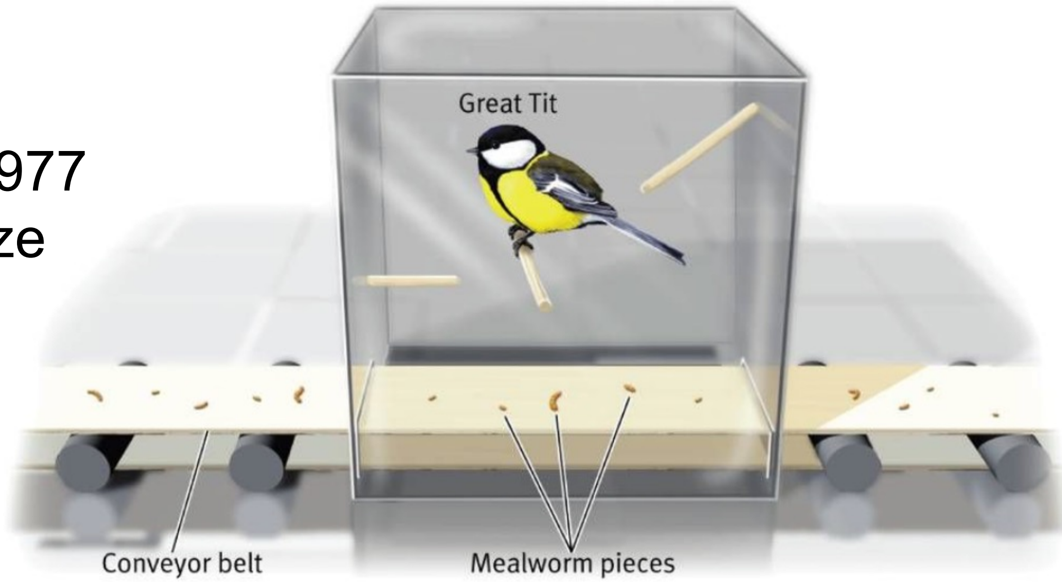
Compare use (r) vs availability (p)

Jacobs index

$$D = \frac{r - p}{r + p - 2rp}$$

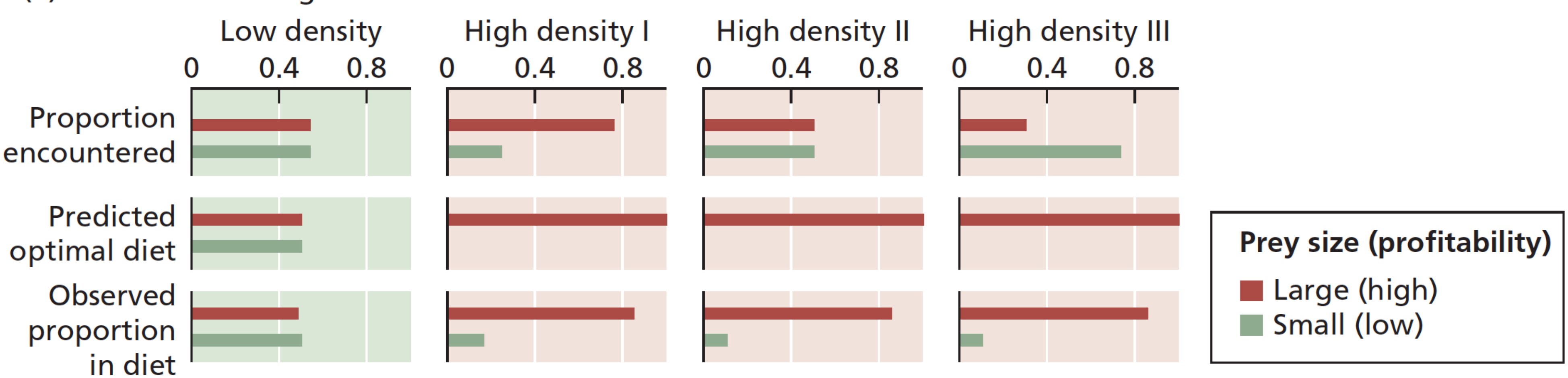
# Predators can adjust their behavior to maximize energy gain as predicted by optimal foraging theory

Krebs et al . 1977
Varied prey size
Varied density




Large/Small
via Speed

(B) Great tits feeding on mealworms



# Selective predation affects coexistence and diversity

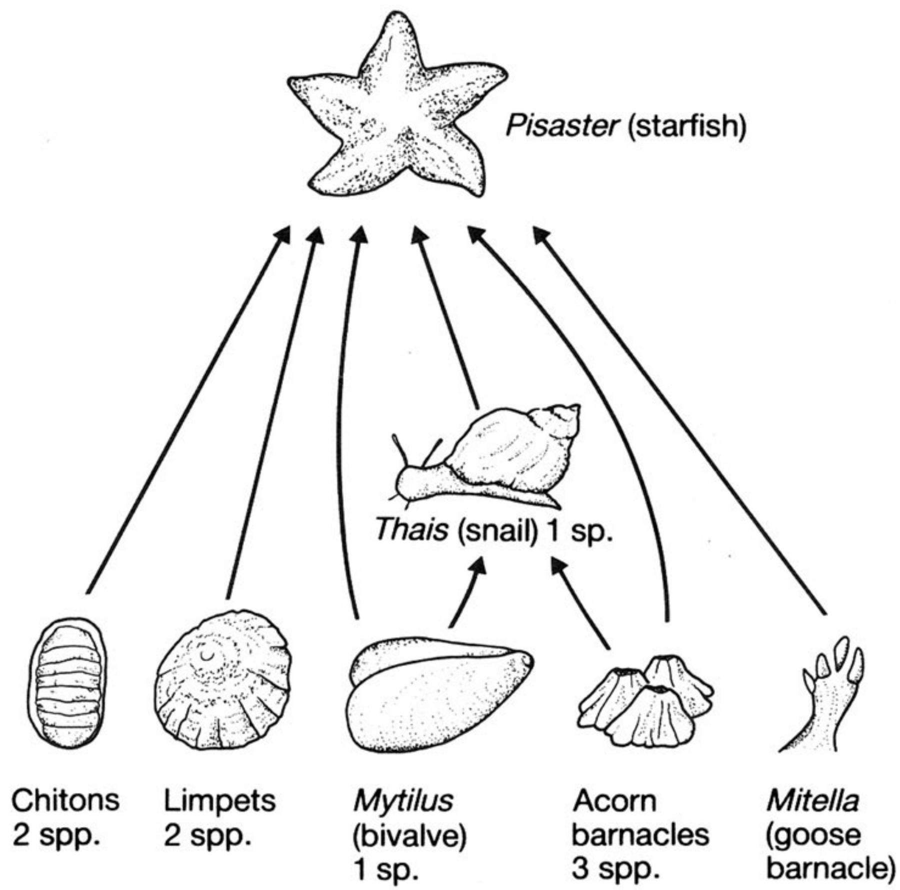
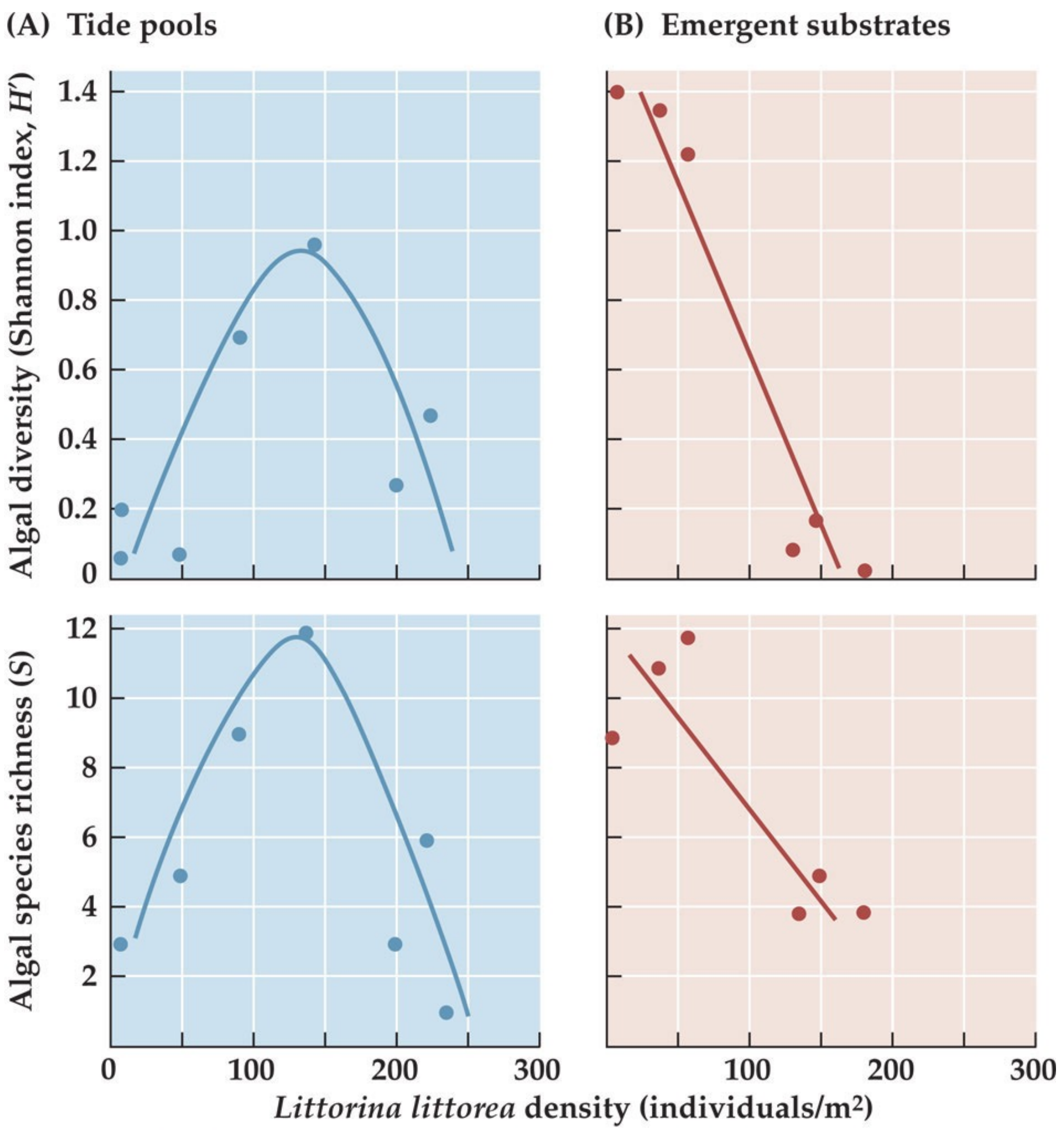



**Figure 21.3.** Paine's rocky shore community. (After Paine, 1966.)

Dr Robert Paine 1933-2016

preference for competitively dominant species → promotes diversity

# Selective predation affects coexistence and diversity




COMMUNITY ECOLOGY, Figure 6.6



A. Littorina prefer most competitive algae

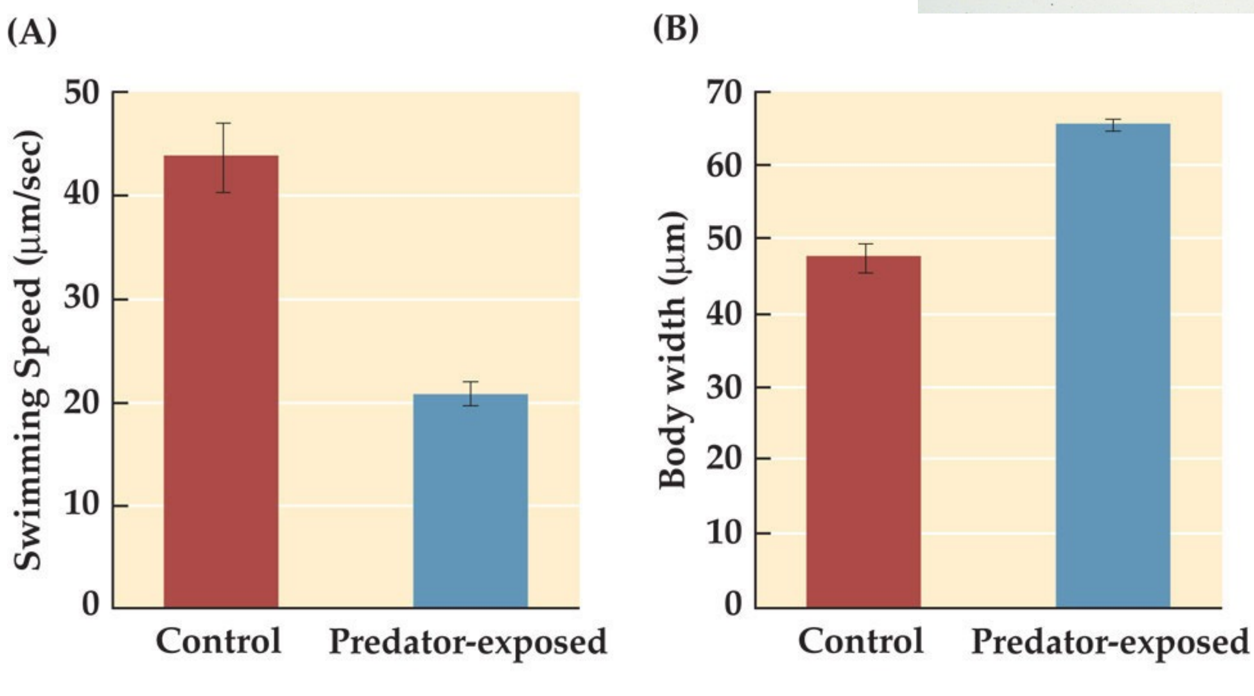
B. Littorina prefer algae that are inferior competitors

**Predators have consumptive and non-consumptive effects on prey**

| Consumptive | Non-consumptive |
|---|---|
| Lethal | Nonlethal |
| Density mediated interactions | Trait mediated interactions |

- **habitat use and habitat shifts**
- **life history evolution**
- **activity level**
- **morphological changes**

# Paramecium (prey) + Flatworm (predator)




Hammill et al. 2010.
American Naturalist 176: 723-31.

# The relative importance of consumptive and non-consumptive effects

“Predation” spider
– Pisaurina mira

Prey
– Melanoplus femurrubrum


glue mouthparts

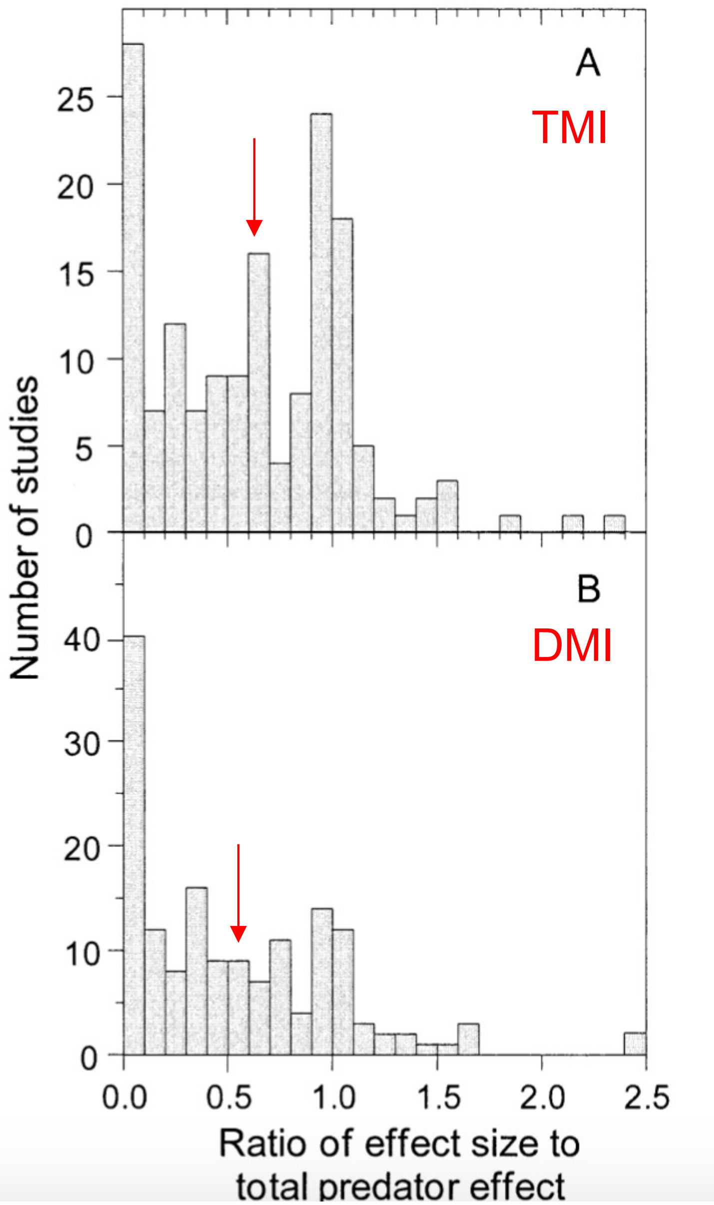
→“Risk” spider

Compare effects of
Predation and Risk spiders

Movement
Densities of grasshopper nymphs
Diet
Amount Grass/Forbs consumed

Preisser et al. 2005 Ecology

TMI = trait mediated (non-consumptive) effect
DMI = density mediated (consumptive) effect




Meta-analysis – weighted by sample size

| Effect | Two-level food chain | | |
|---|---|---|---|
| | Mean | 95% CI | *N* |
| Response ratio | | | |
| TMI effect/total effect | 0.58 | (0.50, 0.67) | 136 |
| DMI effect/total effect | 0.54 | (0.47, 0.63) | 133 |

**Classic paper**

Hammill et al. 2010. **Predator functional response changed by inducible defence in prey.** American Naturalist 176: 723-31.

**Discussion papers**

Predator-prey dynamics – stabilizing factors

Predators and community structure

Consumptive and non-consumptive effects

save trophic cascades for later