

Lecture 12: Predation

I. Introduction

A. Objectives

1. Summarize influences of predation on prey individuals
2. Summarize influences of predation on prey populations
3. Summarize influences of predation on communities and ecosystems

II. Influences of predation on prey individuals

- extension of discussion of feeding adaptations
- obvious lethal effects (no fitness produced thereafter)
- subtle non-lethal effects (lead to risk-averse behavior)
- fishes are not eaten just by other fishes (vert's and invert's)

A. Non-lethal effects: predation threat is an energy drain

- general theme: trade-offs between vigilance (survival → fitness) vs feeding (growth → fitness)

1. Shifts in habitat use -- exclude prey from most productive or optimal habitats
 - a. in streams, small minnows move to shallow habitat when bass are introduced into pools
 - more energetically costly positions (higher velocity) or less productive
 - b. many examples in streams, where prey avoid predators
 - distribution of algivores, both tropical (grazing catfish) and temperate (stoneroller), is predicted better by the presence of predators than the availability of food
 - c. in Toolik Lake, AK, young lake trout shifted to suboptimal inshore habitat to avoid predation
 - very low feeding rates
 - d. some prey fishes more likely to school in presence of a predator
 - can decrease feeding efficiency of individuals
2. Stress
 - a. predation threat can cause physiological responses (↑ alertness, metabolism)
 - b. threatened prey exhibit higher mobility, skittishness
 - c. guppies and rivulines in Trinidad streams produced fewer eggs when predatory fish were abundant
3. Emigration/Immigration rates
 - a. if system is open, rather than shifting habitat use, prey may emigrate to avoid predators
 - high predation risk can also inhibit immigration

III. Influences of predation on prey populations (remember... $N = R - M + I - E$)

- predation can directly affect M, I, E
- predation can indirectly affect R via effects on growth and fecundity

A. Direct mortality

1. Predation often plays large role in M
 - most M (>99%) in planktonic eggs, larvae believed to be via predation
2. Predation also affects R if targeted at young
 - a. many fishes eat young fishes, even individuals of the same species (cannibalism)
 - b. older fish eating younger fish can establish density-dependent population cycles
 - 2-yr cycles in pink salmon abundance in Pacific Northwest (3 year-classes)

B. Predation as a perennial limiting factor (ie, does it set K?)

- yes, under a narrow set of conditions
- predation can impose density-independent control OR density-dependent control on N

1. Density-independent predation
 - predators consume the same number of prey no matter how many prey there are
 - does not set K for prey but may affect prey density
 - a. depensatory predation
 - proportion of prey pop'n affected \uparrow as size of prey pop'n \downarrow
number of prey eaten may remain constant
 - predators eat prey to extinction
 - applies to highly preferred and/or naïve prey
 - may occur where predators and prey have not coevolved
eg, introduced peacock bass in Gatun Lake (Panama), Nile perch (Lake Victoria)
 2. Density-dependent predation
 - predation may (or may not) set K for prey
 - a. incidental predation
 - prey not a preferred food
 - when prey density is high, ease of capture overrides predator's preference
 - does not set K for prey
 - can set upper limit on prey density; depends on availability of other, preferred foods
 - b. compensatory predation
 - predators eat more prey when prey are abundant, fewer prey when prey are scarce
 - most fishes take advantage of abundant foods, rather than seek increasingly scarce foods
eg, search image may play role
 - inhibits predator-induced extinction; at low prey densities, predators choose alternative prey
 - can set K for prey IF prey are also near limits set by other factors

eg, prey fish density on coral reefs closely related to availability of refugia from predators;
removing predators \rightarrow greater density of prey fish (predation-competition interaction)
 3. Predator population responses to increased prey abundance
 - a. immigration
 - short-term response, requires open system (ocean, river)
eg, fish, birds, mammals converge on schools of marine prey fish – creates feeding frenzies
 - b. recruitment
 - long-term response, involves time lag
 - respond via enhanced growth, fecundity, and eventually recruitment
 - only option in closed system (lake)
 - time lag can induce oscillations in predator and prey abundances
ie, predators overshoot prey \rightarrow predator starvation \rightarrow low predator recruitment \rightarrow
prey increase \rightarrow cycle repeats
- C. Effects of predators on genetic composition (evolution in action)
1. Guppies in Trinidad streams
 - a. in areas of low predation risk, males exhibit many colorful spots
 - attractive to females, conspicuous to predators
 - spot number, size, brightness are heritable traits
 - b. experiments exposed fish to different levels of predation over several generations
 - spot number, size, brightness responded negatively to predation pressure (adaptive response)

IV. Influences of predation on fish communities

A. Sidebar introduction to community ecology

1. A biotic community = a group of interacting pop'ns of different species that occupying a given area
 - a. communities exhibit distinctive biological organization
 - b. understanding community organization is crucial to predicting responses to environmental changes
2. Community structure is determined by many biotic and abiotic factors, including predation, competition, productivity, disturbance, evolutionary history, and chance
 - more context after spring break

B. Predatory fish as keystone species

1. Distinguish between “dominant” species and “keystone” species
 - a. dominant species are very abundant
 - cannot be top predators
 - effects on community stem from many interactions with other community members
eg. anchovies, menhaden in oceans, introduced common carp in Midwestern rivers
 - b. keystone predators are not especially abundant, but interact very strongly with prey populations

C. Indirect effects of predation (effects on non-prey populations)

1. Release from competition
 - a. increased abundance of non-prey species via predation-induced reduction of competitor
 - in Toolik Lake, AK, predators restricted small lake trout to marginal habitats
 - allowed slimy sculpin free access to open areas, increasing sculpin growth rate and pop'n size
2. Shifts in species composition (presence/absence, proportional abundance)
 - a. experimental introduction of northern pike to previously pike-free lake in WI
 - dramatic shift in dominant species from redbelly dace to bluegill and creek chub
 - much of the shift attributed to emigration into creek, not to consumption
 - new dominants less susceptible to predation, so didn't emigrate
 - removal of pike caused shift back to original species composition
 - b. experimental introduction of brown trout into Bottom Cr., VA
 - experimental reaches fenced to preclude E
 - large flux in dominance of some prey species
esp. torrent sucker, stoneroller, bluehead chub

V. Influences of predation on ecosystems

- effects on multiple trophic levels, non-fishes

A. Trophic cascades

1. Top-down (top-predator-induced) effects on food webs
 - a. community composition driven mostly by species interactions near top of food web
 - effects trickle down to lower levels
2. Bottom-up (micro-organism-induced) effects on food webs
 - a. community composition driven mostly by availability of abiotic nutrients
 - productivity fueled at low levels of food web, which allows upper levels to flourish
3. Trophic cascades occur only when control is largely top-down

4. Trophic cascades seem most likely under
 - a. low species diversity
 - fewer predator and prey types to buffer predator/prey oscillations
 - b. simple food webs with specialized consumers
 - fewer options to re-route energy/production
 - c. small ecosystems
 - large proportion of populations experience same fate; no options to buffer effects
 - d. environmental severity or stochasticity is not an overriding factor
 - enough time for strong biotic interactions to develop between waves of severe conditions

B. Evidence of trophic cascades

1. most good examples are from temperate lakes and midwestern US streams (meet criteria above)
 - a. lake eg -- removal of piscivorous bass → increase in zooplanktivorous bluegill → decrease in zooplankton → increase in phytoplankton
 - b. stream eg -- addition of piscivorous bass to pools → decrease in algivorous stonerollers → increase in filamentous algae
 - indirect effects: other prey species use algae for cover to avoid predation by bass
 - c. ocean eg, -- long-term data on commercial fish catches on the continental shelf near Nova Scotia
 - overfishing of benthic piscivores (cod, haddock, hake, pollock → cascading trophic fx in marine food web

C. Predation as a nutrient pump from the ocean to Pacific Northwest forests

1. Unusual, counter-intuitive example of marine nutrients flowing uphill via migratory fishes
 - a. Influx of nutrients as salmon biomass → predation by mammals, birds → transport, deposition of nutrients off-stream → increased production of riparian forests → increased future food availability for young salmon (positive feedback)