Formulas

discrete time growth:

- $N_T = N_0 \lambda^T$
- $\lambda = f + p$
- $\mathcal{R} = f/(1-p)$

continuous time growth:

- $N(t) = N(0)\exp(rt)$
- $r = b - d$
- $\mathcal{R} = b/d$

structured growth:

- $\ell_x = p_1 \times p_2 \times \dots p_{x-1}$
- $\sum \ell_x f_x \lambda^{-x} = 1$
- $\mathrm{SAD}(x) \propto \ell_x \lambda^{-x}$

1. Which of these traits would be characteristic of an r-strategist?

A. Large final size
B. Good dispersal
C. Production of a small number of high-quality offspring
D. Good competitive ability
E. Iteroparity

2. The value f_x in a life table incorporates: survival of the x year old individual from __________, survival of new individuals from the reproductive period to the census time, and __________ the number of new individuals produced by an individual during the reproductive period.

A. the reproductive period to the census time; not
B. the reproductive period to the census time; also
C. the census time to the reproductive period; not
D. the census time to the reproductive period; also

3. Which of the following is *not* usually an advantage of dispersal:

A. More likely to find a suitable habitat
B. Less likely to compete with siblings
C. Distributes risk (bet hedging)
D. Genetic mixing

4. A correct mathematical explanation for bet-hedging strategies is that: organisms average over environments ________ generations to achieve a higher mean; the ________ mean.

A. within; arithmetic
B. within; geometric
C. between; arithmetic
D. between; geometric

5. If every individual of an annual species has 100 offspring, which are dispersed such that within any year half of them land in good spots (5% survival) and half of which land in bad spots (1% survival), which of the following is closest to its long-term average growth rate?

A. 0.5
B. 1
C. 2.2
D. 3
E. 6

6. A pile of radioactive material is decaying *continuously* at an instantaneous rate of 1% per minute. After two minutes, what proportion is left?

A. A little more than 98%
B. Exactly 98%
C. A little less than 98%
D. About 30%
E. None

7. A population meets the assumptions of the balance argument for sexual allocation. If the population has more females than males at birth, this means that, on a ________ basis, there is ________ investment of resources in in producing females than in producing males

A. population; higher
B. population; lower
C. Per-offspring; higher
D. Per-offspring; lower

8. Which of the following is *not* an example of a tradeoff?

A. Birds with heavier beaks are more efficient at cracking seeds and better at defending territory
B. Bushes which survive better in dry conditions grow more slowly in wet conditions
C. Trees which grow fastest in full sunlight have higher mortality in the shade
D. Rabbits which need less food to survive produce fewer offspring when food is plentiful

9. Which of the following would you expect to lead to a population producing more females than males at birth?

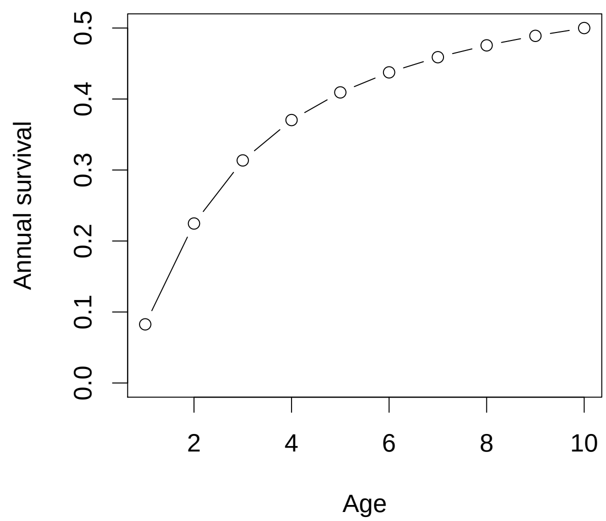
A. Increased cost of producing females
B. Higher population density
C. Lower population density
D. Greater variation in male reproductive success
E. Restricted dispersal leading to within-family mating

10. If we are thinking about a simple, continuous-time model, then for a population to be regulated:

A. The average reproductive number $\mathcal{R}$ must be low at high density and higher at either low or intermediate density
B. The birth rate b must be low at high density and higher at either low or intermediate density
C. The death rate d must be high at high density and lower at either low or intermediate density
D. All of the above

11. Polio has a finite-time growth rate λ of about 11, and a generation time of about 10 days. If we start with one case, about how many cases do we expect to see (provided there is no density-dependence) 20 days later?

A. 2.2
B. exp(2.2)
C. 22
D. 121
E. 220

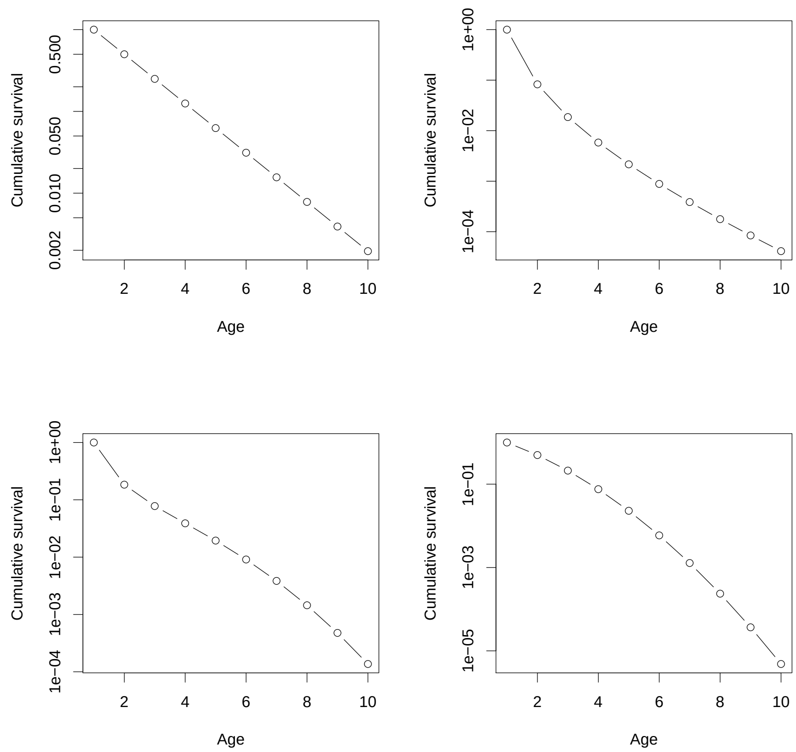


Use the picture above for the following 2 questions.

12. What does this picture of survivorship in an idealized age-structured population indicate about *mortality* in this population?

- **A.** Mortality is constant
- **B.** Mortality is elevated in older individuals
- **C.** Mortality is elevated in younger individuals
- **D.** Mortality is elevated in both older and younger individuals

13. The pictures below show *cumulative* survival. Which one corresponds to the picture shown above?



14. Which of the following is true of the age distribution of a decreasing population with a constant life table?

A. It matches the ℓ_x curve exactly
B. It is more top-heavy (more individuals in older age classes) than the ℓ_x curve
C. It is more bottom-heavy (more individuals in younger age classes) than the ℓ_x curve
D. Insufficient information to answer
E. A population can't be decreasing if it has a constant life table

15. The carrying capacity for an organism in an environment is the density at which crowding reduces the average of __________ to zero:

A. The birth rate
B. The death rate
C. The recruitment rate
D. The amount of free habitat
E. The difference between the birth rate and the death rate

16. A population of oak trees is estimated to be at stable age distribution, with a constant life table, with reproductive number $\mathcal{R}$= 1.2. It takes the trees several decades to reach maturity and reproduce. This population is

A. declining
B. stable
C. increasing
D. showing damped oscillations
E. there is not enough information to answer this question

17. If an annual species produces an average of 10 offspring in odd years and an average of 1 offspring in even years, which of the following is closest to its long-term average growth rate?

A. 1
B. 3
C. 3.2
D. 5.5
E. 10

Answer questions on this page *in pen.* *Briefly* show necessary work and equations. Points may be *deducted* for wrong information, even when the correct information is also there.

18. A rat population is growing without any population regulation. Females produce an average of 1.6 offspring each year for two years. The probability of each offspring surviving to reproduce is 0.5; one-year-old rats survive to age 2 with probability 0.8; two-year-old rats never survive, because they don't want your life table to be too long. The sex ratio in the population is 1:1.

a) (2 points). Explain *briefly* how you calculate the values of f_x for this population. You should explain whether you are counting before or after reproduction (either is fine).

b) (2 points). Explain briefly what values you use for p_x to be consistent with your census choice in the previous answer.

c) (1 point) Explain briefly what ℓ_x means, and show how you calculate the values.

d) (1 point) Fill in the life table and calculate $\mathcal{R}$ for this population.

x	f_x	p_x	ℓ_x	$\ell_x f_x$
1				
2				
$\mathcal{R}$				

e) (1 point) Write an expression showing the relationship between λ, $\mathcal{R}$ and 1 (e.g., $\lambda > \mathcal{R} = 1$ or $\lambda < 1 < \mathcal{R}$).

f) (1 point) Write an equation that you could use to calculate λ for this population. Fill in numbers for all values except for λ.