## Population Regulation

- Density dependent effects:
- Influence a population in proportion to its size
- The larger the population becomes (in relation to K), the greater the degree of interaction among individual members
- Density dependent mechanisms act largely through shortages and competition for resources

## Population Regulation

- Intraspecific competition (competition among individuals of the same species for environmental resources)
- When does competition occur?
- Needed resource in short supply relative to the number of individuals seeking it
- As long as resources are abundant to allow each individual a sufficient amount for survival and reproduction, there is no need for competition

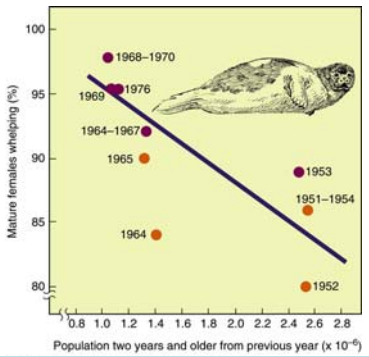
## Population Regulation

- Intraspecific competition affects the parameters that directly influence the dynamics of populations in a density-dependent manner
  - births
  - deaths
  - individual growth (fecundity and survival)
- Thus it affects individual success and overall fitness
- Two types:
  - Scramble → all individuals have equal access to resources (usually results in each individual obtaining insufficient amounts of the limiting resource)
  - Contest → successful individuals take over the resource and the unsuccessful are denied access to it

## Population Regulation

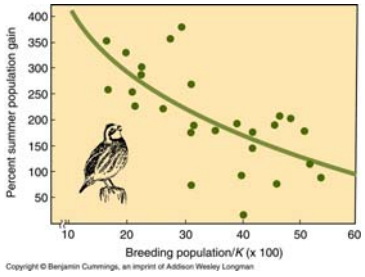
- Effects on growth and fecundity
- What happens if resources are insufficient to meet the needs of individuals? (food in particular)
  - Common responses to lower levels of food:
    - Reduced growth (poikilothermic vertebrates)
    - Reaching sexual maturity at older age
    - Some examples

Density dependent effects on fertility for the harp seal (*Phoca groenlandica*)




As the population of seals increases, the percentage of females giving birth to young decreases markedly. Why? Seals reaching sexual maturity @ older stage

Population growth rate of northern bobwhite quail on the SIUC Research area (1954-1979) as a function of breeding population size expressed as % of K. Change in breeding population and overall carrying capacity reflect changes in land use for the area

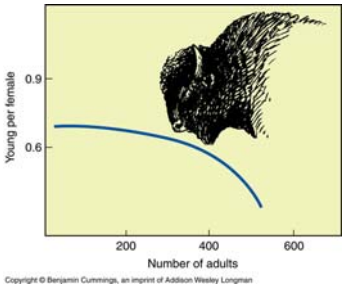





As population increases, the number of offspring/additions (births) decreased as necessary resources were being depleted by the larger population

Roseberry and Klimstra (1984)

Density dependent effects on the population of the American bison (*Bos bison*) expressed as decline in birth rate (young per female) as population increases





# Population Regulation

- Effects on growth and fecundity
- Why does it happen?
- Reproduction and growth → expensive and resources (energy) need to be allocated appropriately
- Do we spend the resource ($$) in one need or another?
- Can I obtain enough of the resource to meet individual needs?
- Is the competitive pressure (and its effects) the same for plants and animals

# Population Regulation

- Effects on plant biomass
  - Self thinning: progressive decline in density of plants associated with the increasing size of individuals in a population of growing individuals
  - In other words, as some individuals increase in size (dominate), other (smaller) individuals may become out competed
  - Remember what we've learned from Beer's law as it relates light availability and canopy cover

# Population Regulation

- Mechanisms of population regulation
- By what means does intraspecific competition regulate populations?
- Stress
- Dispersal
- Social interactions

We will focus on these two

# Population Regulation

- Mechanisms of population regulation
- Dispersal (some individuals run away from a bad situation)
  - Requires a source and sink (empty or unfilled habitat)
- Individuals who disperse are not necessarily a random selection of the population, rather a select group:
  - Good condition
  - Belong to any sex or age group
  - Good chance of survival
  - High probability of settling in a new area
- Dispersal carries with it certain costs and benefits

# Population Regulation

- Stay at home (philopatry)
- Costs:
  - Inbreeding depression
  - Reduced fitness (resource shortage)
  - Reduced indirect fitness (competition)
- Benefits:
  - Optimal inbreeding (locally adapted genes)
  - Reduced physical risk
  - Familiarity with local terrain (security)
  - Familiar social environment
  - Adaptive local transitions
  - Maintain kin association

## Population Regulation

- Disperse
- Costs:
  - Outbreeding depression: disrupt co-adapted genes
  - Hybrid young not well adapted
  - Alleles less suited to the environment
  - Greater risk in movement: predators, local diseases, unfamiliarity with terrain
- Benefits:
  - Outbreeding enhancement
  - Avoid overcrowding
  - Avoid competing with kin
  - Improve fecundity

## Population Regulation

- Two types of dispersal
  - Presaturation → takes place during the increase phase of population growth before population reaches carrying capacity (resources not yet depleted)
  - Saturation → occurs when carrying capacity has been exceeded (mostly juveniles and subdominants)
    - Stay and not breed or leave the area and take your chances

## Population Regulation

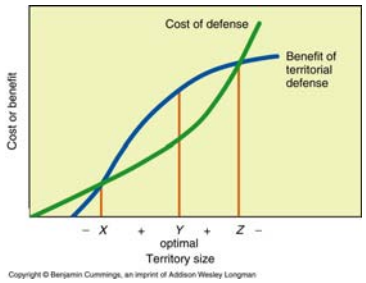
- Social Interactions
  - Usually expressed as the degree of tolerance between individuals of the same species (social behavior)
  - Limits the number of animals that can live in a particular habitat, have access to food supply, and engage in reproductive activities
  - Two main forms:
    - Dominance
    - Territoriality

## Population Regulation

- Social Interactions
  - Social Dominance →behavioral, hierarchical order that gives high-ranking individuals priority of access to essential requirements
    - Examples: pecking order, alpha vs. beta
  - Territoriality → social organization involving the division and exclusive occupation of space by a social unit or individual with a defending boundary
    - General purpose territory
    - Breeding nesting territory

Territorial ownership has costs and benefits (need to be balanced by owner):

- Cost of territorial defense increases as size of territory increases
- Minimum territory size necessary for individuals to meet their needs
- Can function as population regulator by creating a surplus population of sexually mature individuals prevented from breeding by territory holders

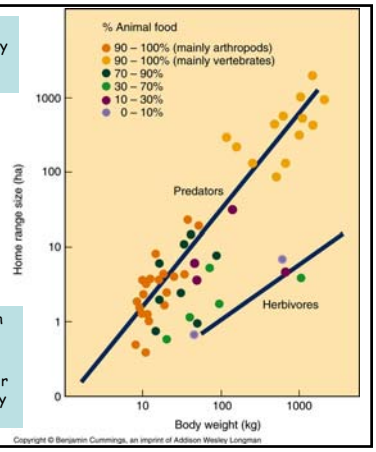




## Population Regulation

- Home range
  - Non-territorial animals occupy home ranges (seasonally or throughout the year)
  - May overlap with other animals home range
    - Social hierarchy becomes a factor
  - Advantages:
    - Familiarity with local area
    - Food, cover, and shelter from enemies
    - Minimum energy expenditure
  - Size specific (larger animals have larger home ranges than smaller ones)

Relationship between the size of home range and body weight of North American mammals




Note differences based on diets:

Large herbivores required smaller home range as their source of food (plants) may be more readily available



# Population Regulation

- Density Independent influences
  - Effective regardless of population size (density)
  - Examples: weather extremes, unpredictable changes in the environment or habitat
  - They can affect but not regulate populations
  - Can reduce local populations (even to the point of extinction), but their effects do not vary with density

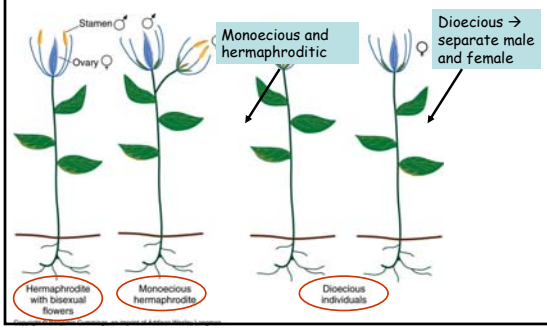
# Life history patterns

- How can different life history phenomena maximize individual fitness?
  - Mate choice
  - Sexual selection (strategies)
  - Parental investment in reproduction
- Can we approach this in a cost/benefit perspective?
  - Energetic and nutritional expenditures
  - Mating, producing, and rearing offspring
- Evolutionary ecology

# Patterns of reproduction

- If the key to fitness is to produce viable offspring then reproduction is crucial to an organisms success
- Two types: Sexual vs. Asexual
  - Asexual → only one parent (no fusion of gametes, no fertilization) (i.e., budding, mitosis, etc.)
  - Sexual → production of gametes by males and females as separate individuals (or as hermaphrodites)
- Either way, sexual reproduction is expensive

# Sexual reproduction




# Mating systems

- A mating system describes some aspects of reproductive strategies:
  - Number of mates acquired
  - Manner in which they are acquired
  - The nature of the bond
  - Patterns of parental care provided
- Two major types:
  - Monogamy → formation of one pair bond between male and female
  - Polygamy → acquiring two or more mates, non of which is mated to other individuals

# Mating systems

- Monogamy
  - Occurs mostly among species in which cooperation by parents is needed for the successful rearing of young (i.e., birds; seasonally)
  - Does not mean they are always "faithful"
  - Extra-pair copulations → "cheating" while maintaining a primary relationship. Why?
  - Fitness
  - Depends on parental care strategy

# Mating systems

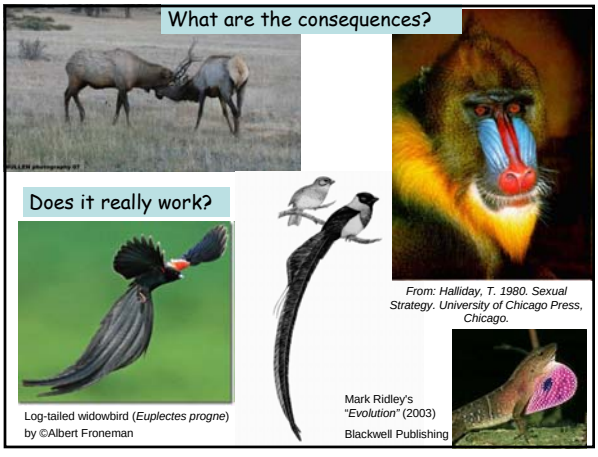
- Polygamy
  - Can involve one male and several females (polygyny) or one female and several males (polyandry); a pair bond exists between the individual and the each mate
  - Promiscuity → polygamy without the formation of pair bonds
  - Why?
  - Fitness

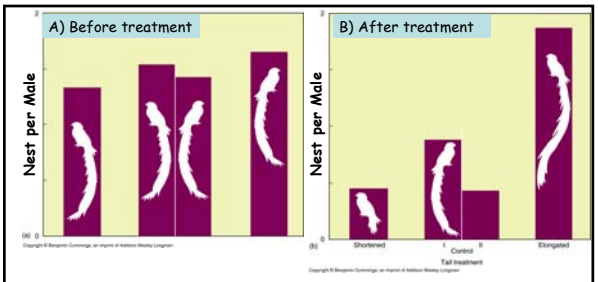
# Sexual selection

- Choosing a proper mate (or mates) is essential to an organisms fitness
- Usually falls more on the female. Why?
  - Males not selective → "sperm is cheap"
  - Females, however, very selective … thus males must prove their fitness or go mateless
  - Leads to intense rivalry among males for female attention (intrasexual competition)

# Sexual selection

- How does a female select the fittest male?
- Processes of selection:
  - Intrasexual selection → male vs. male competition for the opportunity to mate with a female
  - What about female choice? What does the female have to say about it?
  - Intersexual selection → female choice of a mate
    - Resource-based selection (access to food, territory, etc.)
    - Gene-based selection (access to genes → improve fitness)
      - Lek behavior → "mating arenas" (hotspot or hotshot)




Anderson (1982). Mating success in male long-tailed widow birds subjected to different tail treatments

A) Before treatment

B) After treatment

## Reproductive effort

- The nature and amount of allocations to reproduction over a period of time
  - If reproduction is expensive, yet necessary to attain maximum fitness, what can be done?
  - Organisms need to make tradeoffs between growth, maintenance, protection, and reproduction
  - Examples:
    - Parental care
    - Parental investment

## Reproductive effort

- Parental care
  - Caring for the young is a major expenditure
  - Increase offspring fitness by providing:
    - Food
    - Shelter
    - Protection from predators
    - Brooding
    - Grooming

  - Influenced by maturity of young at birth
    - Precocial → young able to cope shortly after birth
    - Altricial → animals that are born helpless

## Reproductive effort

- Parental investment
- Costs of reproduction are high in terms of energy expenditure and survival (i.e., physical drains, time & energy consuming)
- How to allocate those resources?
- Semelparous → one major reproductive effort in a lifetime
- Iteroparous → repeat reproduction throughout their lifetime (produce fewer young)

## Reproductive effort

- Parental energy budgets
- How organisms allocate energy to growth and reproduction is central to their reproductive strategy
- Examples:
  - more energy for reproduction = less energy for growth
  - Adjustments in clutch size (many small young or few large ones)
  - Brood reduction (# of young that are cared for or survive)

## Life history strategies

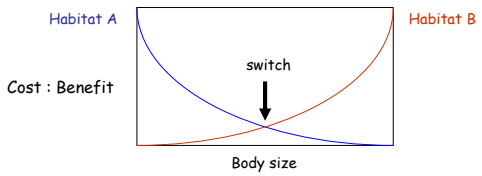
- R-selection and K-selection (R. MacArthur & E. O. Wilson - 1967)
  - Some species are small, have > reproductive rates, and live short lives
  - Other species are large, have < reproductive rates, and live long lives
- r-selected
  - Maximize b
  - Small adults w/ many offspring
  - Short lifespan
  - Rapid population growth
  - Colonizers
- K-selected
  - Minimize d
  - Large adults w/ few offspring
  - Long lifespan
  - Slow population growth
  - Established population

## Habitat selection

- Regardless of strategy, an organisms overall reproductive success is going to be influenced by habitat quality
- Thus habitat selection will be an important part of an organism's life history pattern
- How do organisms cue in on habitat quality?
  - Resources? Food? Security? Availability of mates?
- How can we determine if a habitat is good or bad?
- How can it affect the distribution of organisms?

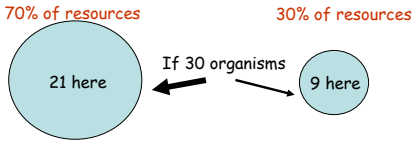
## Habitat selection

- Population distribution → habitat patch is critical!!!
- For example:
  - Reproductive area likely different than other areas critical for life
  - Think about migratory patterns (March of the Penguin)
- Different life stages have different habitat needs




## Habitat selection

- Population distribution
  - Free distribution would be ideal, but…
    - Distribution will be proportional to the distribution of resources (recall spatial patterns of distribution)




## Summary

- Individuals and populations have different characteristics that lead to unique approaches (strategies)
- Demographic characters → important for forecasting population size and structure
- Individual adaptations (both through natural and sexual selection) lead to important population level strategies