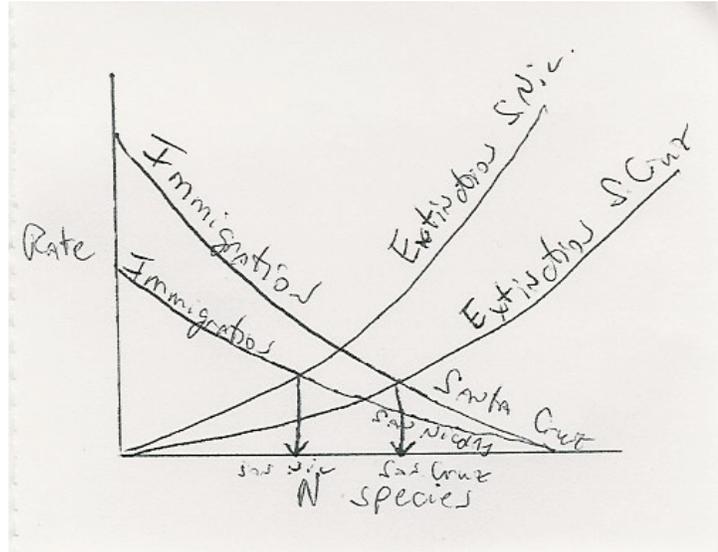


Your name: \_\_\_\_\_

# EEB 122b SECOND MIDTERM

**Question 1.** A scientist is interested in understanding the biodiversity of the California Channel islands located off the coast of Southern California. The focus is on two islands, San Nicolas and Santa Cruz islands, that differ in total area and distance from the mainland of California.

a) Using the map and axes provided, draw and label the curves that define the equilibrium conditions of San Nicolas and Santa Cruz islands (two curves for each island). Be sure to label each curve. (6 pts)



b) Assuming each island is at equilibrium, which should we expect to have fewer species present? Briefly explain your answer. (3 pts)

*San Nicolas. It is smaller (higher extinction rate) and farther from the continent (lower immigration rate).*

d) The scientist spends an entire summer counting the number of species on each island and finds that the island predicted to have fewer species actually has more. Give one reason why this might be. (3 pts)

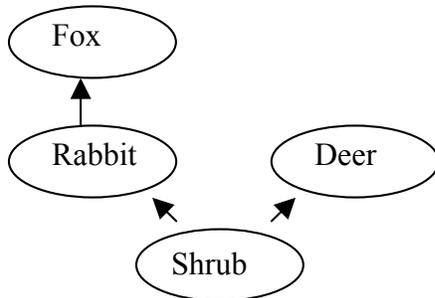
*Speciation could be occurring on the smaller, more distant island, where the local adaptive radiations could be overwhelming the effects of size and isolation on species number.*

*Habitat heterogeneity on the larger island could actually be less than on the smaller island.*

*Many other correct answers possible – Williamson’s critique lists several.*

**Question 2.** On an isolated oceanic island 3,000 miles from any continent, you find only 4 species: a flowering shrub, a rabbit, a large deer, and a small fox.

a. Draw a food web for this island ecosystem (3 pts)



b. Which species are in competition? (2 pts)

**The deer and the rabbit**

c. If predation is NOT the reason they can coexist, and the deer and the rabbit eat PRECISELY the same parts of the flowering shrub, at PRECISELY the same rates, then what explains how they manage to coexist? (2 pts)

**Intraspecific competition is stronger than interspecific competition**

d. Identify an empty niche. (2 pts)

**A predator that consumes deer**

e. An extreme weather event results in the extinction of the fox population. What change do you expect in the flowering shrub population? (3 pts)

**The shrub population would decrease**

**Question 3.** You are studying a population of endangered Devil's Hole pupfish (*Cyprinodon diabolis*). So far your research has produced this life table for a population from one pond:

Age in years	Survival, or the probability of an individual of age $x$ surviving to age $x + 1$ . ( $s_x$ )	Fecundity, or the birth rate for individual of age $x$ . ( $b_x$ )
0 to 1	0.1	0.0
1 to 2	0.2	0.0
2 to 3	0.0	50.0

a. Given this information calculate the number of individuals for the next two years. (6 pts)

Age in years (X)	# of age X ( $n_x$ ) Year 1	# of age X ( $n_x$ ) Year 2	# of age X ( $n_x$ ) Year 3
0	250	250	250
1	25	25	25
2	5	5	5

b. What is the per generation rate of increase of ( $R_0$ ) when the population is at stable age distribution? (1 pt).

*For this we accepted answers consistent with the work in part a.*

c. Based on your work in part (a), what is the annual per capita rate of increase from year 2 to year 3? (1pt)

*For this we accepted answers consistent with the work in part a.*

c. This model takes birth and death rates into account. If your fish population lives in ponds that are intermittently connected, what other two reciprocal factors are important when calculating your population size? (2 pts)

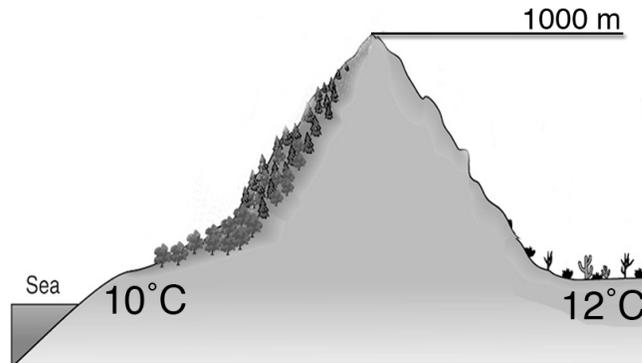
*Immigration and Emigration*

d. How would you incorporate the factors from (c) into this equation for population size? (2 pts)

$$N = B - D + I - E$$

Where  $N$  = Pop. size;  $B$  = Births; &  $D$  = Deaths;  $I$  = Immigration;  $E$  = Emigration

**Question 4.** In the Pacific Northwest, the rise of the Cascade mountain range has had a major impact on the structuring of the region's biological communities. The western (coastal) side of the range contains lush temperate rain forests, while the eastern side of the mountain range is mostly dry, containing arid desert areas similar to those found in Nevada and Utah.



a. On the illustration above, draw or write where you'd expect to find dry and wet areas, plus where precipitation is greatest and the direction of the air currents. (3 pts)

*Arrow going left to right*

b. Explain why the eastern slope of the above mountain is 2°C warmer than the western (coastal) slope. (3 pts)

*Warm coastal air rises against the mountain, and cools as it gains elevation. Cooling moist air condenses and precipitates out on the western side. It warms because water releases heat when it condenses into rain. The air continues to move eastward, but without moisture it heats up faster. The eastern side has dry, warm air.*

c. During 'normal' years, the coastline of Peru possesses some of the richest marine fisheries in the world. Yet despite Peru's proximity to the equator, the temperature of the ocean water surrounding it is quite cold. Explain how the Coriolis force and offshore winds cause these 'normal' conditions (3 pts).

*CF and offshore winds push warm, surface waters into the western Pacific. The surface waters are replaced with by cold, nutrient-rich waters of the deep ocean upwelling against the coast. The correct answer must address both the CF/offshore winds AND upwelling. There must be descriptors accompanying these two forces.*

d. On Peru's coast, El Nino has been associated with the collapse of marine fisheries and the organisms that depend on them. El Nino events are associated with warm water in the EASTERN Pacific Ocean. Explain where this water came from and how its movement during El Nino events alters fishery productivity in the WESTERN Pacific Ocean. (3 pts)

*A, 3pts) During normal years, the water from the eastern Pacific Ocean (at Peru's coast) is pushed away into the western Pacific Ocean by CF and offshore winds. This water accumulates to a level approaching 1 meter above that of Peru's coastline. During El Nino events, the winds die down and the accumulated, warm water rushes back toward Peru, covering the cold, nutrient-rich waters. Upwelling cannot continue, shutting off the influx of nutrients to Peru's fisheries. Hence, the fisheries off Peru suffer during El Ninos. B, 1pt) There is no change to the fisheries in the Western Pacific. There is no continent there to force any cold, deep, nutrient-rich waters up to feed the fisheries. Moreover, the water was warm there to begin with, and it will remain at those temperatures during El Nino events.*

**Question 5.** Dominant male bluegill sunfish defend nests into which females deposit eggs. Smaller males try to sneak copulations while the nest-defending male is distracted. Fights ensue. The pay-off matrix below describes the costs and benefits of each strategy. The benefits result from successful breeding attempts; the costs result from fights; both are reckoned in the currency of fitness.

Focal Strategy	Interacting with	
	Nester	Sneaker
Nester	-30	+50
Sneaker	-15	+20

The population is at equilibrium when the average pay-off for a nesting male equals the average pay-off for a sneaker male.

a. What proportion of the population will be nesters at equilibrium? What proportion will be sneakers? Let the proportion of nesters =  $n$  and the proportion of sneakers =  $1-n$ . Show all work. (6 pts)

*Using the information provided, the goal is to solve for  $n$ , the proportion of the nesters in the population, such that  $E(\text{Nester}) = E(\text{Sneaker})$  (where  $E()$  is expected value).*

*Calculate the expected payoff of each type by taking the payoff in each scenario multiplied by the probability of experiencing such a scenario.*

*As such:*

$$E(\text{Nester}) = -30n + 50(1-n)$$

$$E(\text{Sneaker}) = -15n + 20(1-n)$$

*Setting them equal and solving for  $n$  gives:*

$$-30n + 50 - 50n = -15n + 20 - 20n$$

$$50 - 80n = 20 - 35n$$

$$30 = 45n$$

$$n = 30/45 = 2/3$$

$$\text{(for sneakers: } 1-n = 1/3\text{)}$$

*-0.5 pt for correctly setting up equations but confusing the algebra partial credit:*

*+4 for setting up correct equation but multiplying by an extra population frequency term or for appropriately assigning the frequency of costs and benefits encountered but not solving the equation appropriately*

*+3 for setting up equation accounting for interactions with both strategies, but placing strategy interacted with rather than focal individual on the same side of the equation.*

*+2 for setting up equation using only 1 of paired set of interactions*

*+1 for identifying need to account for costs/benefits of interactions but incorrectly*

How do you expect sneaker and dominant males will differ in:

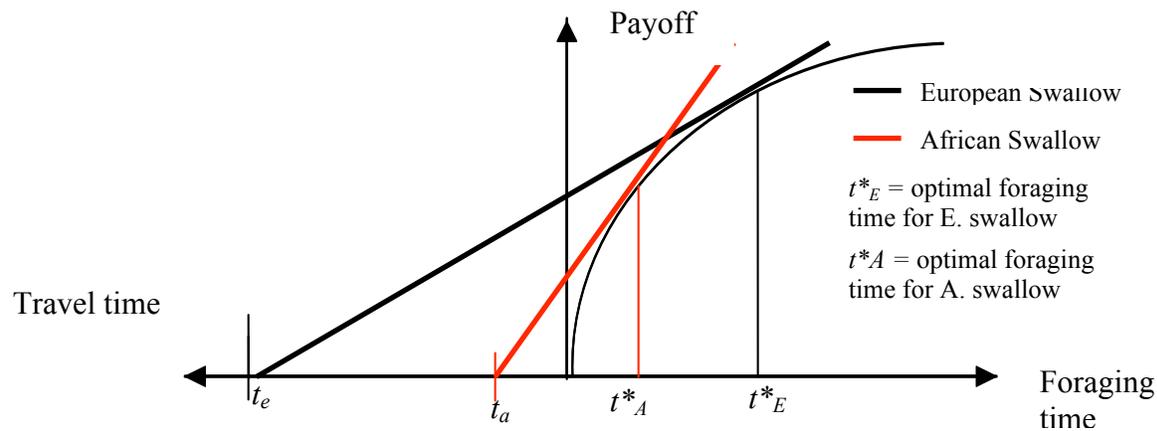
b. Age and size at maturity (3 pts)

Sneakers mature faster (1.5 pts) Sneakers mature at a smaller size (1.5 pts)

c. Distinctive coloration/resemblance to females (3 pts)

*Sneakers will mimic females in size and color while dominant males are more likely to be dimorphic with a larger size and distinctive coloration (3 pts)*

**Question 6.** The curve below depicts a possible payoff curve for African and European swallows with respect to foraging time (right side of the time axis).



a) In the graph above, assume that  $t_e$  represents the traveling time from an individual European swallow's nest to the foraging patch. What is the optimal foraging time for such a bird? Please depict your answer graphically using the template above, and be sure to label the optimal foraging time. (3 pts) *In the depiction above, please assume that lines are drawn tangent to the payoff curve.*

b) Now, consider the case of an African swallow (assumed to have the same payoff curve). If the airspeed velocity of an African swallow is faster than that of a European swallow (i.e. the travel time is shorter), do you expect it to spend more or less time foraging than the bird in part (a)? Please use the same graph for your answer. (3 pts)

*As shown above,  $t^*_A$  is less than  $t^*_E$ , where  $t^*_A$  and  $t^*_E$  are the predicted optimal foraging times for African and European Swallows, respectively. ( $t_a$  is a possible African swallow traveling time.)*

c) What is the geometric explanation for why these times are optimal? (3 pts)

*Full Credit: The slope of a line drawn from the traveling time to the payoff curve represents the rate of payoff per unit time spent traveling and foraging. A tangent line will have the highest slope of any such line which could be drawn. A higher slope would not touch the payoff curve and would be impossible, whereas a lower slope would provide a lower rate of payoff with respect to time invested in the process. Therefore, the foraging time at which such a tangent line touches the payoff curve is the predicted, optimal foraging time. As such, the European swallow is predicted to spend more time in the foraging patch in order to compensate for its greater travel time. (Other acceptable answers, such as using triangles were possible, provided that the explanation was still correct)*

*Half Credit: Mentioning only that tangency implies optimality without explanation, or correctly discussing why shorter (or longer) traveling times suggest shorter (or longer) foraging times, but without providing a geometric explanation.*

Your name: \_\_\_\_\_

d) Suppose you have a chance to observe the actual behavior of European swallows in the wild. Early in your observations, you notice that there are more potential predators in the foraging patch than you had originally assumed. How would this new information affect your graphical model? (3 pts)

*In general, it is expected that the added risk of predation during foraging would reduce the amount of time spent foraging (this could also be visualized as a payoff curve with a lower slope at all points). Answers suggesting that foraging time would increase were also possible (generally requiring the assumption that the predator attacks while the swallow is traveling between patches).*

**Question 7.** Two species of herbivorous zooplankton (A and B) colonize a small pond. Both populations start at low densities and increase for several generations. After many generations the biomass of species A accounts for 95% of the zooplankton biomass.

a. Do you think intraspecific or interspecific competition is a stronger limitation on the population growth of species A (3 points)?

**Intraspecific Growth**

b. Do you think intraspecific or interspecific competition is a stronger limitation on the population growth of species B (3 points)?

**Interspecific Growth**

The change in the populations over time can be represented by the Lotka-Volterra model below where  $N_A$  and  $N_B$  are the population densities of species A and species B at time  $t$  respectively. Parameter values for the two species are shown below.

$$\frac{dN_A}{dt} = r_A N_A \frac{(K_A - [N_A + \alpha_{AB} N_B])}{K_A}$$

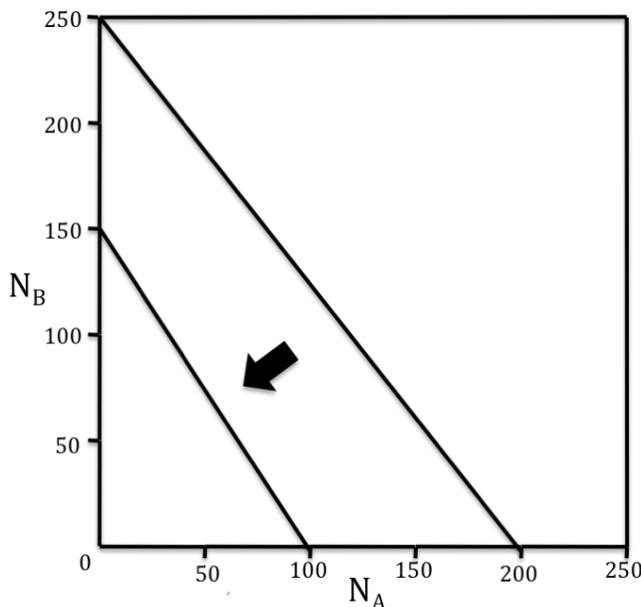
$$\frac{dN_B}{dt} = r_B N_B \frac{(K_B - [N_B + \alpha_{BA} N_A])}{K_B}$$

Parameter	A	B
r – growth rate	1	1
K – carrying capacity	200	150
$\alpha$ – competition coefficient	$\alpha_{AB}=0.80$	$\alpha_{BA}=1.5$

c. If species B is growing alone, at what density does species B experience zero growth ( $dN_B/dt=0$ ) (2 points)?

**Zero Growth = K = 150**

d. Below the zero growth isocline for species A is drawn across densities of species A and Species B. Draw the zero growth isocline for species B (4 points).



**Question 8.**

a. If an altruist sacrifices his life to save the life of his full siblings, how many full siblings must he save to make it pay from the point of view of his genes? (2 pts)

2

b. Another altruist performs a self-sacrificing act that costs him C children, but that benefits a full sibling's fitness. How many additional children must the full sibling have as a direct result of the altruist's act in order for the altruist's genes to "break even?" (4 pts)

2C

Vampire bats need to ingest 50-100% of their body weight in blood per evening, and will starve after 60 bloodless hours. They will often regurgitate blood into the mouths of their roost mates to keep them alive. The data below depict the time individual bats spend in association with the individuals with which they share blood meals (1), their percent relatedness to those individuals (2), and their percent relatedness to other members of the colony (3). Using these data, answer the following two questions:

c. What evidence does each graph provide to support the hypothesis that kin selection is driving the sharing of blood meals in this group? (3 pts)

1. Individual bats spend a high proportion of time in association with members of the colony they share meals with, which could be mostly kin.

2. Individuals share most frequently with kin

3. Multiple Solutions

d. What evidence does each graph provide to support the hypothesis that reciprocal altruism is driving the sharing of blood meals in this group? (3 pts)

1. Individual bats spend a high proportion of time in association with members of the colony they share meals with, repeated association is condition for reciprocal altruism

2. Multiple Solutions

3. Individuals often share with unrelated members of the colony

