

NAME: _____ Student #: _____

MIDTERM EXAM – BIO 2129 – ECOLOGY

WRITE YOUR NAME ON THE EXAM RIGHT NOW. Answer all questions in the space provided. Write clearly: illegible answers will NOT be marked. Show all necessary calculations. Questions have different values, so budget your time accordingly.

1. An ecologist wants to predict population size for a bird species. The bird species breeds in April. The ecologist observes the total population size for the bird species in two successive years and finds that it has 5280 individuals at the start of the study and 5126 individuals in year 1.
 - a. What will the population size be in year 11 if present trends continue? (2 marks)

$$N(0) = 5280$$

$$N(1) = 5126$$

$$\text{Therefore, } \lambda = 5126/5280 = 0.9708$$

$$N(t) = N(0) \times \lambda^t$$

$$N(11) = 5280 \times 0.9708^{11}$$

$$N(11) = 3813$$

- b. If individuals bred continuously, instead of once per year, what would be the population's intrinsic rate of increase? (2 marks)

$$\lambda = e^r$$

$$\text{So, } \ln(\lambda) = r$$

$$\ln(0.9708) = r$$

$$r = -0.0296$$

2. According to Rabinowitz' classical definitions, rarity can take seven forms, based on combinations of three criteria. What are these criteria? (3 marks)

1. Numerical abundance or population size (i.e. small populations = greater rarity)
2. Range restriction (or geographical range size -> small ranges = greater rarity)
3. habitat specialization (greater specialization = greater rarity)

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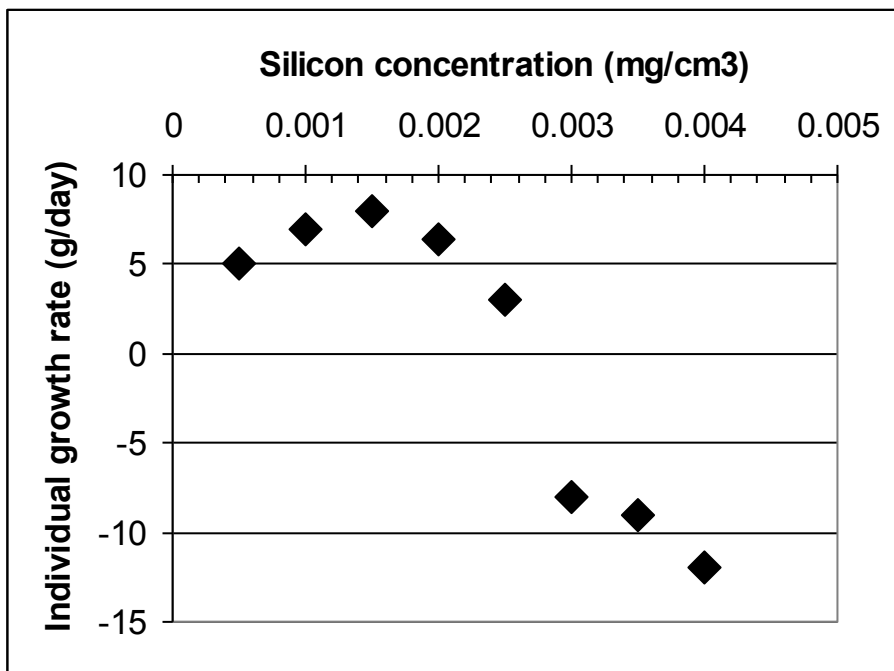
3. An ecologist is interested in determining what nutrient limits a particular population's growth rate and makes a series of observations:

Nutrient	Concentration within the organism's tissues (mg/cm ³)	Concentration within the organism's food source (mg/cm ³)
Glucose	1.1×10^{-2}	16
Galactose	0.9×10^{-2}	12
Fructose	0.08	0.02
Phenylalanine	0.51	0.01
Glucosamine	0.09	0.003
Silicon	0.001	0.002

a. What is the limiting nutrient? Explain fully. (2 marks)

Phenylalanine (1 mark). It must be concentrated by 51 times ($0.51/0.01 = 51$) in the organism's tissues relative to the environmental concentration. (something like this for 1 mark)

b. The organism's growth with respect to silicon in food shows the following pattern:



Discuss the effect of silicon on this organism. (2 marks)

Silicon is a limiting nutrient at low concentrations. The organism's growth rate is positive at low concentrations up to about 0.0025 mg/cm³ or so. The optimal concentration appears to be just about 0.001 mg/cm³. (something like this for 1 mark) However, at high concentrations, the organism's growth rate is actually negative, suggesting that Si is actually a poison for this organism at high concentrations. (must note the negative effect at high concentrations for 1 mark)

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4. An ecologist is curious about what factors control metabolic rates in fish. She builds a hypothesis that metabolic rate is positively related to the availability of food and a second hypothesis that metabolic rate is positively related to water temperature.
 - a. She makes two sets of observations of metabolic rate as a function of food and as a function of water temperature. She discovers a negative correlation between metabolic rate and food availability and a positive correlation between water temperature and metabolic rate. What should she conclude about her two hypotheses? Why? (2 marks)

Her evidence is contrary to the first hypothesis about food availability, so she rejects it. The second hypothesis is supported by her evidence so it is not rejected. (easy two marks)

- b. Experimental results yield 3 regression equations:

$$\text{Metabolic rate} = 2.5 + 0.62 \text{ Temperature} - 0.09 \text{ Food}, R^2 = 0.52$$

$$\text{Metabolic rate} = 2.2 + 0.54 \text{ Temperature}, R^2 = 0.51$$

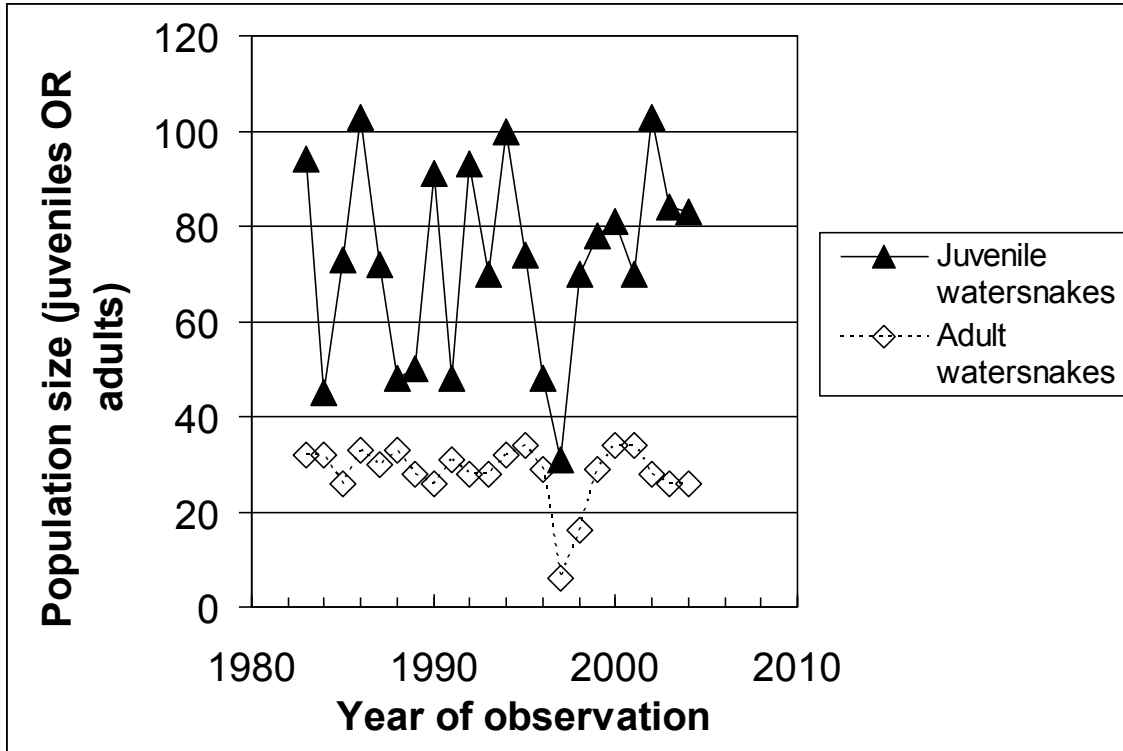
$$\text{Metabolic rate} = 2.48 - 0.11 \text{ Food}, R^2 = 0.43$$

Discuss the relationships between the dependent and predictor variables fully. Also identify which equation is preferable and why. (4 marks)

Temperature is clearly the strongest individual predictor variable – it is strongly, positively related to MR and explains 51% of the variation in the dependent variable. Food availability is negatively and less strongly related to MR and explains only 43% of the variability. Temperature and food availability are also related to each other. (2 marks). The second equation is preferable. It has essentially identical capacity for prediction to the first equation ($R^2 = 0.51$ instead of 0.52), but has only one predictor in it. According to Occam's razor (or law of parsimony, whatever), the simpler explanation is to be preferred. (2 marks)

One could argue the first equation is preferable because it has the highest R^2 but then the student must make a case that the extra 1% is actually important.

5. Biologists have monitored a population of watersnakes over a long period and find the following data for population trends of adults and juveniles per year. Explain fully. (4 marks)



This population shows **density dependence**. It's adult snake population remains roughly at a constant level almost every year, irrespective of how many juvenile snakes arrive into the population. This means that mortality rates vary with population size: as more juveniles are born, mortality among them increases such that adult snake populations remain roughly consistent (maybe a predator, maybe resource availability). However, there is a **density-independent** event (probably some sort of environmental catastrophe) around 1997 that leads to a sharp dip in both juvenile and adult survivorship. The population does recover, however, and regular density dependent control takes over.

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6. An ecologist goes to two locations to survey population size for two species. The ecologist takes 7 randomly placed samples throughout the two locations and observes the following population sizes.

	Species 1 Location 1	Species 1 Location 2	Species 2 Location 1	Species 2 Location 2
Sample 1	57	104	0	0
Sample 2	50	97	1	24
Sample 3	56	111	120	22
Sample 4	40	116	110	0
Sample 5	41	77	4	23
Sample 6	51	104	108	0
Sample 7	47	58	5	25

a. Calculate the variances for “Species 1, Location 1” and “Species 2, Location 1”. (4 marks)

Students who don't show any calculations and get the wrong answer or write the wrong thing get NO MARKS. Students can get two marks if they get the right answer but not if they get the wrong one. If their calculations are basically right but they make some small error, then half marks.

$$\text{Variance} = \frac{\sum(X_i - X_{\text{mean}})^2}{(n-1)}$$

$$\text{Variance of spp 1, location 1} = 44.47$$

$$\text{Species 2, location 1 variance} = 3484.238$$

b. Identify the population distributions shown by each of these species. (2 marks)

Species 1 shows a random distribution (not a uniform distribution)

Species 2 shows a clumped distribution.

c. Describe differences between the two locations with respect to these species. (2 marks).

Both species show similar distribution types in both habitats, BUT location 2 is a more favourable environment for species 1. Evidence for this statement comes from its population size in location 2: it tends to be much higher.

Species 2 finds location 1 more favourable – evidence is the same (higher population size in that location).

7. Discuss three sources of mortality among wildebeests based on “The Year of the Wildebeest” and their relative importance. (4 marks)

Everything kills wildebeests. Crocodiles, turning disease, lions, getting separated from your parents (this is not “stupidity”), starving to death. Must be specific to get marks. “Predators” is not a good answer as you don't need to see the movie to know this is true. Must actually name the predator...