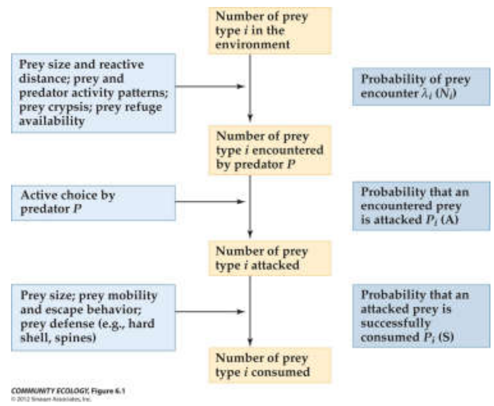
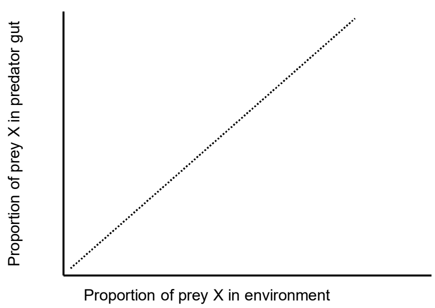
Energetics of Predation

- Predator benefit = calories in meal – search cost – handling cost
- Predator strategies – maximize benefit by minimizing search or handling
- Prey strategies – minimize calories in meal, maximize search, maximize cost
  - Crypsis
  - Escape
  - Avoidance
  - Prey quality
- **Evolutionary arms race (Red Queen hypothesis) –** why don't they "end" ?

Process of Predation



How do you quantify predatory preference for prey?



$$E = \frac{(r_i - p_i)}{(r_i + p_i)}$$

Selectivity index (E)
r_i = % of diet is prey type i
p_i = % of available prey is type i

How do you quantify predatory preference for prey?

- Chesson's index (a)
- $a_i = \frac{d_i/N_i}{\sum_{j=1}^{k}\left(d_j/N_j\right)}$
- Where
  - K – number of types of prey
  - d – number of prey in the diet (d_i=in diet, d_j=in environment)
  - N – number of prey available (in diet or in environment)

Generalist vs. Specialist Predator

- Advantages/disadvantages of broad or specific diet

Optimal Foraging Theory

- Predict foraging strategy based on:
  - Handling time (T_h)
  - Search time (T_s)
  - Energy in prey item
- Predators should forage to maximize energy gains (E)

$$\frac{E}{T_s + T_h}$$

- For any given prey, E/T is the net energy gain:

$$E_n/_T = \frac{E}{T_s + T_h}$$

Optimal Foraging Theory

- We know not all prey are:
  - Equally abundant
  - Provide the same energy content
  - Require the same search and handling time
- Adding these to the model (equation 6.2 in text):

$$-\frac{E_n}{T} = \frac{\sum_i^k \lambda_i E_i P_i}{1+\sum_i^k \lambda_i h_i P_i}$$

- Where
  - E = energy gain (prey type i)
  - λ = number encountered (prey type i)
  - P = probability of pursuit (prey type i)
  - h = handling time (prey type i)

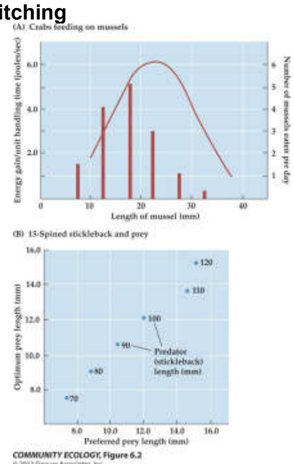
Assumptions and Predictions of OFT

- Perfect Knowledge of environment, including distribution of *i* prey items
  - energy content
  - handling and search time
- Fitness optimized by maximizing energy intake.
- Predictions:
  - Specialist -> Generalist gradient
    - Specialist: maximize E_i even though s_i and h_i high
    - Generalist: minimize T_s and T_h, take whatever E available
  - Predators with long handling times ($T_h > T_s$) should be specialists
  - Predators in unproductive habitats (large T_s) should be generalists
  - Predators should ignore unprofitable prey, regardless of abundance

Prey quality, abundance and switching

- Optimal foraging model works well. Lots of data indicating this is how predators behave.

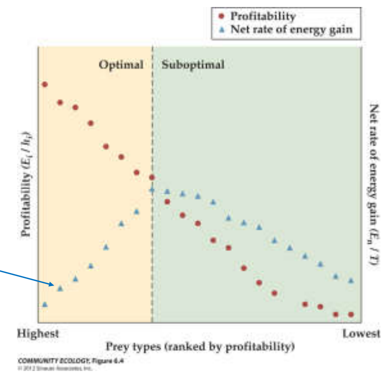
- Some other predictions:
  - **Zero rule** – in any specific set of conditions prey are either ignored or pursued 100% of the time (P_i= 0 or 1.0). This is the basis of switching behavior.



Prey quality, abundance and switching

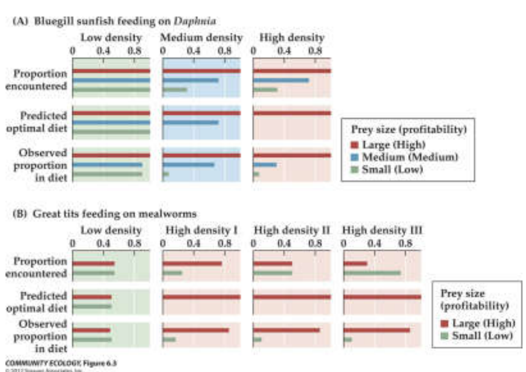
- Changing focus is based on the profitability of the prey encountered (E_i/h_i)

Net rate of energy gain as you add prey in rank order of profitability.



Empirical Evidence for OFT from Experiments

- No selectivity at low density, focus on higher profit prey as density increased.

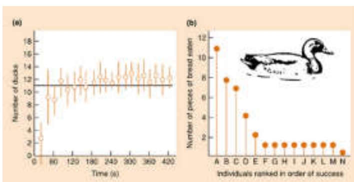


Giving Up Density (GUD)

- **Giving Up Density** (GUD) – density of prey at which a predator will abandon a prey type or area.
  - Prey are depleted – cost/benefit of pursuing prey no longer beneficial
  - Competing predator more efficient – cost/benefit of prey no longer beneficial
  - Predator response – switch or find new patch

Ideal Free Distribution (IFD – Fretwell and Lucas 1970)

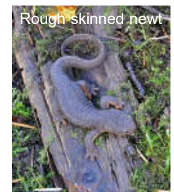
- Consumers should aggregate where resources are most abundant (OFT)
- Consumers will compete and interfere.
- Thus, patches with fewer competing consumers are most profitable
- Consumers should continually redistribute themselves to match patch quality
  - Assumes movement among all patches equal
  - Simultaneous knowledge of all patches



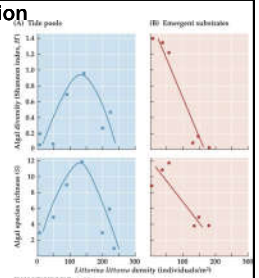
Prey Responses

- We expect prey to respond by minimizing their profitability.
  - Increase T_s
    - Crypsis
  - Increase T_h
    - Escape
    - Avoidance
    - Mechanical defenses
  - Decrease caloric quality
    - Chemical defenses

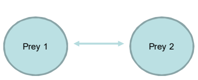
Tetrodotoxin toxicity and resistance



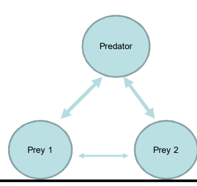
Community Composition and Predation



- Predators selecting specific prey will tend to increase diversity
  - reducing the abundance of dominant species that exclude others
  - Potential explanation for higher diversity in tropical systems



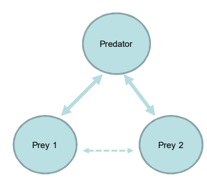
Competition, 1 winner



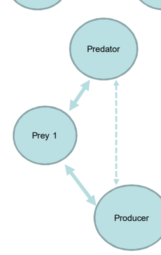
Both populations reduced, less competition

Community Composition and Predation

- **Apparent competition**: indirect interaction between two species via shared predator



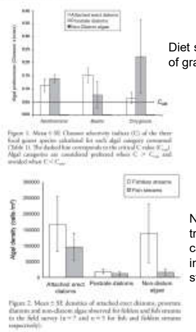
- **Trophic cascade**: predation alters abundance of consumer at one trophic level, cascades through food web.



Non-consumptive cascade

Cascading effects of predatory fish on the composition of benthic algae in high-altitude streams

Marusa Alvarez and Barbara L. Peckarsky



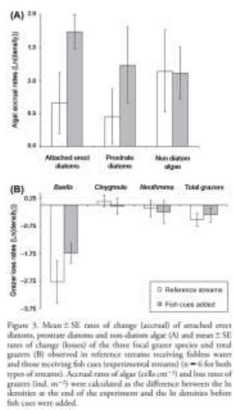
Fish

Grazers

Algae

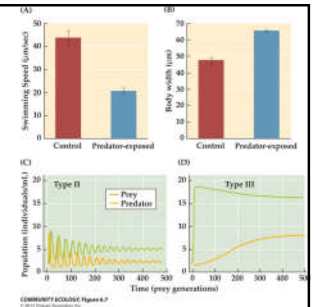
Diet selectivity of grazers

No clear trophic cascade…shift in community structure.



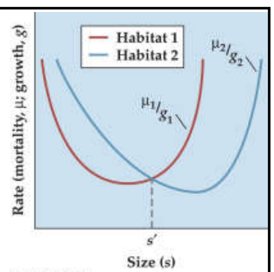
Prey Responses

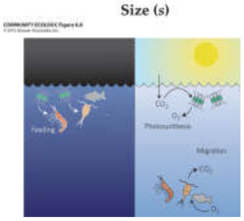
- Prey responses to the presence of predators (**nonconsumptive effects**)
- Changes in movement or habitat



Habitat Shifts

- Prey will shift habitats to mediate the tradeoff between acquiring resources (increasing fitness) and avoiding predation.
- Zooplankton diel migration
  - More algae available at the surface where predation is high.
  - Most predators are visual, predator efficiency decreases at night.





Algae-grazing minnows (*Campostoma anomalum*), piscivorous bass (*Micropterus* spp.), and the distribution of attached algae in a small prairie-margin stream

Mary E. Power and William J. Matthews
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University of Oklahoma Biological Station Star Route B, Kingston, OK 73439, USA

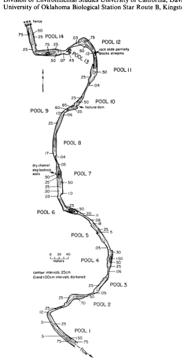
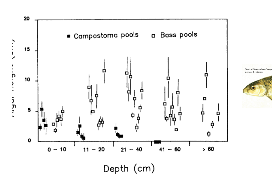


Fig. 1. Map, drawn to scale, of 1 km study reach in Brier Creek



ig. 2. Height of attached algae ($\bar{x} \pm 1$ S.E.) at sites along cross-tream transects in four *Campostoma* and nine bass pools. Data re grouped into depth intervals. Heights of attached algae are ignificantly greater in bass pools than *Campostoma* pools at depths f 11–20 cm, 21–40 cm and 41–60 cm (P's from Mann-Whitney J tests < 0.002, 0.01 and 0.006, respectively)