Zoology 357 - Evolutionary Ecology - Second Exam ____________________________

1. **(12 points) Diagram, name and give one real life example of any three different indirect interactions. Name each of the interacting species clearly: Show direct interactions with solid lines and indirect ones with dashed lines. Depict positive effects with arrows pointing to the party that benefits and negative effects with circle-headed arrows pointing to the party that suffers.**

Important that:

1. You clearly mark the direct Vs. indirect interactions,
2. +ve and –ve effects.
3. No need to write any sentences , as long as you clearly indicate the identity and position of all the protagonists.

2. (20 points) Following are the coupled Lotka-Volterra differential equations for competition between two species.

$$\frac{dN_1}{dt} = r_1 N_1 \left(\frac{K_1 - N_1 - \alpha_{12} N_2}{K_1} \right)$$
$$\frac{dN_2}{dt} = r_2 N_2 \left(\frac{K_2 - N_2 - \alpha_{21} N_1}{K_2} \right)$$

(a) Name what variables and constants the symbols in the right hand sides of the above equations represent (4 pts)

r_1, r_2 = Growth rates of spp 1&2

N_1, N_2 = Populations sizes of spp 1&2

K_1, K_2 = Carrying capacities of spp 1&2

α_{12}, α_{21} = Competition coefficients

(b) Using the equations above, derive the conditions for stability. Show all your work. (10 pts)

Setting $\frac{dN_1}{dt} = 0$ gives $r_1 N_1 \left(\frac{K_1 - N_1 - \alpha_{12} N_2}{K_1} \right) = 0$ i.e., $K_1 - N_1 - \alpha_{12} N_2 = 0$.

NOTE THAT I AM GIVING FULL CREDIT FOR HAVING DONE STUFF UPTO THIS STAGE. ALL THAT FOLLOWS IS ADDITIONAL STUFF THAT WOULD HAVE BEEN IDEALLY INCLUDED.

Now, to find the boundary conditions (i.e., the situations where either species has gone extinct), we first set $N_1 = 0$ i.e., $K_1 - \alpha_{12} N_2 = 0$, or $N_2 = \frac{K_1}{\alpha_{12}}$ and then $N_2 = 0$, i.e., $K_1 - N_1 = 0$, or $N_1 = K_1$

Repeat this for the second species, and we have $N_1 = \frac{K_2}{\alpha_{21}}$ and $N_2 = K_2$ as the boundary conditions.

Therefore, the two species will coexist when $N_2 < \frac{K_1}{\alpha_{12}}$, $N_1 < K_1$, $N_1 < \frac{K_2}{\alpha_{21}}$ & $N_2 < K_2$

(c) Now graph the isoclines for both species showing a scenario where both species will <u>definitely</u> coexist. Label both axes and their intercepts neatly. Show the stable equilibrium point(s). (6 pts.)

See figure 12.3d

3. (6 pts) Show how you can convert the competition equations in question (2) to model mutualism, by writing out two corresponding mutualism equations spp 1 and 2. Define all variables and constants.

$$\frac{dN_1}{dt} = r_1 N_1 \left(\frac{K_1 - N_1 + \beta_{12} N_2}{K_1} \right)$$

$$\frac{dN_2}{dt} = r_2 N_2 \left(\frac{K_2 - N_2 + \beta_{21} N_1}{K_2} \right)$$

Here, β_{12}, β_{21} = Mutualism coefficients; all other parameters are the same as 2 (a).

YOU COULD USE ANY NOTATION, AS LONG AS THE INTERACTION SIGN AND YOUR INTERPRETATION OF THE INTERATIONCOEFFICIENT IS CORRECT.

4. (6 points) Draw two <u>clearly labeled</u> diagrams depicting the difference between a population with high between-phenotype variation and one with high within-phenotype variation for the <u>same niche width</u>.

SEE FIGURE IN NICHE CHAPTER

5. (4 pts) Interpret the α's in the Lotka-Volterra competition equations in terms of niche overlap.

The α's, which represent competition coefficients, can be interpreted as a single scalar value that summarizes the niche overlap between two species. Thus the α's must be proportional to amount of niche overlap.

6. (8 pts) We assumed that competition coefficients (the α's) are constant in a community matrix. Need this always be the case in nature? Name one evolutionary, and one ecological mechanism by which α between two species could change. Hint: think about your answer to question 5 above.

No, they needn't be fixed. Niche overlaps can change.

Behavioral character displacement within a generation is an ecological mechanism.

Assuming that that at least a part of the phenotype for niche utilization/occupancy is heritable, change in phenotypic frequencies because of interspecific selection is an evolutionary mechanism for character displacement (The phenotype range of species *i* that overlaps the least with spp *j* will have the highest fitness).

7. (8 pts) Describe one experimental and one observational approach you would use to detect/estimate the following in nature

(a) Predation (4 pts)

Observational
*Make direct observations of predation events

Experimental
*Remove potential predator and see effect on prey population growth

(b) Diet niche overlap between two species (4 pts).

Observational

*Measure and compare food intake OR measure stomach contents OR Observe feeding behavior

Experimental

* remove one competitor and see effect on other OR remove certain food items and see effect on both consumers

8. **(6 points) E.O. Wilson proposed four equilibria that take place over the course of time as a community assembles. Name these four and give a one-sentence summary of what is happening during each of the stages.**

SEE PAGE ON COMMUNITY ASSEMBLY, (AFTER THE DEFAUNATION EXPT. STUFF) IN T. BOOK

9. **(6 pts) Explain Rosenzweig and MacArthur's argument for why the prey isocline should have a hump.**

See pp. 307-309 in textbook

10. (12 points) Discuss the challenges facing a parasite and indicate how selection operating on parasites differs from that on predators. Include considerations of virulence and transmission.

The answer should include:

1. Key life history differences between Predators and parasites
2. The problem that predators do not face, but parasites do: achieving an optimum tradeoff between transmission ability/probability and virulence (exploiting the host)

11. (12 pts) Define (or explain in 1-2 lines) each of the following (2 points each):

Fundamental Niche

The ideal nice volume that a species' genetic variation and phenotypic plasticity can occupy, without the effects of predation, competition, etc.

Niche breadth

The range of resources that a species' population can utilize, along one or more niche dimensions/axes

Keystone species

A species that plays a pivotal role in a food web/chain or community, the removal of which leads to sudden changes (perturbs the stability) in populations of the other members of the community. e.g., The predator *Psiaster* in the inter-tidal community.

Coevolution

Reciprocal evolution of two or more species due to selection by inter-specific interactions.

Alpha Matrix

A matrix of community interaction coefficients (to be more specific, the α matrix represents competition) between all interacting species of the community.

Trophic cascade

Three or more linked trophic levels (e.g., by predation) that results in alternating/complementary increases or decreases in abundance or biomass across levels.