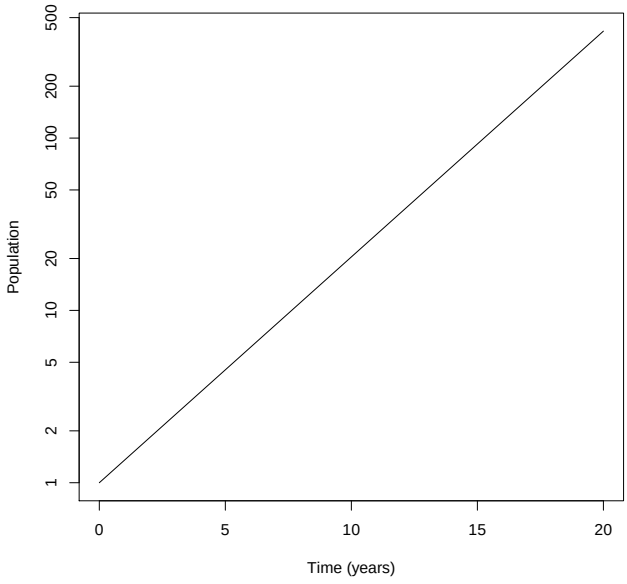
Formulas
discrete time growth:

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

continuous time growth:

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

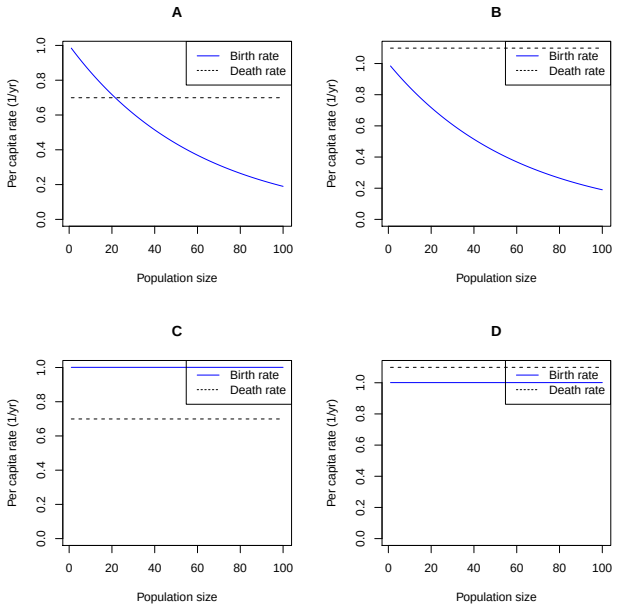
Use the picture below for the next two questions. It shows a time series for a continuous-time birth-death model.



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 small pictures shows the assumptions that generated the time plot?



A. A
B. B
C. C
D. D

3. An exponentially growing rabbit population takes 10 years to grow from 20 individuals to 500 individuals. If it continues to grow exponentially at the same rate, how long would it take to increase from 500 individuals to 2500 individuals?

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

4. Compared to the instantaneous rate 0.05/day, the instantaneous rate 1.2/hr:

A. Means exactly the same thing
B. Is not directly comparable, because they refer to different time steps
C. Is comparable, and refers to a larger (faster) rate
D. Is comparable, and refers to a smaller (slower) rate

5. Blood disease caused by malaria parasites is rarely seen in Washington, DC, even though mosquitoes there can transmit malaria, and people travel there from around the world. This is likely because the _____ have _____ < 1

A. Parasites; reproductive number (R)
B. Parasites; instantaneous growth rate (r)
C. Mosquitoes; reproductive number (R)
D. Mosquitoes; instantaneous growth rate (r)

6. Researchers studying a gypsy moth population make the following estimates: The average reproductive female lays 400 eggs; 10% of eggs hatch into larvae; 20% of larvae mature into pupae; 25% of pupae mature into adult females; 60% of adult females survive to reproduce. What is the correct value of fecundity f for this population?

A. 1.2
B. 2.4
C. 1.2 moths/year
D. 2.4 moths/year
E. There is not enough information to answer this question

7. 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

8. Which of the following statements about the continuous-time exponential growth model $dN/dt = rN$ is *incorrect*?

A. The per capita growth rate is a constant.
B. The population will increase if and only if the instantaneous rate of increase $r > 0$.
C. The total growth rate increases or decreases linearly with population size.
D. Population size increases or decreases linearly with time

9. If d represents the unit days, then what is exp(4d)?

A. 55d
B. 55 [unitless]
C. 55/d
D. Nonsense

10. A population of gophers is censused annually. Researchers conclude that the density is 100 gophers/ha, and the finite rate of increase λ is 0.9. If the finite rate of increase remains constant, what density do the researchers expect to see after 10 years?

A. 0 gophers/ha
B. 9 gophers/ha
C. 35 gophers/ha
D. 90 gophers/ha
E. 613 gophers/ha

11. When researchers make a model _____ age structure, they usually *avoid* thinking about the population as being censused _____ reproduction, because this makes the model assumptions *less* realistic.

A. with; before
B. with; after
C. without; before
D. without; after

12. A population of birds has an annual mortality probability of 10%; females have 0.25 surviving offspring per year, with an equal sex ratio, on average. If the population starts from 5 individuals, approximately how many years will it take to reach 40 individuals? (It will be easiest to do this problem in a discrete-time framework.)

A. 20 years
B. 40 years
C. 45.5 years
D. 85 years
E. 100 years

13. Which of the following is *not* generally true of an exponentially growing population?

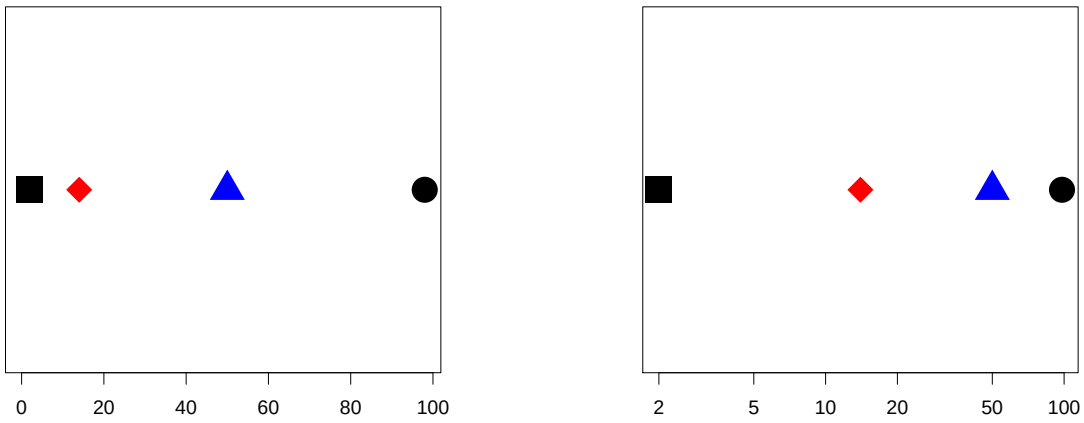
A. The *per capita* birth and death rates are constant
B. The *per capita* birth rate is greater than the *per capita* death rate
C. The equilibrium point at zero is stable
D. $R > 1$
E. The total death rate continually increases over time

14. If we are comparing a 1 kg rat, a 60 kg human, and a 600 kg buffalo, the _____ is most different from the human on the linear scale, and the _____ is most different on the log scale

A. rat; rat
B. rat; buffalo
C. buffalo; rat
D. buffalo; buffalo

15. We model a population of perennial plants with a discrete-time model, and attempt to calculate growth rate using the formula $\lambda = p + f$. We count individuals just before reproduction. If the probability that seeds survive to become seedlings increases, how will our calculation change?

A. The fecundity f will increase, while the year-to-year survival probability p will remain the same
B. The fecundity f will stay the same, while the year-to-year survival probability p will increase
C. Both p and f will increase
D. Both p and f will stay the same



16. These pictures illustrate that the *geometric* mean of 2 and 98 is _____. This is visually suggested by the _____ scale.

A. 14; log
B. 50; log
C. 14; linear
D. 50; linear

Nonlinear

17. Which of the following is *not* a likely reason why there may be a delay in population regulation (i.e., not a reason why population growth rate is likely to depend on population size *in the past*)?

A. Depletion of resources
B. Competition for space
C. Predators and pathogens
D. Length of the organism's life cycle

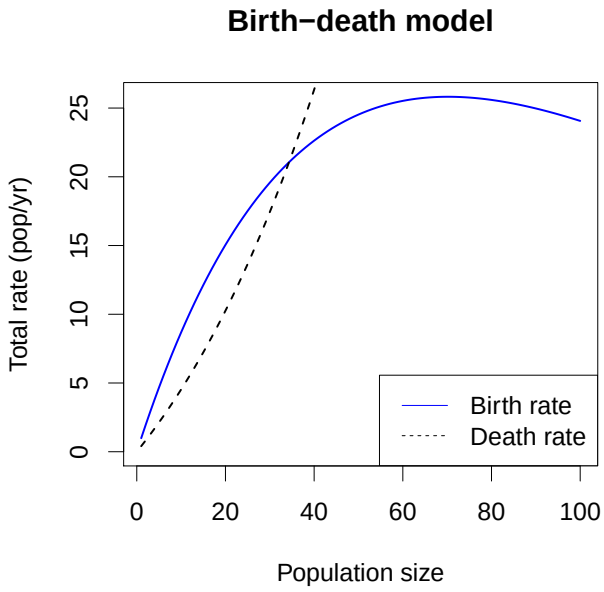
18. A population consisting of individuals whose birth rate and death rate does not change through time, and whose behaviour is independent of other individuals in the population, will tend to:

A. Grow linearly
B. Either grow or decline linearly
C. Grow exponentially
D. Either grow or decline exponentially

19. Populations are *regulated* (kept under control) when:

A. Their growth rate increases through time
B. Their growth rate decreases through time
C. Their growth rate tends to increase when the population becomes larger
D. Their growth rate tends to decrease when the population becomes larger

Use this picture for the next three questions.



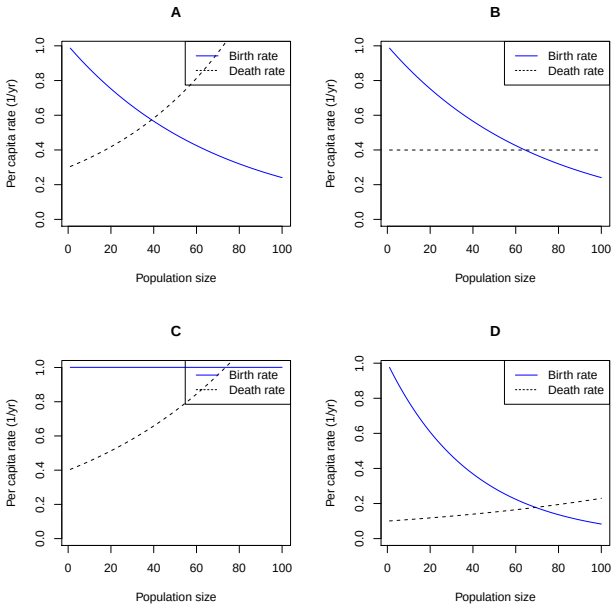
20. This population displays:

A. An Allee effect in both the birth rate the death rate
B. An Allee effect in the birth rate and density dependence in the death rate
C. An Allee effect in the death rate and density dependence in the birth rate
D. Density dependence in the both the birth rate and the death rate

21. A population following this model will _____ if started from a low density, and _____ if started from a high density

A. go extinct; decline to equilibrium
B. go extinct; grow indefinitely
C. grow to an equilibrium; decline to equilibrium
D. grow to an equilibrium; grow indefinitely

22. Which of the pictures below shows the same model as the picture above?



A. A
B. B
C. C
D. D

23. Which of the following is a sign that resource *depletion*, and not just resource competition, is taking place?

A. When $\lambda < 1$
B. When $\lambda > 1$
C. When N_{T+1} increases with N over some range
D. When N_{T+1} decreases with N over some range

24. A population of birds in a dry area is primarily limited by the supply of insects for it to eat. Another population of the same species in a wetter area has plenty of insects to eat, and is limited by nesting spaces in trees. If the birds' population affects the insect population, but has no effect on the trees, we would expect that the wet population is _____ likely to show a negative relationship between N_T and N_{T+1} (turnover), and _____ likely to show oscillations

A. less; less
B. less; more
C. more; less
D. more; more

25. Which of the following is *least* likely to explain population regulation in a population of swallows?

A. Competition among individuals for nest sites
B. Competition among individuals for food
C. Reduction of insect availability due to swallow feeding
D. Reduction of insect availability due to environmental fluctuations
E. An increase in infectious disease when swallow densities are high

Name _____ **Macid** _____**Tutorial section** _____**VVV**

Short-answer questions

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