Intraspecific population regulation

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Intraspecific population regulation

- Logistic Equation
- Growth and development
- Mortality rate
- Reproduction
- Other changes

Environment limit Population Growth

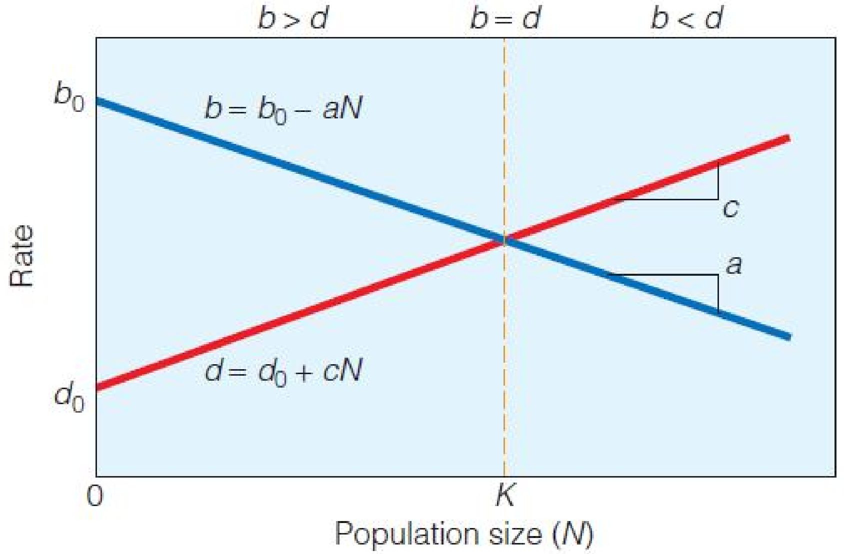


Figure 11.1 Rates of birth (b) and death (d), represented as a linear function of population size N. The values b_0 and d_0 represent the ideal birth and death rates (respectively) under conditions where the population size is near zero and resources are not limiting. The values a and c represent the slopes of the lines describing changes in birth and death rates as a function of N (respectively). The population density where $b = d$ and population growth is zero is defined as K, the carrying capacity. For values of N above K, b is less than d and the population growth rate is negative. For values of N below K, b is greater than d, and the population growth rate is positive.

- Exponential model
  - Unlimited resources
  - Constant environment

$$\frac{dN}{dt} = (b - d)N$$

- Logistic model: **No population continues to grow indefinitely**

$$K = \frac{(b_0 - d_0)}{(a + c)}$$

The constant K is the carrying capacity—the maximum sustainable population size for the prevailing environment (see

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

This is the equation for the logistic model of population growth.

Environment limit Population Growth

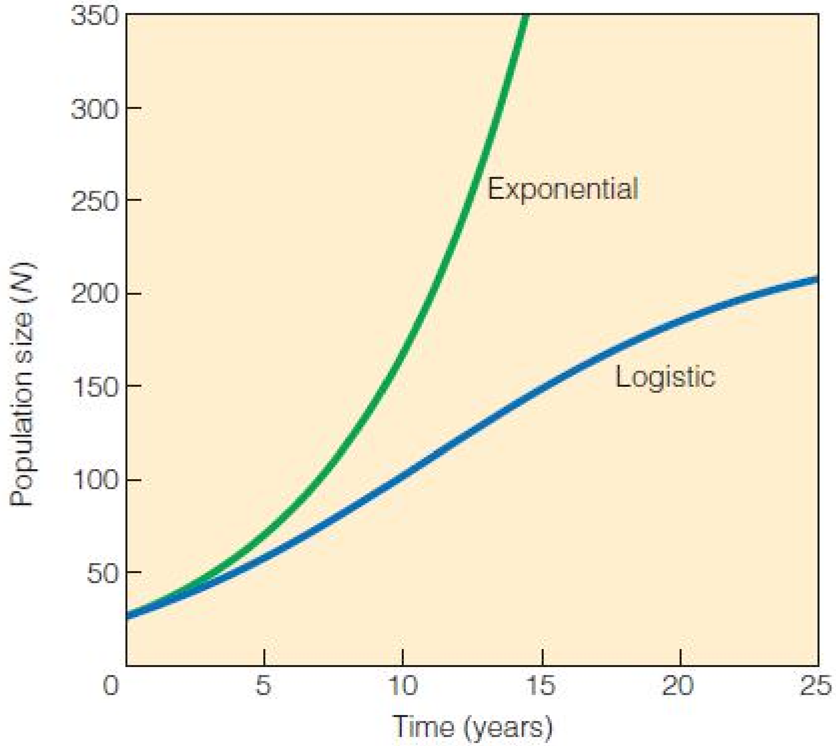


Figure 11.3 Predictions of the exponential and logistic population growth models for the gray squirrel population from Tables 9.1 and 9.6; $r = 0.18$, $K = 200$, and $N(0) = 30$.

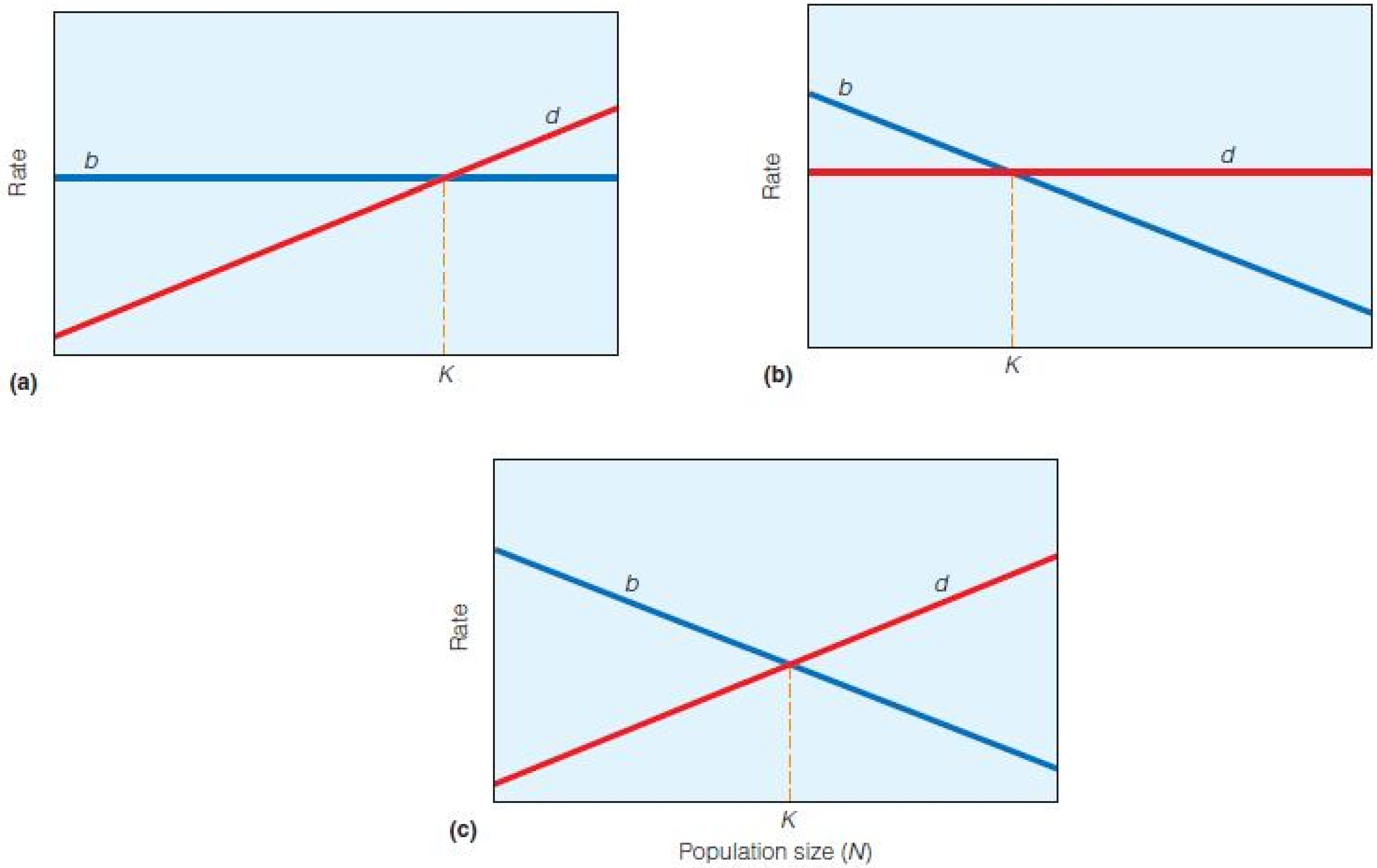


Figure 11.4 Regulation of population size in three situations. **(a)** Birthrate (*b*) is independent of population density, as indicated by the horizontal line. Only the death rate (*d*) increases with population size. At *K*, equilibrium is maintained by increasing mortality. **(b)** The situation is reversed. Mortality is independent, but birthrate declines with population size. At *K*, a decreasing birthrate maintains equilibrium. **(c)** Full density-dependent regulation. Both birthrate and mortality are density dependent. Fluctuations in either one hold the population at or near *K*.

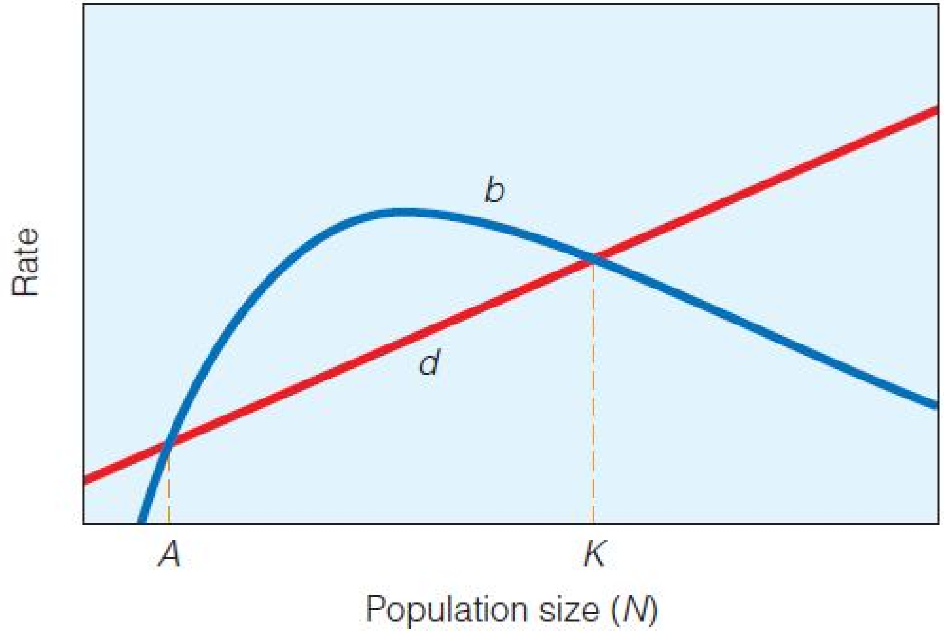


Figure 11.5 The Allee effect provides an example of how density dependence can operate in small populations. In this example the per capita birth rate (b) declines at low population size (or density) because of the increased difficulty of finding a mate (see example in Figure 9.14). In theory, a low-density equilibrium would be sustained at population density A, where the birth rate equals the death rate. However, given the susceptibility of small populations to demographic and environmental stochasticity, the population could be driven below the low density equilibrium, and thus continue to decline into extinction.

What is Competition?

- **Competition** occurs when individuals use a common resource that is in short supply relative to the number seeking it
- Competition among individuals of the same species is referred to as **intraspecific competition**
- Two responses
  - **Scramble competition** occurs when growth and reproduction are depressed equally across individuals in a population as the intensity of competition increases. (e.g. during larval stage in some insects)
  - **Contest competition** takes place when some individuals claim enough resources while denying others a share.
- Indirect interaction during competition referred as **Exploitation**
- Direct interaction referred as **Interference**

Growth and Development

- Inverse relationship between population density and growth

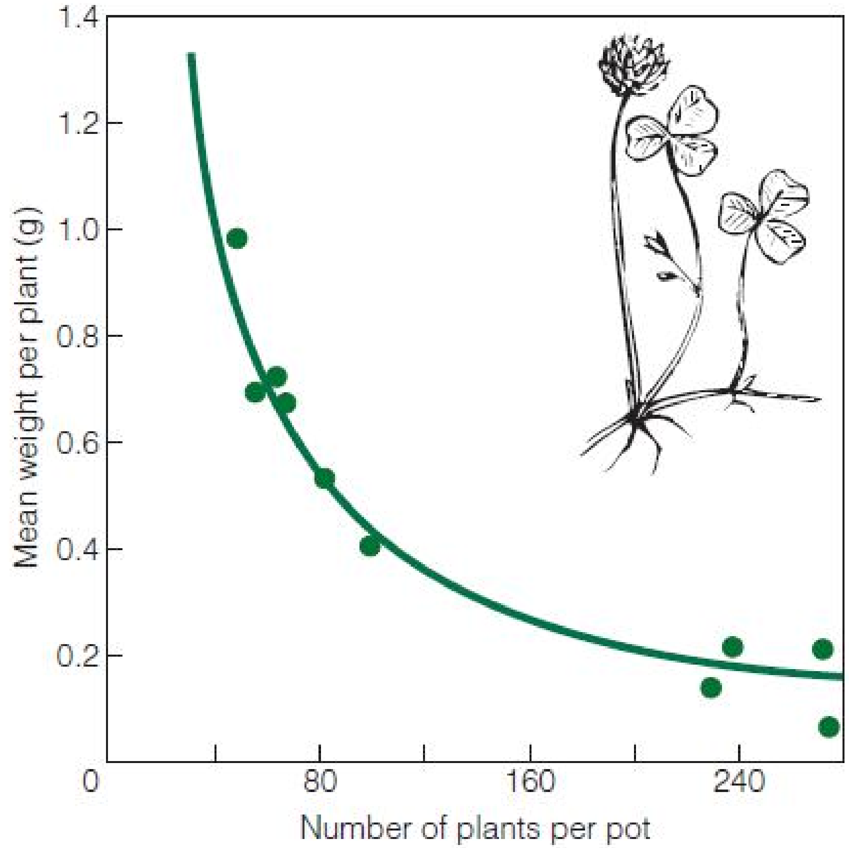


Figure 11.6 Effect of population density on the growth of individuals. The growth rate and subsequent weight of white clover (*Trifolium repens*) plants declines markedly with increasing density of individuals planted in the pot.

(Adapted from Chatworthy 1960.)

Growth and Development

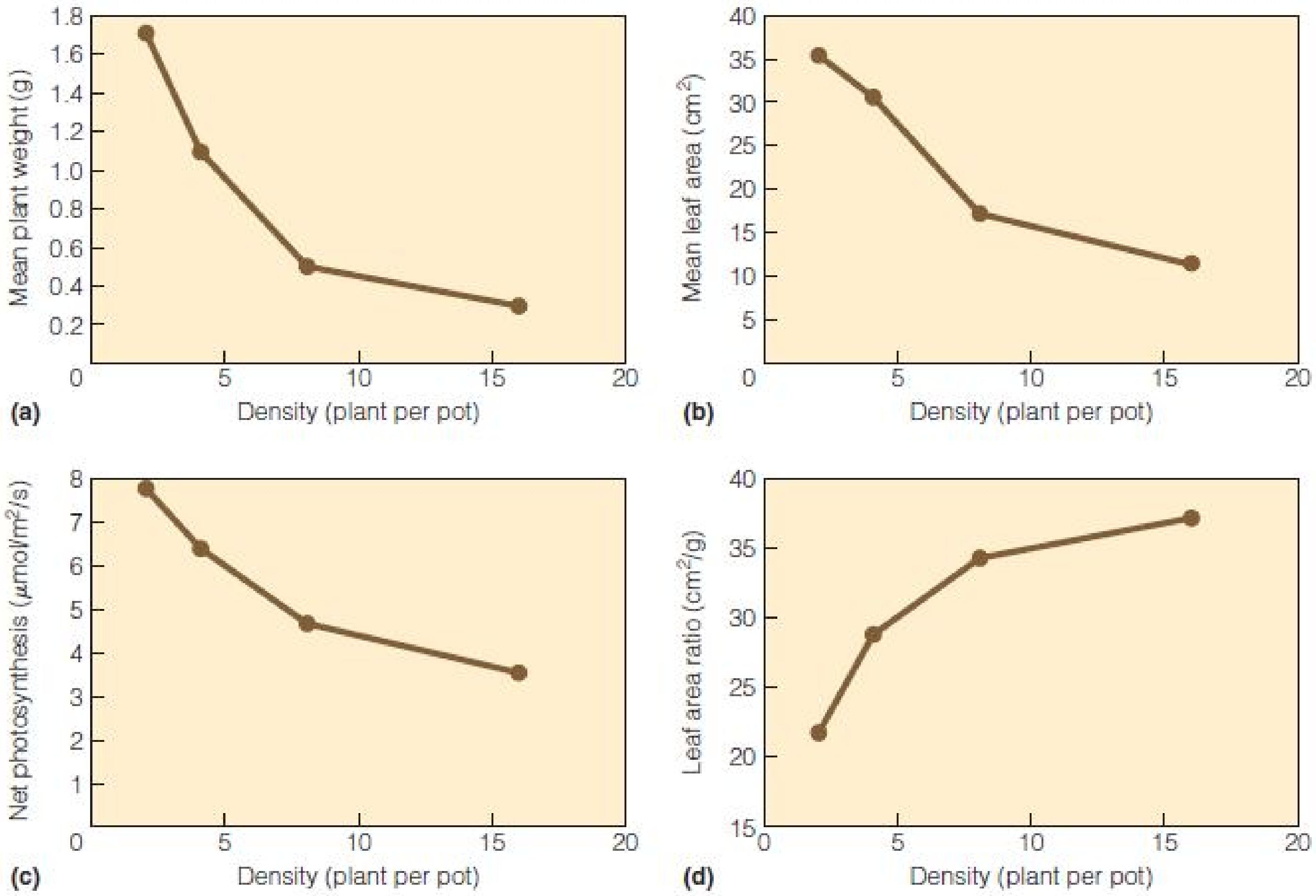
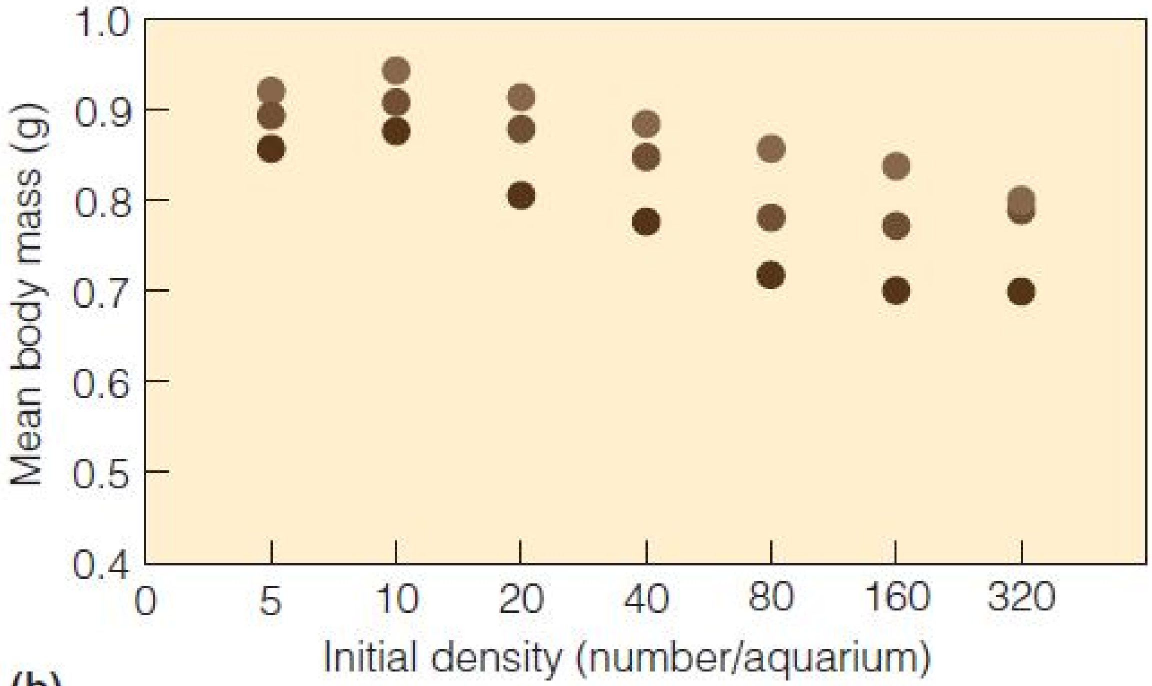


Figure 11.7 Effects of intraspecific competition on growth and photosynthesis of *Atriplex prostrata.* Mean values of **(a)** plant dry weight (accumulated biomass), **(b)** leaf area, and **(c)** net photosynthetic rate plotted as a function of varying densities of individuals per pot in the experiments. Besides the general pattern of reduced photosynthesis and growth experienced under increasing competition, individual plants exhibit a shift in patterns of carbon allocation, as illustrated by the increase in leaf area ratio (leaf area cm^2:plant weight g) with increasing density of plants per pot **(d)**. The increase in leaf area ratio is characteristic of reduced light availability during plant development.

(Data from Wang et al. 2005.)

Growth and Development



(b)

Figure 11.8 Effect of population density on the growth and development of individuals. **(a)** The growth rate of the tadpole *Rana tigrina* declines swiftly as density increases from 5 to 160 individuals confined in the same space. **(b)** As a result, the mean body mass at metamorphosis declines as a function of the population density.

(Adapted from Dash and Hota 1980.)

Growth and Development

- Competition induced phenotypic plasticity

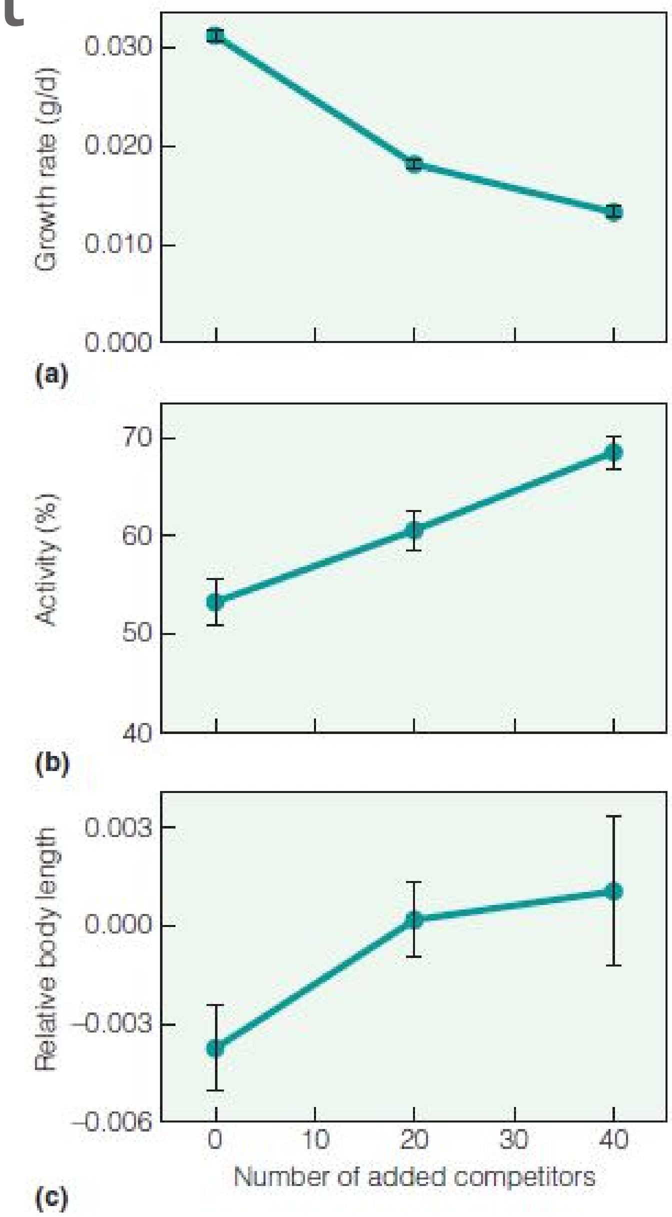


Figure 11.9 Mean **(a)** growth rate, **(b)** activity, and **(c)** relative body length (±SE) of larval wood frogs as a function of density of intraspecific competitors. Activity was measured by determining the proportion (%) of observed individuals in motion during the observation period. The measure of relative body length is the residual of the regression of body length as a function of body mass. This approach removes differences in body length among individuals due purely to differences in overall size (body mass). Mean values (and estimates of variance) for the residuals were then calculated for each treatment, as presented in graph (c).

(Adapted from Relyea 2002.)

Intraspecific Competition influence mortality rates

- A common response to high population density is reduced survival. **Mortality** functions to increase resource availability for the remaining individuals, allowing for increased growth.
- Progressive decline in density and increase in biomass (growth) of remaining individuals caused by the combined effects of density-dependent mortality and growth within a population is known as **self-thinning**

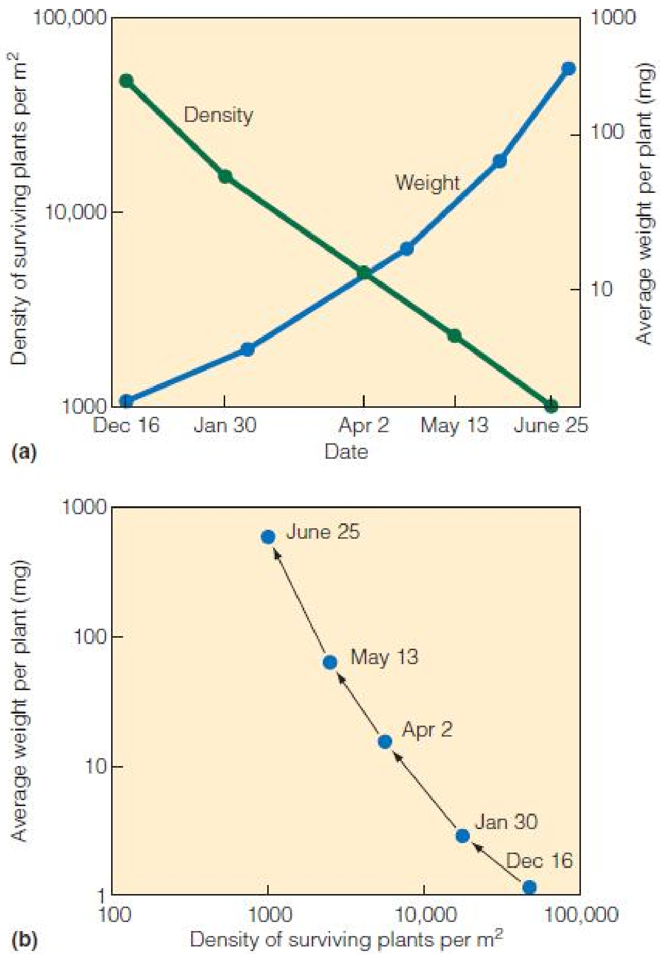


Figure 11.10 (a) Changes in the number of surviving individuals and average plant size (weight in milligrams) through time for an experimental population of horseweed (*Erigeron canadensis*). (b) Data from (a) replotted to show the relationship between population density and average plant weight. Competition results in mortality, which in turn increases the per capita availability of resources, resulting in increased growth for the survivors.

(Adapted from Yoda 1963.)

Intraspecific Competition Can Reduce Reproduction

- High population density and competition can also function to delay reproduction in animals and reduce fecundity in both plants and animals.
  - Reduce fecundity
  - Reduce growth rate – delay reproductive age
  - Reduce clutch size

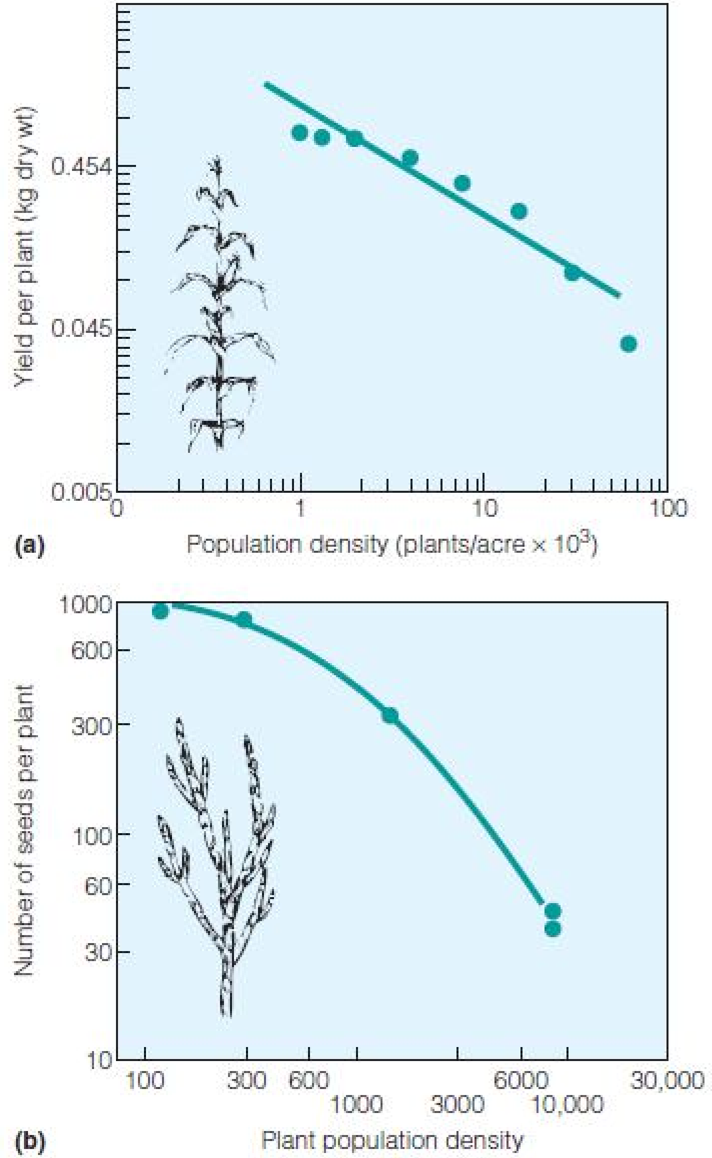


Figure 11.16 Two examples of density-dependent effects on fecundity in plants. (a) Grain (seed) production of individual corn plants declines with increasing density of plants per acre. (b) Number of seeds produced per plant declines with increasing population density in the marsh shrub *Salicornia europaea.*

(a) (Adapted from Fery and Janick 1971.) (b) (Adapted from Watkinson and Davy 1985.)

Other changes due to Intraspecific competition

- **Density and Stress:** In animals, the stress of crowding may cause delayed reproduction, abnormal behavior, and reduced ability to resist disease and parasitic infections; in plants, crowding results in reduced growth and production of seeds.
- **Density and Dispersal:** Dispersal is a constant phenomenon in populations. When dispersal occurs in response to the overexploitation of resources, or crowding, it is not a mechanism of population regulation. It can, however, regulate populations if the rate of dispersal increases in response to population growth. Dispersal reduces the risk of inbreeding.

Other changes

- **Social Behavior:** Intraspecific competition may be expressed through social behavior. The degree of tolerance can limit the number of animals in an area and access of some animals to essential resources. A social hierarchy is based on dominance. Dominant individuals secure most of the resources. Shortages are borne by subdominant individuals. Such social dominance may function as a mechanism of population regulation.
- **Territoriality:** Social interactions influence the distribution and movement of animals. The area an animal normally covers in its life cycle is its home range. The size of a home range is influenced by body size. If the animal or a group of animals defends a part or all of its home range as its exclusive area, it exhibits territoriality. The defended area is its territory. Territoriality is a form of contest competition in which part of the population is excluded from reproduction. These non reproducing individuals act as a floating reserve of potential breeders, available to replace losses of territory holders. In such a manner, territoriality can act as a population-regulating mechanism.

Other changes due to Intraspecific competition

In general, carnivores require a larger home range than herbivores and omnivores of the same size. Males and adults have larger home ranges than do females and juveniles.

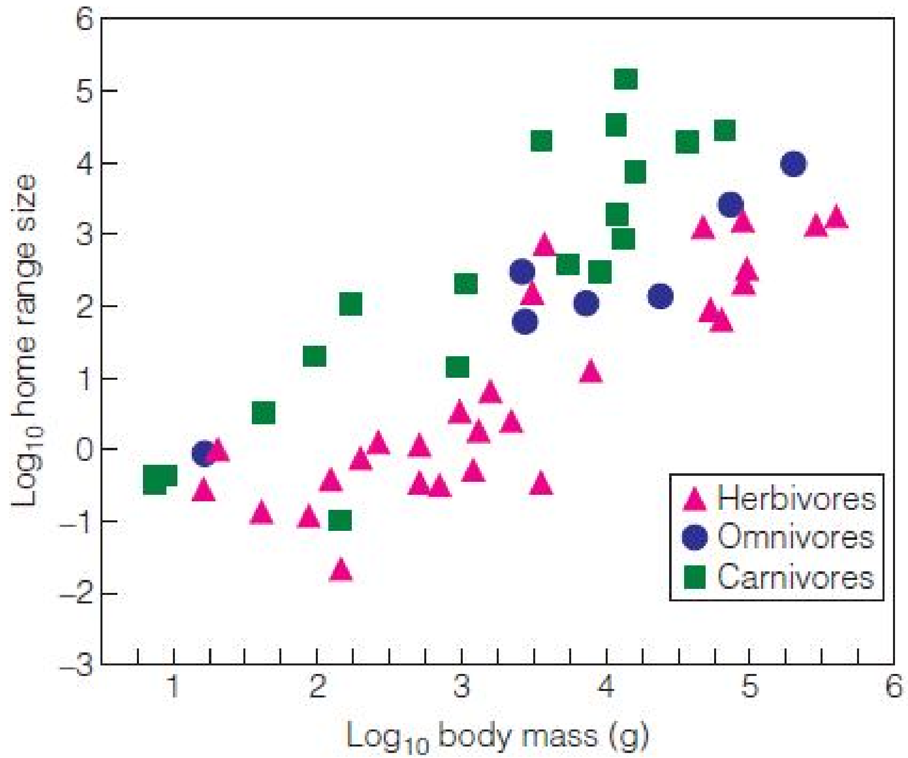


Figure 11.17 Relationship between the size of home range and body weight of North American mammals. For a given body mass, the home range of carnivores is larger than that of herbivores because the home range of a carnivore must be large enough to support a population of the prey (other animals) that it feeds upon.
(Adapted from Harastad and Bunnell 1979.)

Density-Independent Factors Can Influence Population Growth

- Temperature
- Precipitation
- Natural disasters
  (fire, flood, drought)

- They can reduce populations to point of local extinction. Their effects, however, do not vary with population density. Regulation implies feedback.