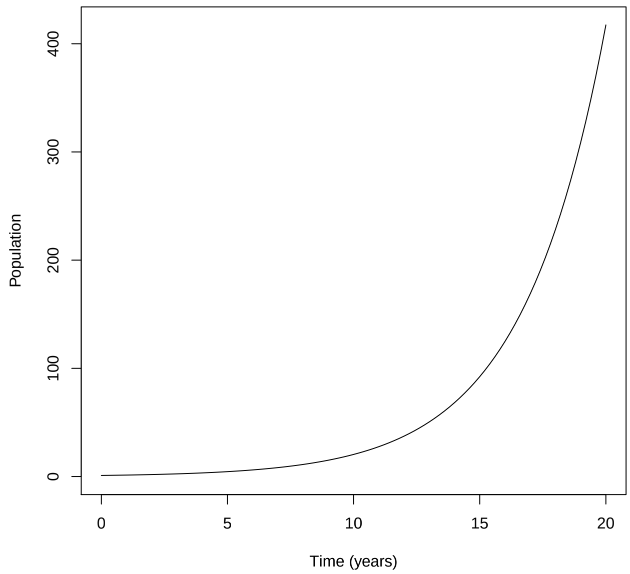
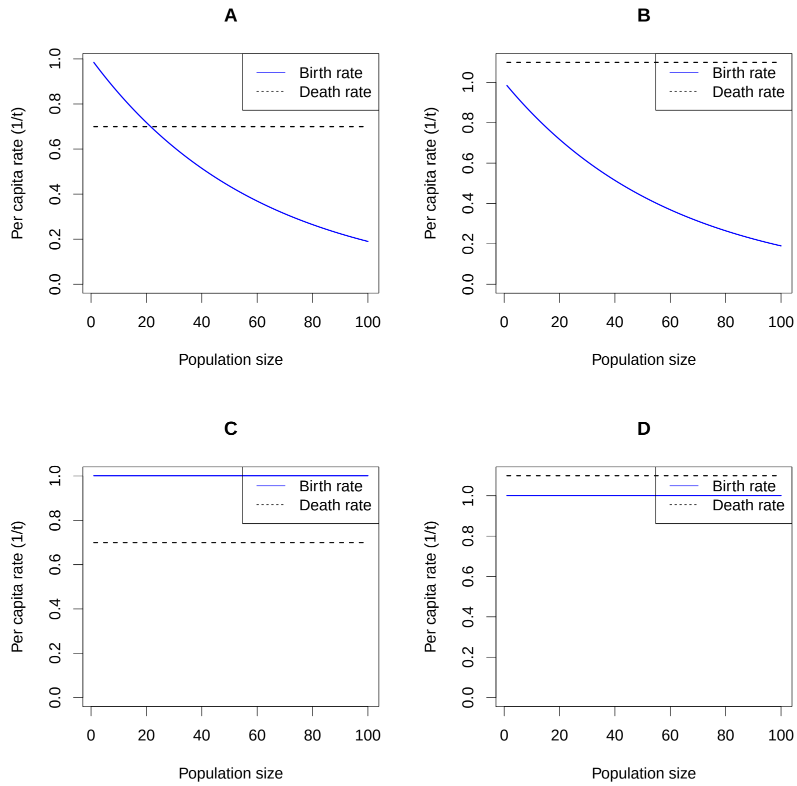
Use the picture below for the next two questions. It shows a time series for a continuous-time birth-death model.



1. This picture shows a population that is:

A. Increasing arithmetically
B. Increasing geometrically
C. Increasing arithmetically on the log scale, but geometrically on a linear scale
D. Increasing geometrically on the log scale, but arithmetically on a linear scale

2. Which of the four pictures below shows the assumptions that generated this time plot?



3. An exponentially growing rabbit population takes 10 years to grow from 20 individuals to 100 individuals. If it continues to grow exponentially at the same rate, how long would it take to increase from 100 individuals to 500 individuals?

A. 5 years
B. 10 years
C. 20 years
D. 40 years
E. 50 years

4. A population of small plants has discrete, overlapping generations, with year-to-year survival probability $p = 3/4$ and year-to-year fecundity $f = 1/2$. This population has:

A. $\lambda = 2$ and $\mathcal{R} = 1.25$
B. $\lambda = 1.25$ and $\mathcal{R} = 2$
C. $\lambda = 0.67$ and $\mathcal{R} = 0.75$
D. $\lambda = 0.75$ and $\mathcal{R} = 0.67$

5. Which of the following is *not* a process by which populations change size?

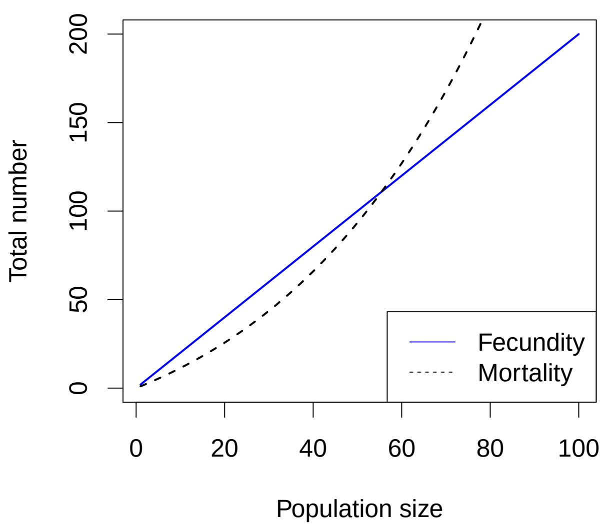
A. Immigration
B. Emigration
C. Birth
D. Death
E. Competition for mates

6. A biologist hypothesizes that her population is growing faster than exponentially, following the formula $N = N_0 \exp(kt^2)$, where N_0 is the initial population in units of [indiv]/[area], and t has units of [time]. What are the units of k, if the right hand side is a valid expression?

A. 1/[time]
B. [indiv]/[time]
C. [area]/[time]
D. [area]/[time]^2
E. 1/[time]^2

7. The long-term average finite rate of growth λ of a successful species should be:

A. Very close to 0
B. Substantially greater than 0, but substantially less than 1
C. Very close to 1
D. Substantially greater than 1

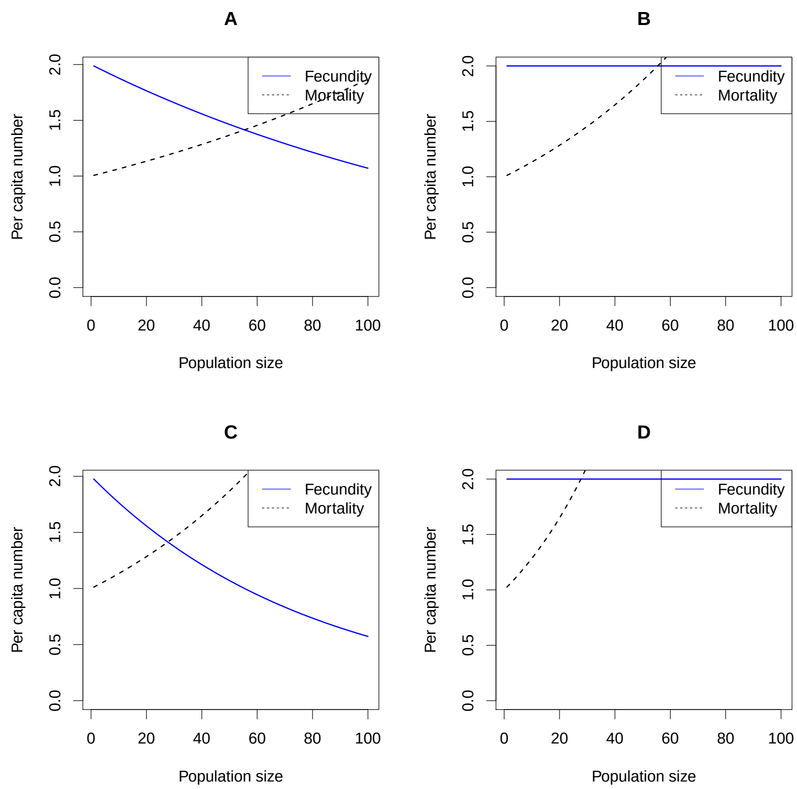


The figure above shows the assumptions made for a discrete-time birth-death model. *Use it for the next 3 questions.*

8. The figure shows:

A. Density dependence in mortality only
B. Density dependence in both mortality and fecundity
C. An Allee effect in mortality only
D. An Allee effect in both mortality and fecundity

9. Which of the four pictures below was generated by the same model as the picture above?



10. A population following this model will:

A. Increase exponentially without limit
B. Decrease exponentially to zero
C. Approach an intermediate equilibrium
D. Decrease to zero if started near zero, and increase to an intermediate equilibrium otherwise

Use the following information for the next three questions. An ecologist censuses a gopher population before reproduction, and finds the following. Females observed in their first year produce an average of 1 female that will be observed next year, and have a 40% chance of surviving until their second year. Females observed in their second year produce an average of 2 females that will be observed the next year. No femailes survive from their second year to reproduce again.

11. What is the value of ℓ_1 in this population?

A. 0.2
B. 0.4
C. 0.8
D. 1
E. 1.2

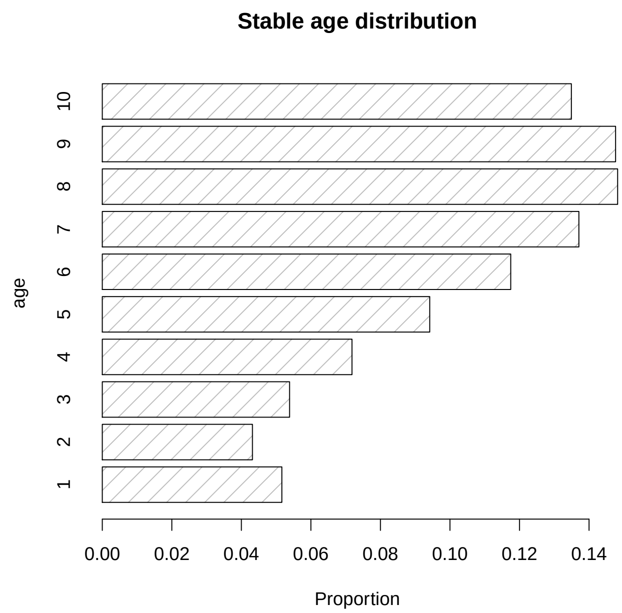
12. What is the value of f_2 in this population?

A. 0.4
B. 0.8
C. 1
D. 1.2
E. 2

13. Which of the following is a true statement about this population?

A. $\lambda = 1.4$
B. $\mathcal{R}= 1.4$
C. $\lambda = 1.8$
D. $\mathcal{R}= 1.8$

Use the picture below for the next question.



14. The picture above represents a stable age distribution for a population. In this population, we know that λ:

A. > 1
B. < 1
C. is increasing
D. is decreasing
E. it is not possible to say

15. If a bacterium is highly adapted to dramatic changes in conditions (ranging from very good growth conditions to very bad), we would expect it to:

A. Have a very fast life cycle
B. Have a very slow life cycle
C. Have adaptations that speed up its life cycle in good conditions and slow it down in bad conditions
D. Have adaptations that speed up its life cycle in bad conditions and slow it down in good conditions

16. Which of the following is most likely?

A. Organisms living in highly variable environments will evolve to put more resources into female than male offspring

B. Organisms living in highly variable environments will evolve to put more resources into male than female offspring

C. Organisms living in highly variable environments will evolve to put relatively more resources into dispersal

D. Organisms living in highly variable environments will evolve to put relatively less resources into dispersal

17. In an environment where seed survival is highly variable from year to year, we expect that iteroparous plants (reproducing more than once) are likely to invest relatively ________ than semelparous plants in ________.

A. more; mechanisms for seed dispersal
B. less; mechanisms for seed dispersal
C. less; each individual seed
D. more; each individual seed

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

A. Birds with heavier beaks that allow them to access more kinds of food have higher mortality before reaching maturity

B. Bushes which produce more defensive chemicals live longer, and produce more viable seeds.

C. Trees that grow quickly in full sunlight are more likely to die when shaded

D. Rabbits which need less food to survive produce fewer offspring when food is plentiful

19. 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

Use the following information for the following two questions. The growth rate of species 1 in the presence of species 2 is given by $\frac{dN_1}{dt} = r_1(1 - (N_1 + \alpha_{21}N_2)/K_1)N_1$

20. If species 1 is counted in units of indiv_1 species 2 in units of indiv_2, and time is counted in units of years, α_{21}?

A. Has units of $1/\text{year}$
B. Has units of $1/\text{indiv}_2$
C. Has units of $\text{indiv}_1/\text{indiv}_2$
D. Has units of $\text{indiv}_1/\text{year}$

21. If species 2 is governed by a similar equation, we expect to see a tendency towards co-existence:

A. When $\alpha_{21}\alpha_{12} < 1$
B. When $\alpha_{21}\alpha_{12} > 1$
C. When $\alpha_{21}/\alpha_{12} < 1$
D. When $\alpha_{21}/\alpha_{12} > 1$

22. We expect mutual exclusion to occur when

A. Each species does better in an environment dominated by conspecifics than it does in an environment dominated by the other species
B. Each species does better in an environment dominated by the other species than it does in an environment dominated by conspecifics
C. One species does relatively better in an environment dominated by conspecifics, while the other does relatively better in an environment dominated by the other species
D. One species does better than the other in any environment

23. In a certain environment, algal species compete primarily for light in small pools, which may be disturbed. If the disturbance rate is very high, which species would we expect to dominate?

A. The species with the highest growth rate at high light (r_{max})
B. The species with the lowest r_{max}
C. The species with the highest light level at which it reaches equilibrium (R^*)
D. The species with the lowest R^*

24. The growth rate of species 1 in the presence of species 2 is given by $\frac{dN_1}{dt} = r(N_1 + \alpha_{21}N_2)N_1$. If species 1 is counted in units of indiv_1, species 2 in units of indiv_2, and time is counted in units of years, α_{21}:

A. Has units of $1/\text{year}$
B. Has units of $1/\text{indiv}_2$
C. Has units of $\text{indiv}_1/\text{indiv}_2$
D. Has units of $\text{indiv}_1/\text{year}$

Use this information for the next two questions. Two competing species of vulture use more or less exactly the same food resources. Species A is more efficient at finding food resources, and outcompetes Species B in favorable environments. Species B is more efficient at using water, and outcompetes Species A in drier environments. In intermediate environments, the two species co-exist.

25. In this case, we expect:

A. Species A and B both have larger fundamental than realized niches
B. Species A and B both have larger realized than fundamental niches
C. Species A has a larger fundamental than realized niche; while Species B has a larger realized than fundamental niche
D. Species B has a larger fundamental than realized niche; while Species A has a larger realized than fundamental niche

26. In intermediate environments:

A. The unitless strength of competition C, and both of the competition coefficients $\alpha < 1$
B. The unitless strength of competition $C < 1$, but we don't know if both $\alpha < 1$
C. The unitless strenth of competition C, and both of the competition coefficients $\alpha > 1$
D. The unitless strength of competition $C > 1$, but we don't know if both $\alpha > 1$

Use the following information for the next two questions. Big fish and small fish in a large lake are fished by people, and are at equilibrium (with fishing) under reciprocal control – ie., the small fish are controlled by predation from large fish, and the large fish are controlled by the food supply of small fish. People stop catching both the large fish and the small fish (because of health concerns about eating them).

27. What effect would you expect to see in the *short term*?

A. Populations of both small and large fish increase
B. Populations of small fish decline, while populations of large fish increase
C. Populations of large fish decline, while populations of small fish increase
D. Populations of both small and large fish decline

28. What effect would you expect to see in the *long term*?

A. Populations of both small and large fish increase
B. Populations of small fish decline, while populations of large fish increase
C. Populations of large fish decline, while populations of small fish increase
D. Populations of both small and large fish decline

29. In the basic pattern of oscillations involving exploiters and resource species, we expect:

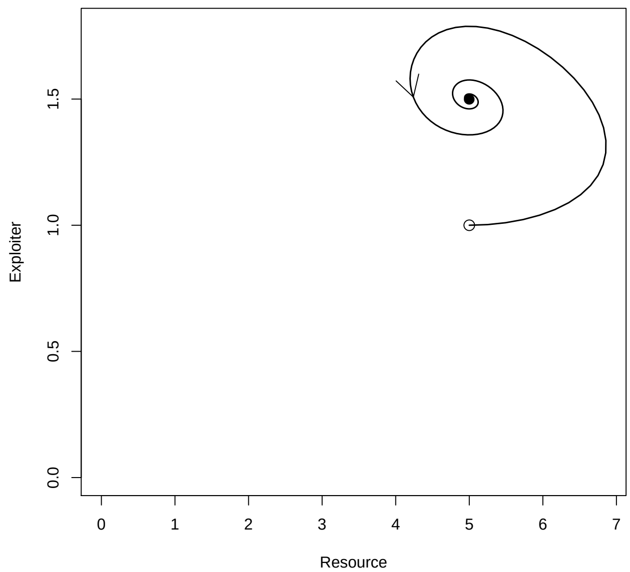
A. The resource species to have higher peaks and lower troughs than the exploiter species
B. The resource species to have lower peaks and higher troughs than the exploiter species
C. The resource species population to reach both its peak and its trough before the exploiter population reaches *its* peak and trough, respectively
D. The resource species population to reach both its peak and its trough after the exploiter population reaches *its* peak and trough, respectively

30. Why do we usually add density dependence in the resource species in a model of exploitation, but less often add it for the exploiter species?

A. Because exploiters are not likely to experience density dependence
B. Because explicitly modeling the resource species already provides a form of density dependence for the exploiter
C. Because density dependence for the resource species is stabilizing, while density dependence for the exploiter species is destabilizing
D. Because density dependence for the resource species is destabilizing, while density dependence for the exploiter species is stabilizing

31. Which of the following can lead to *unstable* cycles between exploiters and resource species?

A. Heterogeneity in susceptibility of the resource species
B. Heterogeneity in space
C. Exploiter satiation
D. Density dependence of the exploiter species
E. Density dependence of the resource species



Use the picture above for the next 3 questions. This is a phase plot the behaviour of a predator-prey system.

32. The figure above shows:

- **A.** Neutral cycles
- **B.** Damped cycles
- **C.** Unstable cycles
- **D.** A limit cycle

33. The simplest reciprocal-control model consistent with this figure has:

- **A.** No prey density dependence and no predator satiation
- **B.** Predator satiation
- **C.** Prey density dependence
- **D.** Prey density dependence and predator satiation

34. If we were to add *predator density dependence* to this model, the qualitative behaviour (type of cycles) would:

- **A.** Stay the same
- **B.** *Change* to unstable oscillations
- **C.** *Change* to neutral oscillations
- **D.** *Change* to persistent oscillations
- **E.** *Change* to damped oscillations

35. What does γ represent in the equation

$$dI/dt = \beta SI/N - \gamma I?$$

A. The rate at which individuals make potentially infectious contacts
B. The average amount of time it takes an individual to make a potentially infectious contact
C. The rate at which individuals leave the infectious class
D. The average amount of time it takes an individual to leave the infectious class

36. If a new disease is introduced to a susceptible population, and $\mathcal{R}_0 > 1$, we expect it to:

A. grow linearly until equilibrium is reached
B. grow exponentially until everyone is infected
C. grow exponentially at first and then grow less than exponentially as susceptibles are depleted
D. grow less than exponentially at first and then exponentially as it becomes established in the population

37. Early investigations of disease models suggested that malaria could be eliminated from the Panama Canal zone if __________ could be reduced below __________.

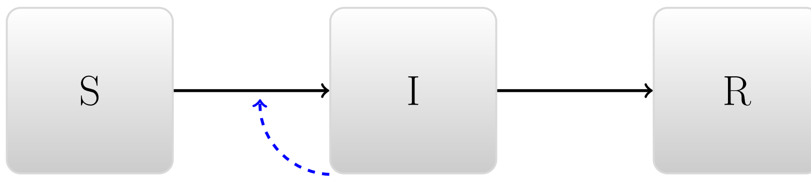
A. $\mathcal{R}_0$; 0
B. $\mathcal{R}_0$; 1
C. $\mathcal{R}_e$; 0
D. $\mathcal{R}_e$; 1

38. Our simple epidemic model was finished after it burned out, whereas real diseases often have recurrent epidemics. Which of the following is *not* a mechanism that explains why a disease might return after it burns out?

A. Births provide new susceptibles to the population
B. People might lose immunity through time
C. The population might have very high levels of risk behaviour
D. The disease might evolve to escape the immune response that it triggered

39. If $\mathcal{R}_0 = \beta D$, where β is the rate of potentially infectious contacts and D is the duration of infectiousness, what are the units of β?

A. [time]
B. [1/time]
C. [indiv/time]
D. [1/(indiv*time)]
E. [time/indiv]



40. At the end of a simple, single epidemic following the model assumptions illustrated above, we expect that everybody will be:

A. infected
B. resistant
C. infected or resistant
D. susceptible or resistant
E. susceptible or infected

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