BIOLOGY 150 Midterm Exam Winter 2007

Before you start please write your name on the top each page!

Read each question carefully before answering to ensure that you fully understand what the question is looking for. Answer the questions in sufficient detail to let us know that you fully understand the critical issues. Do not use the shotgun approach of throwing everything under the sun into your answer in the hope that something will hit the target because we may deduct points for statements that are counter to the correct answer. 60 points total.

The last page is scratch paper for organizing your thoughts. Good luck.

1. Experiments with 'risk-sensitive' foraging behavior reveal that animals sometimes gamble.

a) Show that you understand what 'risk-sensitive' means by describing an experiment you could perform to demonstrate whether or not individual animals make 'risk sensitive' foraging decisions. Note: we are interested in risk-sensitivity in general and recall there are two ways to show risk sensitivity (5 points).

Risk-sensitive foragers pay attention not only to the average reward from a foraging choice, but also the variation or risk of getting nothing. Train the animals on two different trays, a Constant tray that always has a reward, and a Risky tray that either offers nothing or a big payoff. Keep the average reward the same to make sure that average reward does not affect things. Then, run a series of trials and see if the Squeaker shows a clear preference for the constant reward (i.e. risk averse) or the risky reward (i.e. risk prone), either of which shows risk-sensitive foraging (i.e. the animal is sensitive to the variation, or degree of risk). If the animal shows no preference (i.e. 50% time at each tray) it is not showing risk-sensitive foraging

b) Two factors — a particular body size and a specific physiological state —are shared in common with all the different animals that have ever been shown to make risk-prone foraging decisions at times. What are these factors and why does this pattern make sense? (2 points)

Animals took chances (risk prone) when in energy deficit. These are all tiny animals with high mass specific metabolic rates; they starve easily; thus when are in energy deficit and they have an increased risk of starvation, they need to gamble for the risky, but potentially big payoff to survive.

2. At time zero (t = 0) the population size of Stephen Colbert's Wimpy Eagle is 5. The annual growth rate of the Eagle population is $\lambda = 2$. What is the population size at time t = 3 years? Show the equation that allowed you to calculate your answer and your calculations. (3 points)

$N_t = N_0\lambda^t$

$5 \times 2^3 = 5 \times 8 = 40$ (Give them some credit if they write 5 x2x2x2 = 40)
You get zero if you just write 40 because we assume you just copied the answer off a neighbor

3. This question is designed to test your understanding of the process of natural selection as well as one aspect of the field methods required to show natural selection in a wild population (6 points).

i) Outline the three conditions required for natural selection to occur (the three "ifs" we outlined in class). For each condition, also indicate you would require data and comparisons from within a single generation or data from more than one generation to provide evidence for that condition.

Condition	within or across generations?
1) ____ ***phenotypic variation in a trait***	__***within***____
2) ____ ***trait is heritable (genetic)***_____________	__***between***___
3) _ ***trait has reproductive or survival (i.e. fitness) consequences***	__***within***____

4. The population growth rate per individual, r, is a very useful population parameter that is used in many population models. However, the value of r depends on the time scale used. If r per day is 2, what is r per week? (1 point)

r per week = 14

5. You are one of the biologists in charge of conserving the relatively small population of grizzly bears in Yellowstone Park. On your annual bear counts, you notice that the population size fluctuates, and this is also reflected in your estimates of λ, a measure of per individual population growth rate or decline across years. In good years $\lambda = 4.0$, in bad years $\lambda = 0.2$, and good and bad years occur with equal frequency. Your colleague insists that the bear population is in fine shape because the arithmetic mean of λ is 4.2 and plugging this value into the deterministic population model shows that the population will grow over the long-term. Being a well-trained ecologist, you correct them and insist that a stochastic population model is needed here.

a). What is the fundamental difference between stochastic population model and deterministic population models? (2 points).

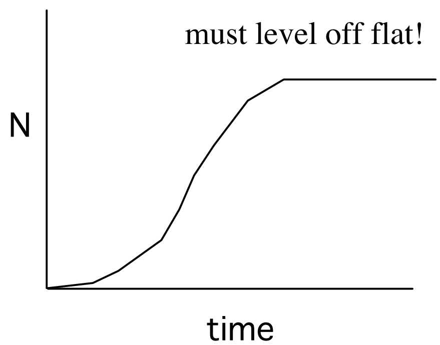
stochastic has chance or random influences on the value of variables, whereas deterministic models do not.

b). Even without running any model you can do a quick calculation with the above λ values to obtain the appropriate estimate of some sort of ‘average’ λ value that accurately predicts long-term prospects for the bear population. Show this calculation. Is the population growing, stable or declining over the long-term? Explain. (3 points).

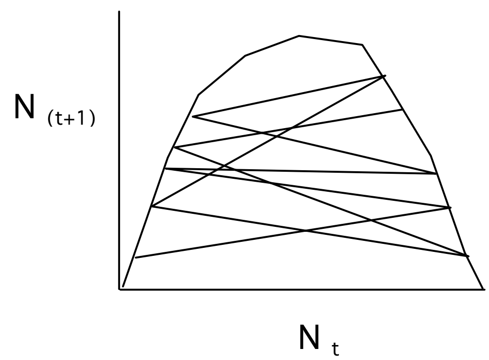
The bears are in trouble . Growth is a multiplicative process: λ this year times λ next year, and so on. Long term growth rate is determined by multiplying the lambdas in different years and taking the square root -- this is the geometric mean, which is used, instead of the arithmetic mean. Thus, in habitat A, growth is the square root of 4 x 0.2 = square root of 0.8, which is less than the one.

6. Fill in each graph below with the curves or lines predicted by the equation or phrase at the top of the graph beside the large letters. Read the x and y axes carefully: don't jump to conclusions (8 points)

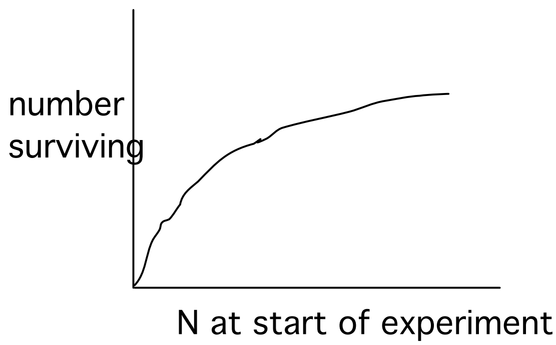
A $dN/dt = rN(1-N/K)$ (where $r > 0$)



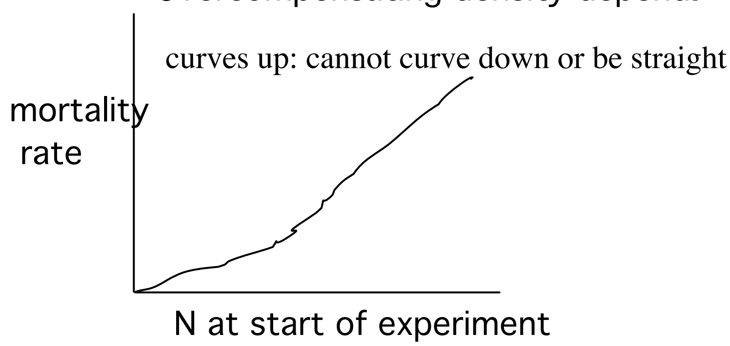
B Signature of chaos: strange



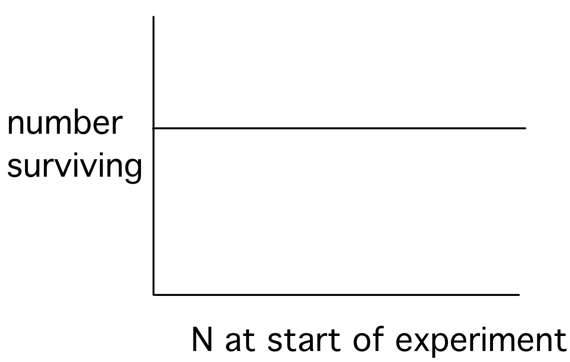
C Undercompensating density dependence



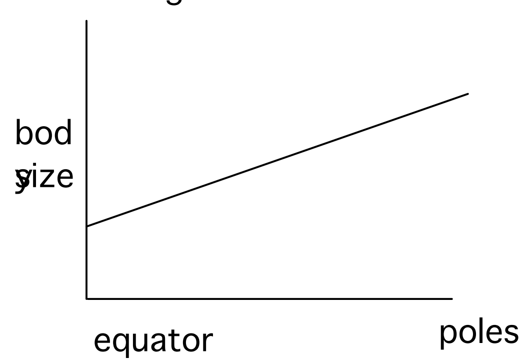
D Overcompensating density depend.



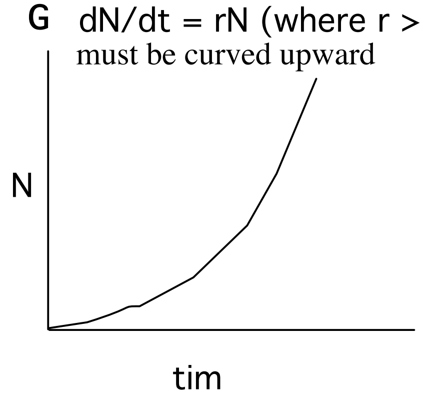
E Exactly compensating density dependence



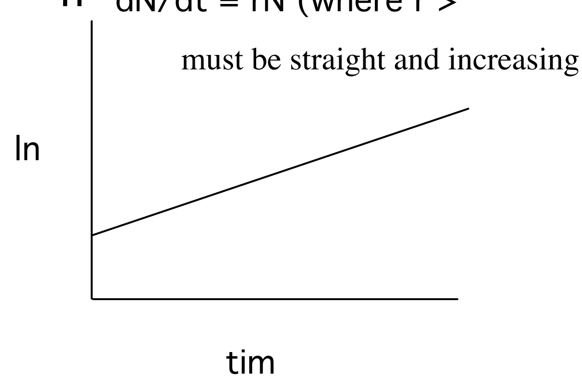
F Bergmann's



G $dN/dt = rN$ (where $r > 0$)



H $dN/dt = rN$ (where r >



7. Match each term on the left with one term on the right that is the BEST match and write the letter of the term in the space provided (7 points).

1. adaptive radiation ___F__	A. Island Rule
2. central place optimal foraging model __G__	B. ecologically similar taxa that are not related
3. Cocos Island finch ___H_	C. fecundity selection
4. convergent evolution __B or I________	D. tilt in earth's rotational axis
5. Wallace's line __J______	E. sink population
6. increased female body size __C______	F. speciation + ecological specialization
7. $\lambda < 1$ __E____	G. travel time + in patch time
	H. behavioral specialization
	I. ecologically (& morphologically) similar but unrelated taxa
	J. continental drift

8. According to population models, the density-dependent effects of intraspecific competition can have very different and interesting consequences for the population dynamics of populations with discrete breeding seasons compared to populations with continuous breeding. These consequences are best illustrated by contrasting the population dynamics (changes in N over time) predicted by the continuous logistic ($dN/dt = rN(1-N/K)$) versus the discrete logistic model ($N_{t+1} = N_t + r_dN_t(1-N_t/K)$).

(i) What is the major difference between these models in terms of the population dynamics each model predicts when r is very high? You can describe in words or you draw a couple of graphs (2 points)

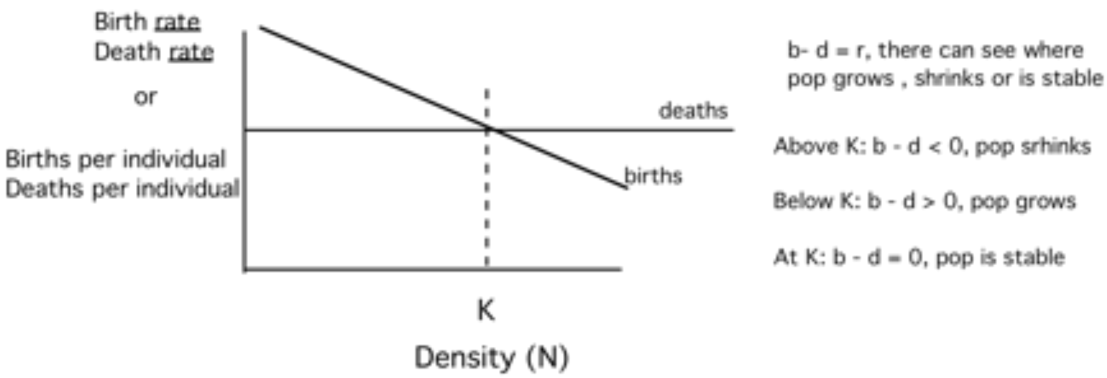
The continuous logistic shows a smooth increase to carrying capacity (K) and then the population stays exactly at K. The discrete logistic increases to K but then overshoots and undershoots, either showing stable limit cycles or if r is very high, chaos.

(ii) Why specifically do these two models produce such different outcomes? (2 points)

Discreteness is the key — it leads to a time lag between population growth and when density dependence kicks in. Time lags plus high r gives rise to strong overcompensating density dependence (drop below K in one time unit), then high r brings pop back above K in one time unit.

9. Density-dependence is of special interest to ecologists because it can potentially explain what limits population growth in some species.

(i) List two mechanisms that can cause density-dependence. (2 points)
space depletion, territories, save hiding spots, resource depletion (intra or intersp), intraspecific predation (cannibalism), parasitism, disease, search image predation, Allee effect, and anything else that seems reasonable)
(ii) Use the graph below to illustrate how a density-dependent birth rate and/or a density-dependent death rate can "regulate" a population so that it will be stable. Label each axis, all lines and indicate where the population is stable. Also, explain clearly in words why the population will be stable in terms of population growth rate parameter r. NOTE: this is general density-dependence, not the logistic model due to intraspecific competition. (3 points)



10. Allometry is the study of how traits or factors change in relation to body size. The relation between metabolic rate and body mass, in particular, has been the focus of intense interest and a couple of key patterns have been discovered.
(i) Fill in the graphs below with a line or curve to show the relation between <u>whole animal metabolic rate</u> (VO_2/unit time) and body mass (left) and <u>mass specific metabolic rate</u> (VO_2/gram/unit time) and body mass (right). Graphs are arithmetic, not logarithmic (2 points)

ii) Two new mammals have just been discovered in the wilds of Alaska — an elephant-sized beast and a tiny shrew-sized creature. Based on the implications of the above graphs, speculate about (i) the expected diet differences between these two species (what they eat) and (ii) the risk that a three-day cold period without food poses to each. (4 points)
- mass specific metabolic rate huge for the tiny mammal, small for the huge animal
- thus, small animal eats energy rich food (nectar, insects); large eats low quality food (herbivore)
- endurance increases with size, tiny animal cannot last cold period without dropping metabolic rate (torpor), cold period is a piece of cake for the big animal
(stating that big animals store more fat is not correct: need to mention efficiency or endurance)

11. The "ideal free distribution" is a theory that predicts how foraging animals will distribute themselves among feeding patches of different intrinsic quality (where quality is based on the total amount of food in patch or the rate at which food is produced). The theory is easily tested with a school of fish in an aquarium and two separate food dispensers that differ in the rate at which they dispense food. (3 points)

i) A test of the ideal free distribution is conducted in a tank with 20 fish. There are two feeding stations. Station A dispenses 3 fish pellets per minute, while Station B dispenses 1 fish pellet per minute. If these fish show a perfect ideal free distribution:

How many individuals will be at Station A? ______15_____________

How many individuals will be at Station B? _______5_____________

ii) What single aspect of the behavior of individual fish is critical for producing the ideal free distribution?

that individuals seek to maximize foraging rate

12. What are three evolutionary benefits of dispersal (3 points):

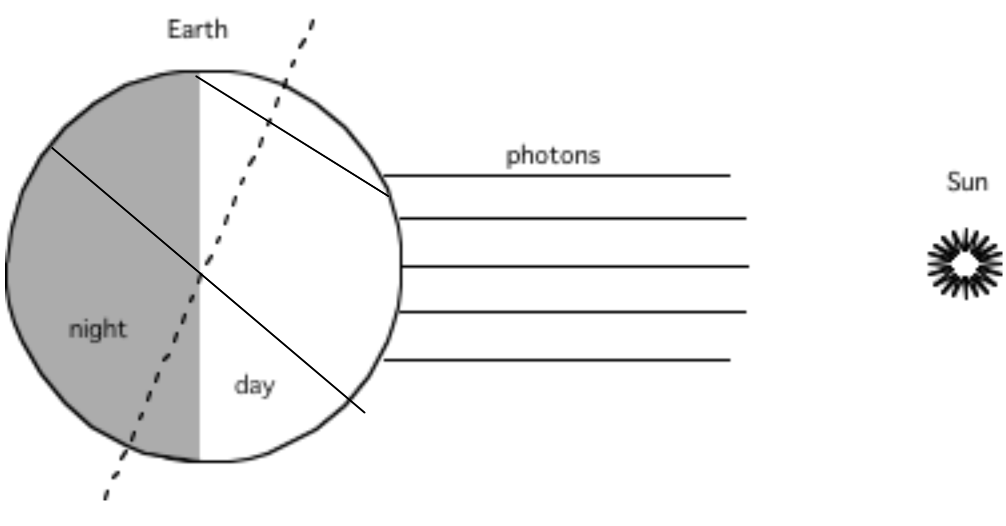
i) avoid competition,, or fill empty sites (either is correct)

ii) habitat change (or escape habitat change)

iii) avoid mating with relatives (inbreeding)

13. The globe illustrated below shows the earth on June 21, the longest day of the year in the northern hemisphere. The top of the globe is the northern hemisphere and the dashed line shows the earth's rotational axis relative to the sun on this day.

On the globe, draw in and label the equator and the arctic circle. Draw carefully as we want the exact location based on information in the drawing. (2 points)



arctic circle touches intersection shade and light at top, equator crosses intersection shade light where it crosses tilt (dashed line) i.e. half equator in dark half in light (12h day, 12 h night)