Species Interactions: Predation and Mutualisms

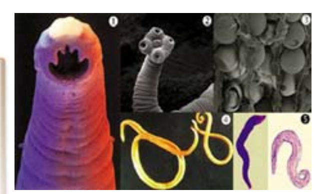
PREDATION

Interactions that increase the fitness of 1 organism at the expense of another

5 types of predation can be identified

1. Herbivores – animals that prey on green plants, seeds or fruits (plants often not killed but often damaged)
2. Carnivores – typical predation, 1 animal consumes another
3. Insect parasitoids – insects (Diptera or Hymenoptera) lay eggs on or in host, host consumed by larvae

4. Parasites and disease – depend on host for nutrition, (little difference between parasitism and herbivory)
5. Cannibalism – predator and prey are the same species



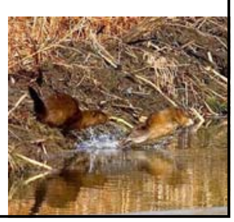
Predation is an important community process from 3 points of view

1. Predation on a population may restrict its distribution or abundance of prey
2. Along with competition, predation is another major type of interaction that can influence the organization of communities
3. Predation is a major selective force, many adaptations result from predation pressure

Major assumption – predators determine abundance of their prey

1. Predators actually control abundance of prey and keep numbers below what they could be
2. Predators only remove "doomed surplus". Individuals that would likely die for other reasons. Thus removing predators will have no effect on population of prey.

- Compensatory mortality – mortality caused by hunting substitutes for other forms of mortality in a population
- Additive mortality – when mortality caused by hunting adds to mortality of populations



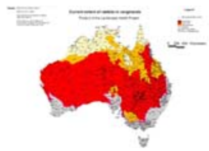
Predation once thought as 2nd to competition. More likely equal to competition in community structure and organization

What effect does predation have on communities?

- Prey abundance and evenness
- Prey population dynamics
- Prey evolution
- Abundances of species in other trophic levels

Example from Biological Controls

European rabbits introduced into Australia 1859



- Exponential growth
- Expanded range 70 miles/year
- Degraded range

Should mammalian carnivore be introduced?

- Rabbits susceptible to specialized virus, *Myxoma.*

Occurs naturally in South American populations of rabbits where it has mild non-lethal infection

But in European rabbits highly lethal

Vector for virus is mosquito/fleas

Initially introduced in 1950/1951

99% lethal

Resulted in drastic population decline and recovery of range and native vegetation

Currently virus is ~ 40% lethal

Properties of effective Biological Controls

Control agent imposes low, stable population equilibrium on pest. Likely to occur if -

- Host specific
- Synchronous
- Control agent should be capable of rapid increase as prey increases
- Control agent should need few host to complete life cycle
- High search efficiency

Impact of predators on Marine Communities

Robert Paine (1966) conducted several influential studies on impacts of predators

- Predators sometimes increase species richness that coexist in limited area
- Predator prevented competitive exclusion

Paine's Study

- Rocky intertidal of Pacific coast
- 16 common invertebrate species (bivalves, snails)
- Space for attachment is limiting and essential resource
- *Pisaster* (starfish) is large, predator in community

Coexistence of so many potential competitors seems at odds with Competitive Exclusion Principle

Experiment: Remove *Pisaster*

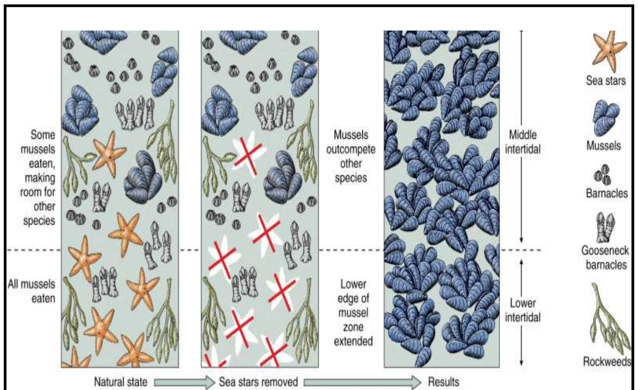
- *Pisaster* removed from some sites and remained in others
- Ran experiment for several years

Results

Removal sites – spp richness declined 15 → 8

bivalve *Mytilus* occupied most of space

Control sites – spp richness unchanged = 15



Pisaster – Keystone species

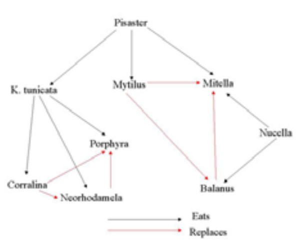
- "The species composition and physical appearance were greatly modified by the activities of a single native species high in the food web. These individual populations are the **keystone** of the community's structure, and the integrity of the community and its unaltered persistence through time."
- Important within community at maintaining species richness and diversity
- Predation increased diversity by

preventing competitive exclusion by *Mytilus*

Criteria for Keystone Species

A keystone species exerts top-down influence on lower trophic levels and prevents species at lower trophic levels from monopolizing critical resources, such as competition for space or key producer food sources.

This paper represented a water
ecological relationships betwee
that followed its publication, it
publications.



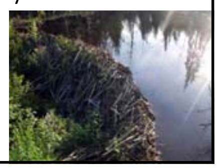
Other Keystone Species

There are a number of other well-described examples where keystone species act as determinate predators.

- Sea otters - regulate sea urchin populations, which in turn feed upon kelp and other macroalgae (Duggins 1980). Otters keep the sea urchin populations in check, allowing kelp forests to remain as a habitat for a variety of other species.
- Fire ants - function by suppressing the numbers of individuals and species of arthropods that could be harmful to agriculture.

Other Types of Keystone Species

- Hummingbirds - referred to as ***keystone mutualists***. Influence the persistence of several plant species through pollination.
- North American beaver (*Casor candensis*) – ***keystone modifer***, determine the prevalence and activities of many other species by dramatically altering the environment
- Saguaro cactus, palm and fig trees - ***keystone hosts*** because they provide habitat for a variety of other species.



Why the world is green?

When is predation likely to regulate prey populations and influence community structure?

Hairston, Smith and Slobodkin proposed elegant scenario that continues to influence ecological research → HSS Theory

HSS Theory

Assume terrestrial communities defined into 4 compartments

- 1' Producers
- Herbivores
- Carnivores
- Detritivores

Asked – "what can we say about the relative importance of predation and competition in communities

- Detritivores (Comp) – food limited since food source (dead plants and animals) accumulates at negligible rates.
- Plants (Comp) – compete for light, water and nutrients
- Herbivores (Pred) – appear to be surrounded by food, thus predation likely important
- Predators (Comp) – top trophic level so can't be predation, so limited by food

Removal Experiments

- Herbivores removed
→ little effects on plants
- Predators removed
→ Inc Herbivores → large effects on plants

End result

Competition for food important in regulating abundances of 1’ producers, top predators, and decomposers

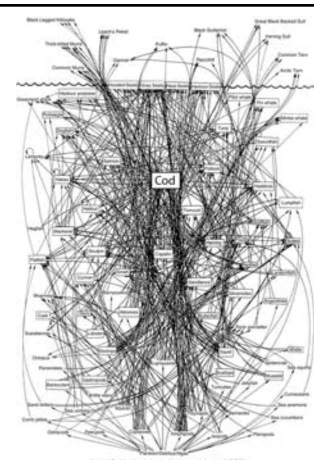
Predation important for herbivores

Menge and Sutherland

Used related approach to predict relative importance of 3 processes

Physical disturbance, predation, and competition

Assumption → web complexity decreases with increasing environmental stress



Menge and Sutherland
3 community predictions

1. High Stress Environment – Herb little effect, plants regulated by env stress (desert and arctic environments)
2. Moderate Stress – Herb ineffective at controlling plants, competition important, plants at high densities
3. Low Stress – Herb control plant numbers, plant comp rare, predation important

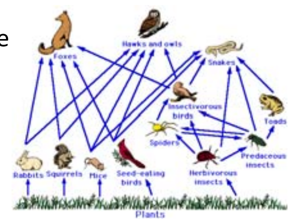
Remove herbivores
→ large effects on plants
Remove predators
→ Inc herbivores → large effect on plants

Menge and Sutherland

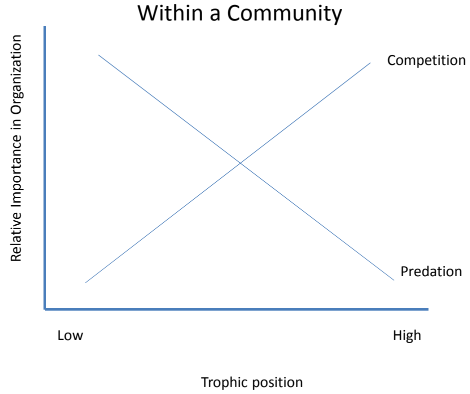
Species at base of food web preyed on by many different species that reside higher in web.

Species low in web likely regulated by predation

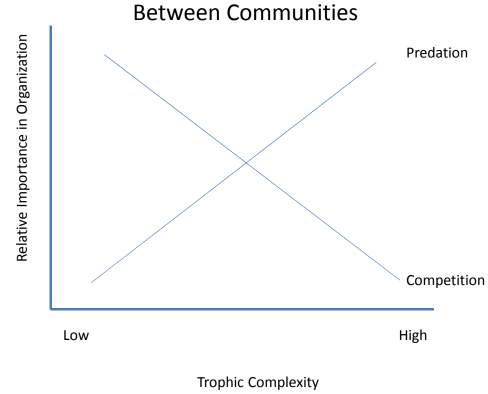
Species higher in web have few predators and thus limited by prey abundance



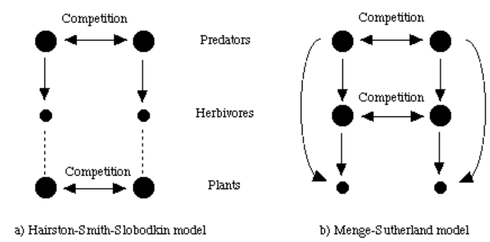
Within a Community



Between Communities



- Communities with low complexity predominantly structured by competition
- More complex communities should be structured by greater number of predator and prey interactions

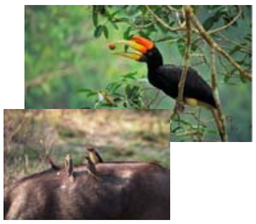


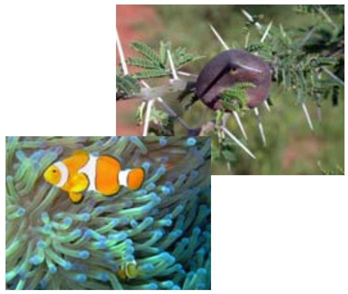
Sih et al reviewed literature for evidence

Looked at trophic level of manipulated predators

- If predator fed low in food chain – striking effects on communities
- Results most consistent with Menge and Sutherland

- Predation can influence communities in striking ways
- When predators feed selectively on dominant competitors, they can enhance community diversity

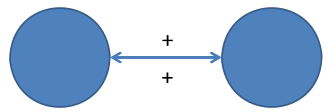




MUTUALISMS

Mutualisms

- Often given little attention
- Neglect importance of these interactions that occur within many communities
- Often inconspicuous but common



Examples

- Mycorrhizae fungi
- Lichens
- Ants and aphids
- Ants and acacia
- Gut flora
- Fruit dispersal
- Pollination

Obligate mutualisms – co-evolved to point at which neither member of a pair can persist without the other

Facultative mutualism – association with other species is not essential but leads to positive effects on fitness

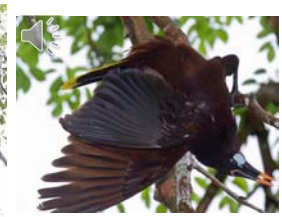
Oropendolas, and Cowbirds: the advantage of being parasitized

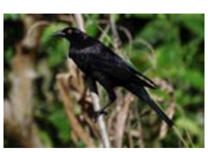
Montezuma's Oropendola

Chestnut-headed Oropendola

Crested Oropendola

Yellow-rumped Cacique





Smith discovered a complex interaction between Oropendolas and Cowbirds.

In some colonies the cowbirds skulked and are sneaky around nests, depositing an egg when females departed their nests.

The eggs they laid resembled the eggs of the oropendolas.

In other colonies, cowbird females are brazen and would occasionally “drive-off” female oropendolas. These cowbirds would lay several eggs at a time (up to 5) in a single nest.

The eggs of these cowbirds are not mimetic.

Effect of brood parasite depends on environment

- Discriminators – can detect and reject cowbird eggs
- Nondiscriminators – can not detect

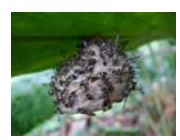
When laying in discriminator nests, cowbirds lay mimetic eggs, and remove oropendola eggs

When laying in nondiscriminator nests, cowbirds don’t remove eggs

- Cowbird young hatch early, fairly precocial
- Cowbirds will pick off eggs and larval bot flies from nest mates

Discriminators

- Build nests near wasp and bee hives
- Wasps aggressive toward bot flies



Non-Discriminators

- Don't build nests near wasp and bees

Discriminators

- Without cowbirds → 0.5 yg/nest
- With cowbirds → 0.25 yg/nest

Cost of having brood parasite

Non-Discriminators

- With cowbirds → 0.5 yg/nest
- Without cowbirds → 0.2 yg/nest

Cost of having insect parasites

Mutualism—mutually beneficial interaction between individuals of two species (+/+).

Commensalism—individuals of one species benefit, while individuals of the other species do not benefit and are not harmed (+/0).

Symbiosis—a relationship in which the two species live in close physiological contact with each other, such as corals and algae.

Symbioses can include parasitism (+/–), commensalism (+/0), and mutualism (+/+).

Mutualistic (+/+) associations

Most plants form **mycorrhizae**, symbiotic associations between plant roots and various types of fungi.

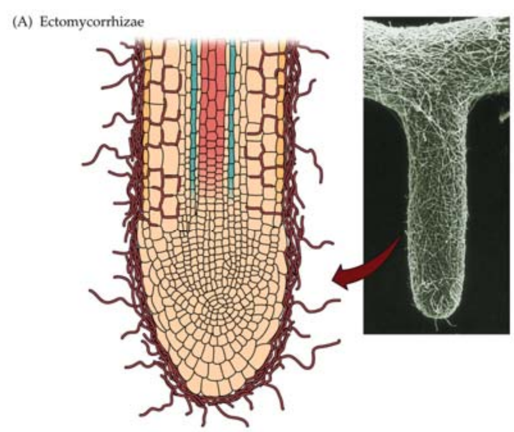
What do the fungi get?

What do the plants get?

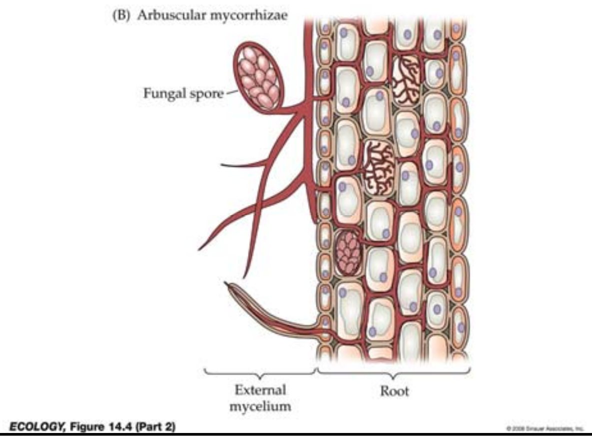
Two categories of mycorrhizae:

Ectomycorrhizae—the fungus grows between root cells and forms a mantle around the exterior of the root.

Arbuscular mycorrhizae—the fungus grows into the soil, extending some distance away from the root; and also penetrates into some of the plant root cells.



ECOLOGY, Figure 14.4 (Part 1)



Commensalism (+/0)

Examples: lichens that grow on trees, bacteria on your skin.

In kelp forests, many species depend on the kelp for habitat, and do no harm to the kelp.

Many mutualisms and commensalisms are facultative (not obligate) and show few signs of coevolution.

In deserts, the shade of adult plants creates cooler, moister conditions. Seeds of many plants can only germinate in this shade. The adult is called a **nurse plant**.

Mutualisms can be categorized by the type of benefits that result.

Often, the two partners may receive different types of benefits, and the mutualism can be classified two ways.

Trophic and habitat mutualisms

A mutualist may withdraw the reward that it usually provides.

In high-nutrient environments, plants can easily get nutrients, and may reduce the carbohydrate reward to mycorrhizal fungi.

The costs of supporting the fungus are greater than the benefits the fungus can provide.

Cheaters are individuals that increase offspring production by overexploiting their mutualistic partner.

If this happens, the interaction probably won’t persist.

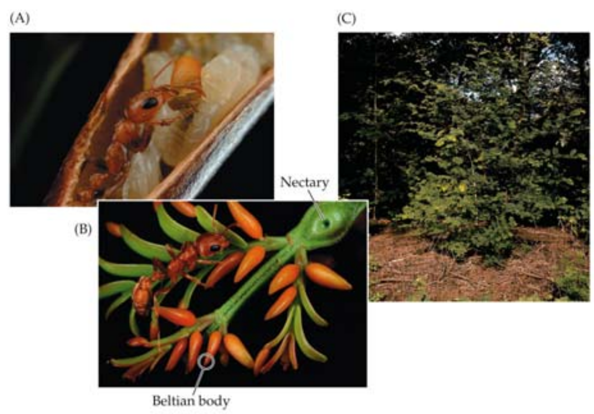
Several factors contribute to the persistence of mutualisms.

“Penalties” may be imposed on cheaters

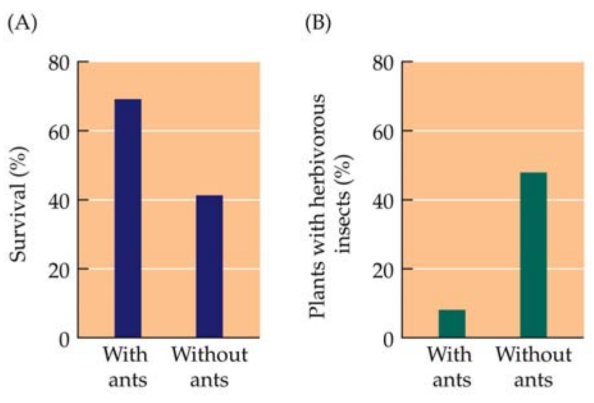
Positive interactions affect the distributions and abundances of organisms as well as the composition of ecological communities.

Mutualism can influence demographic factors.

This is demonstrated by ants (*Pseudomyrmex*) and acacia trees.



ECOLOGY, Figure 14.16

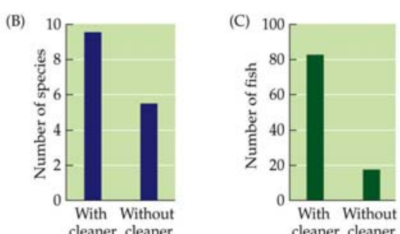


ECOLOGY, Figure 14.17

When one species provides another with favorable habitat, it influences the distribution of that species.

Examples: Corals and algal symbionts; the grass *Dichanthelium* and its fungal symbiont.

Studies of a cleaner fish on the Great Barrier Reef showed that individuals were visited by an average of 2,297 clients each day, from which the cleaner fish removed (and ate) an average of 1,218 parasites per day.



Leaf-cutter ants also introduce large amounts of organic matter into tropical forest soils.

Thus, they affect nutrient supply and cycling in the forest.

Ant refuse areas contain about 48 times the nutrients found in leaf litter.

Plants increase their production of fine roots in ant refuse areas.

Although leaf-cutter ants reduce net primary productivity (NPP) by harvesting leaves, some of the other activities (tillage, fertilization) may increase NPP.

The net effect of the ants on NPP is difficult to estimate.

Evolution of Mutualism

- Theory predicts mutualism will evolve where the benefits of mutualism exceed the costs.
  - *Keeler* developed models to represent relative costs and benefits of several types of mutualistic interactions.
    - Successful mutualists
      - Give and receive benefits.
    - Unsuccessful mutualists
      - Give, but do not receive benefit.

Evolution of Mutualism

- Non-mutualists
  - Neither give nor receive benefit.

- For a population to be mutualistic, fitness of successful mutualists must be greater than unsuccessful or non-mutualists.
  - If not, natural selection will eventually eliminate the interaction.

Evolution of Mutualism

Mutualism can arise from a host–parasite interaction.

This was observed in a strain of *Amoeba proteus* that was infected by a bacterium.

Initially, the bacteria caused the hosts to be smaller, grow slowly, and often killed the hosts.

Evolution of Mutualism

But parasites and hosts can co-evolve.

Five years later, the bacterium had evolved to be harmless to the amoeba; the amoeba had evolved to be dependent on the bacterium for metabolic functions.

Various tests showed that the two species could no longer exist alone (Jeon 1972).

Mutualisms are unique interactions, no single common thread. Some feeding, protection, very diverse interactions.

Predation interactions are all very similar