Use this information for the next two questions. A researcher estimates that a moth population has a density of 10 pupae/ha in 2012, and finite rate of growth $\lambda = 1.4$ (associated with a time step of one year). The sex ratio of the population is 1:1.

1. If λ remains constant, what is the approximate density of pupae she will expect to see in 2020?

A. 14 pupae/ha
B. 27 pupae/ha
C. 54 pupae/ha
D. 74 pupae/ha
E. **148 pupae/ha**

2. What value of the instantaneous growth rate r corresponds to the finite growth model described in the question above?

A. **0.34/yr**
B. 0.34 yr
C. 1.4/yr
D. 1.4 yr
E. There is not enough information to tell

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

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

4. 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**

5. Consider a 500kg moose, a 50kg wolf and a 100g chipmunk. Which animal is the most different in mass from the others?

A. The moose is most different on any scale
B. The chipmunk is most different on any scale
C. **The moose is most different when considered on the linear scale and the chipmunk is most different when considered on the log scale**
D. The chipmunk is most different when considered on the linear scale and the moose is most different when considered on the log scale

Use this information for the next two questions. The simple, time-delayed continuous model we studied is written $\frac{dN(t)}{dt} = (b(N(t-\tau)) - d(N(t-\tau)))N(t)$

6. In this model, τ represents:

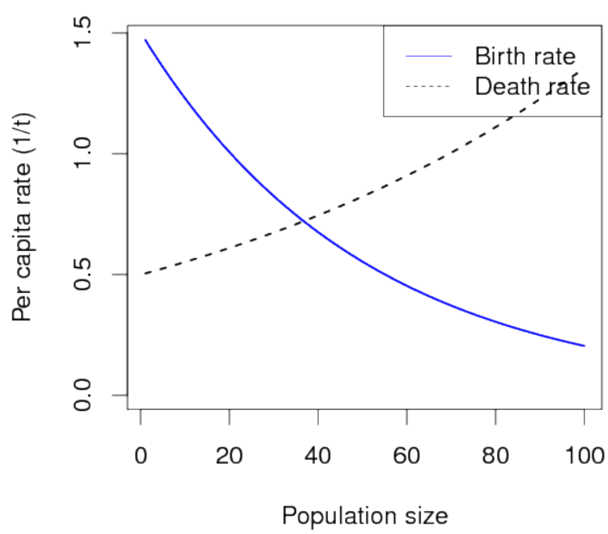
A. The characteristic time for exponential growth
B. **The time delay for the population size to affect growth rates**
C. The carrying capacity
D. Density dependence

7. This model shows what range of behaviour?

A. Smooth convergence to equilibrium only
B. Smooth convergence and damped cycles only
C. **Damped cycles and persistent cycles only**
D. Persistent cycles or chaotic behaviour only
E. All of the above behaviours

8. Which of these is *not* an effect that tends to *balance* the tendency of populations to grow or decline exponentially without limit?

A. **Allee effects**
B. Competition for access to resources
C. Resource depletion
D. Dynamics of natural enemies

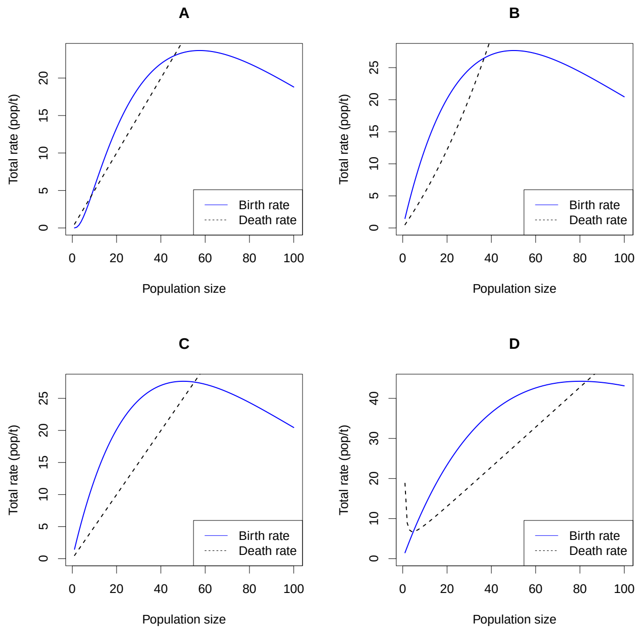


Use the picture above for the next 3 questions.

9. The figure shows __________ in the birth rate and __________ in the death rate:

A. **density dependence; density dependence**
B. density dependence; Allee effects
C. Allee effects; density dependence
D. Allee effects; Allee effects

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



ANS: B

11. This population has a(n) __________ equilibrium at 0 individuals and a(n) __________ equilibrium at 37 individuals

A. stable; stable
B. stable; unstable
C. **unstable; stable**
D. unstable; unstable

Use the following information for the next two questions. A population of oak trees is estimated to be at stable age distribution, with a constant life table, with reproductive number $\mathcal{R} = 0.9$. It takes the trees several years to reach maturity and reproduce.

12. This population is

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

13. What is the *most accurate* statement you can make about the finite rate of growth λ, measured with a time step of one year?

A. We expect $\lambda < 0.9$
B. We expect $\lambda = 0.9$
C. We expect $\lambda < 1$
D. **We expect** $0.9 < \lambda < 1$
E. We expect $0.9 < \lambda$

Since the lifespan is long, we expect λ to be closer to 1 than 0.9. This relates to the theme of slow life cycles producing higher lambda under bad conditions, and so on.

14. Which of the following is true of the stable age distribution of an increasing population?

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 increasing if it has a stable age distribution

15. In general, the value of p_1 in a life table for a species with annual reproduction is: the probability that an organism survives from:

A. birth to the next reproductive period for the species
B. birth to the first census
C. the first census to the following reproductive period
D. the first reproductive period to the following census
E. **the first census to the second census**

16. In general, the value of f_2 in a life table for a species with annual reproduction is the average number of new offspring that will be produced by:

A. an average censused individual in the second age class
B. **an average censused individual in the second age class, multiplied by the probability that the offspring survive to be censused**
C. a censused individual from the second age class which survives to reproduce
D. a censused individual in the second age class which survives to reproduce, multiplied by the probability that the offspring survive to be censused

17. Which of the following needs to be specified in a stage-structured, but *not* in an age-structured model?

A. Survival probability
B. Fecundity
C. **Recruitment probability**
D. Density dependence

18. An annual plant colonizes a new environment that has highly variable weather conditions, and thus highly variable success for the plant population, from year to year. We would expect the population to evolve to:

A. **Have a higher fraction of seeds that germinate (start growing) in their second or third year, even at the expense of a lower fraction that germinates overall**
B. Have a higher fraction of seeds that germinate successfully overall, even at the expense of a lower fraction that germinates later than the first year
C. Produce fewer offspring, with more resources provided to each individual offspring
D. Produce more offspring, with less resources provided to each individual offspring

In a more variable environment, it is more important that the plants can spread out their risk over time, thus they should allocate resources to delayed germination.

19. A plant population is observed to be confined to a single valley, possibly due to habitat disturbance, and individuals always experience very similar conditions. Over a study period, it is observed that the population increases by a factor of 1.5 in good years, and by a factor of 0.6 in bad years. If good years and bad years each occur about half the time, what is the long term average value of the finite rate of increase λ for this population?

A. 0.9
B. **0.95**
C. 1
D. 1.05
E. 2.1

We calculate the geometric mean of 0.6 and 1.5. This example illustrates one reason why reducing habitat size may have negative indirect effects on species – this species would likely have $\lambda > 1$ if it had more places to disperse to.

20. Which of the following does *not* describe a life-history tradeoff?

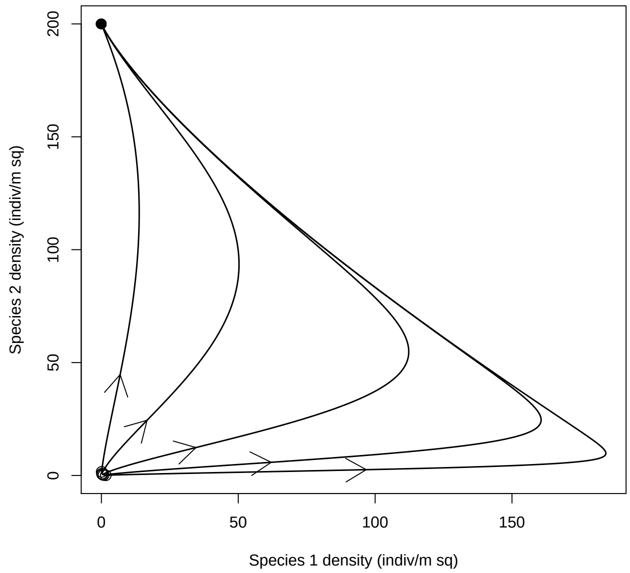
A. **Organisms that use more resources for survival can reproduce more times, and produce more total offspring under good conditions**
B. Organisms that reproduce only once can produce more offspring at that time than if they saved resources so that they could survive and reproduce again
C. Organisms that use more resources to help their offspring disperse cannot produce as many total offspring
D. Organisms that use more resources to help their offspring survive cannot produce as many total offspring

21. A group of tree species shows a tradeoff between $r_{\max}$ and K. We would expect to see:

A. **Species with high K doing well in less disturbed areas and species with high $r_{\max}$ doing well in more disturbed areas**
B. Species with high $r_{\max}$ doing well in less disturbed areas and species with high K doing well in more disturbed areas
C. Species with high K doing well in all areas
D. Species with high $r_{\max}$ doing well in all areas

22. 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

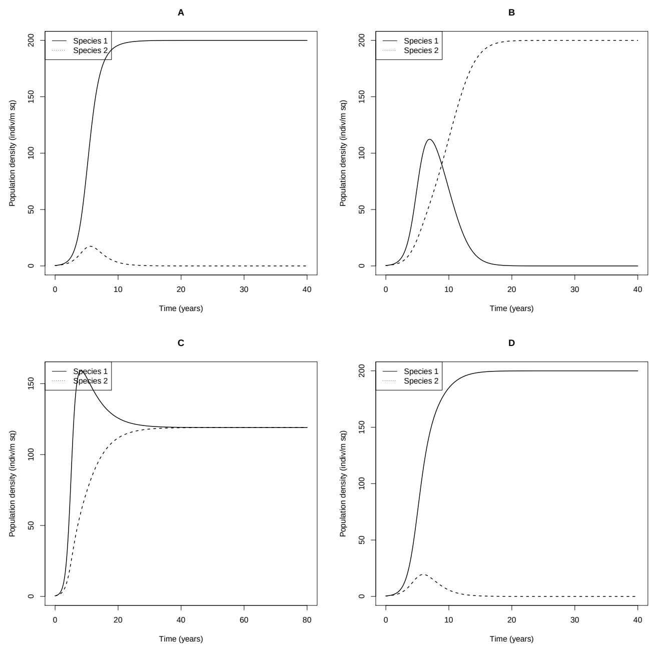


Use the picture above for the next 4 questions. These are phase plots from a simple model of two competing species. The middle path has both species starting at the same density

23. The picture shows:

   A. Dominance by species 1
   B. **Dominance by species 2**
   C. Mutual exclusion
   D. Coexistence

24. Which of the time plots below matches the *middle path* from the phase plot above?



ANS: B

25. If E_{12} is the population-level competitive effect of species 1 on species 2 (and conversely), what can you say about the values of E in this system?

A. Both E_{12} and E_{21} are > 1.
B. Both E_{12} and E_{21} are < 1.
C. E_{12} but not E_{21} is > 1.
D. E_{21} **but not** E_{12} **is** > 1**.**
E. There is not enough information to choose one of these answers.

26. Species ________ has a larger value of ________, but we can't tell which has a larger value of ________.

A. 1; K; r
B. 2; K; r
C. **1;** r**;** K
D. 2; r; K

27. The growth rate of species 1 in the presence of species 2 is given by $\frac{dN_1}{dt} = r(\tilde{N}_1)N_1$, where $\tilde{N}_1 = N_1 + \alpha_{21}N_2$. 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, then the α_{21} has units of:

A. $\text{indiv}_1/\text{year}$
B. $\text{indiv}_2/\text{year}$
C. $1/\text{year}$
D. **$\textbf{indiv}_1/\textbf{indiv}_2$**
E. $\text{indiv}_2/\text{indiv}_1$

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.

28. In this case, we expect:

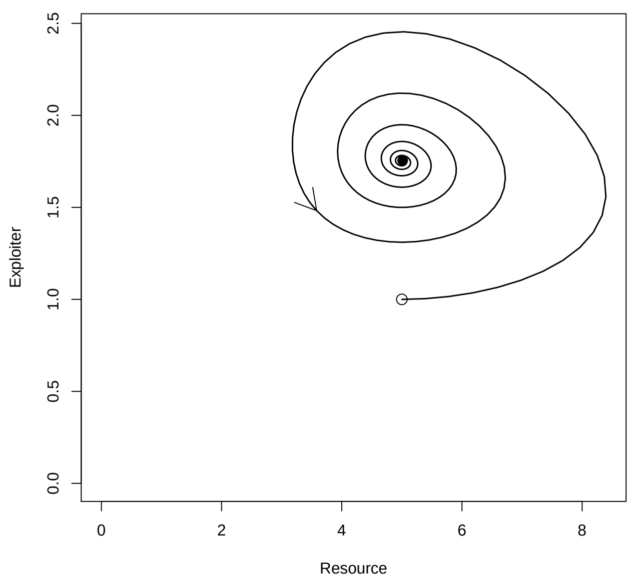
A. **Species A and B both have larger fundamental than realized niches**
B. Species A and B both have larger realized than fundamental niches
C. Species A has a larger fundamental than realized niche; while Species B has a larger realized than fundamental niche
D. Species B has a larger fundamental than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

29. When these vultures are in intermediate environments, we __________ that both of the individual-level competition coefficients (α) < 1, and __________ that both of the population-level competition coefficients (E) < 1.

A. know; know
B. know; don't know
C. **don't know; know**
D. don't know; don't know

30. Which of the following effects tends to damp oscillations in a predator-prey interaction model?

A. Density dependence in the predator
B. Density dependence in the prey
C. Predator satiation
D. **Either A or B**
E. Either B or C



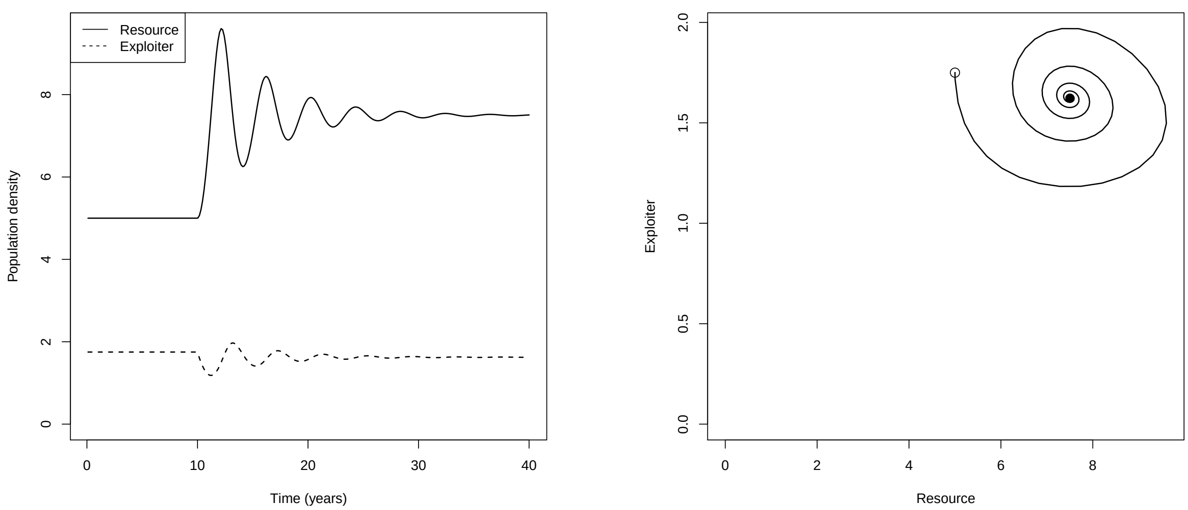
Use the figure above for the next two questions. It shows a simple model of an interaction between an exploiter and a resource species.

31. The figure above shows:

A. Unstable oscillations
B. Neutral oscillations
C. Persistent oscillations
D. **Damped oscillations**

32. This figure is consistent with a simple model that has:

A. No density dependence and weak predator satiation
B. No density dependence and strong predator satiation
C. **Prey density dependence and weak predator satiation**
D. Prey density dependence and strong predator satiation



Use the figure above for the next two questions. It shows a time plot and a phase plot from the *same simulation* of a predator-prey model. We change the parameters at time 10, to reflect a perturbation to the system.

33. At time 10, what changes in our simulation?

A. **The removal rate of the predator is increased (e.g., we start catching sharks)**
B. The removal rate of the prey is increased (e.g., we start catching fish)
C. The removal rate of both the predator and the prey is increased
D. A predator satiation term is added

34. This model has

A. No reciprocal control or density dependence
B. No reciprocal control and density dependence in the prey
C. Strong reciprocal control and no density dependence
D. **Strong reciprocal control and density dependence in the prey**

35. Predator satiation implies that, when the density of ________ goes up, the per capita rate at which ________ goes down.

A. predators; predators eat
B. prey; predators eat
C. predators; prey get eaten
D. **prey; prey get eaten**

36. Resource-exploiter systems have an intrinsic tendency to oscillate because:

A. Each species has a direct, positive effect on its own growth rate
B. Each species has an indirect, positive effect on its own growth rate
C. Each species has a direct, negative effect on its own growth rate
D. **Each species has an indirect, negative effect on its own growth rate**

37. If two species have an exploitation relationship, then:

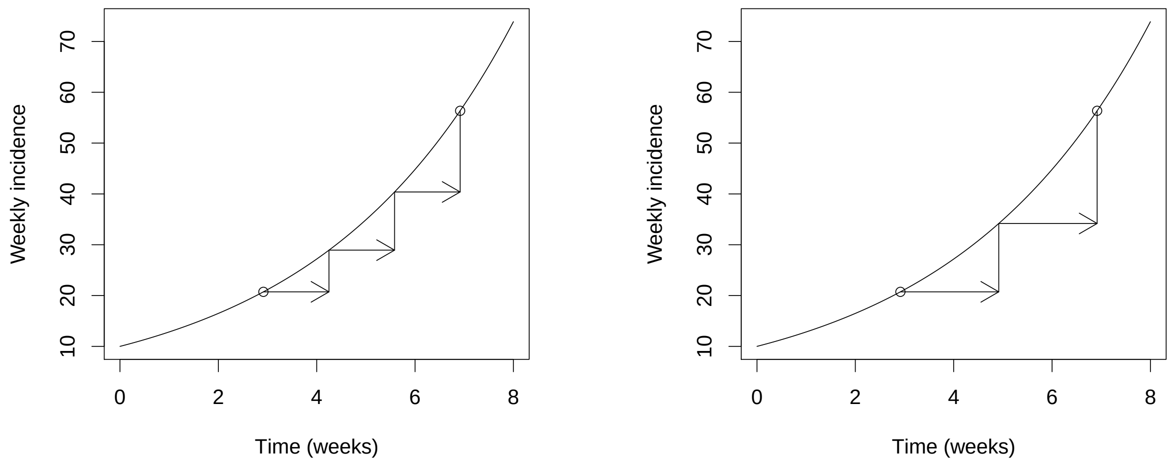
A. The growth rate of each is lower in the presence of the other
B. They do not affect each other's growth rates
C. The growth rate of each is higher in the presence of the other
D. **The growth rate of one is higher in the presence of the other, but the growth rate of the other is lower in the presence of the first one**

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. A disease has a reproductive number of 3. According to our simple model, if we want to stop it from spreading, we should vaccinate:

A. At least 1/3 of the population
B. At least 1/2 of the population
C. **At least 2/3 of the population**
D. The whole population



40. The picture above illustrates the idea that, for a fixed rate of spread, a disease with a slower generation time has a __________.

A. larger instantaneous rate of growth
B. smaller instantaneous rate of growth
C. larger effective reproductive number
D. **smaller effective reproductive number**