# BI2113: Ecology and Evolution (August 2024 Semester)

**Assignment 1: Total Marks = 20**

**1. For all the questions, you can either solve analytically or numerically (using any platform of your choice). But whatever you do, you need to show your work. If you are writing a code, paste it with your answer. If you are doing on a spreadsheet like excel, paste screenshots of your work. Anything else, please mention / give screenshots.**

**2. Your assignment must be submitted via the google form**

**https://forms.gle/ahHZLYUotGDRrVzq8**

**3. Please upload your assignment answers as pdf (<10MB) through this form. The file size limit is a hard one. Please make sure that you make your graphs accordingly.**

**4. Please name your file as <<Name>>_<<Roll Number>>.pdf. For example: Ramu Kaka_12345.pdf.**

**5. You can submit through this form only once. Once submitted, you cannot change your answers.**

**6. You should get an acknowledgement of your submission automatically from google. If you do not get that within 3-4 hours after submission, please check your spam email. If it is not there, write immediately to s.dey@iiserpune.ac.in. This needs to be done at least a day or two before the deadline. If you approach me after the deadline saying you have no idea what went wrong, then there will be little that I can do to help you.**

**7. Last Date: 5.00 PM IST on 07-October-2024.**

**8. If you have missed the deadline, then there is nothing that I can do about it. Please do not email me your pdf, I will neither consider it, nor respond to such emails.**

Q1. For the population described by the transition matrix given below

$$\begin{pmatrix} 0.4 & 3 \\ 0.32 & 0.7 \end{pmatrix}$$

a) What is the ratio of the total population sizes (i.e. sum of both stage classes in a generation) in two successive generations at equilibrium?

b) At equilibrium what is the fraction of the juveniles in any given generation? This refers to the ratio of juveniles to the total population size. **(1.5+1.5 = 3 marks)**

Q2. Assume a Lotka-Volterra competition scenario with the following parameter values:

Species 1: $r_1$=1, $K_1$=200, $\alpha_{12}$ = 0.8; Species 2: $r_2$=0.5, $K_2$=300, $\alpha_{21}$=2

Given below are four starting points for the system. For each case, what will be the population sizes of Species 1 and Species 2 at equilibrium? For this your answer should consist of the filled table as well as the four isocline diagrams showing the **trajectory of the system** (not merely the vectors).

**(4 X 2 = 8 marks).**

| | Starting population sizes | | Equilibrium population sizes | |
|---|---|---|---|---|
| S. No. | Species 1 | Species 2 | Species 1 | Species 2 |
| 1 | 70 | 175 | | |
| 2 | 70 | 75 | | |
| 3 | 30 | 120 | | |
| 4 | 30 | 100 | | |

**For each scenario: 1 mark for generating the plot, 0.5 marks for the trajectory and 0.5 marks for getting the correct equilibrium values.**

Q3a. Suppose we have a hypothetical insect population with a cohort lifetable that looks as on the right. Over time, a population of this insect will be increasing or decreasing in numbers? **(3 marks)**

| Age (in days) | Number surviving | Average Number of eggs per capita |
|---|---|---|
| Egg | 250 | 0 |
| 1 | 239 | 0 |
| 2 | 210 | 0 |
| 3 | 156 | 0.551 |
| 4 | 129 | 0.412 |
| 5 | 109 | 0.251 |
| 6 | 76 | 0.99 |
| 7 | 43 | 0.95 |
| 8 | 32 | 0.71 |
| 9 | 19 | 0.49 |
| 10 | 9 | 0.135 |
| 11 | 0 | 0 |

Q3b. Suppose there was a mutation in the insect population mentioned in Part a due to which this insect now lives two days longer with an enhanced egg-output during late life. However, the insect now starts reproducing one day later. The modified life-table is given to the right. From the perspective of long-term dynamics, is this a beneficial mutation or a harmful one? **(3 marks)**

| Age (in days) | Number surviving | Average Number of eggs per capita |
|---|---|---|
| Egg | 250 | 0 |
| 1 | 239 | 0 |
| 2 | 210 | 0 |
| 3 | 156 | 0 |
| 4 | 129 | 0.412 |
| 5 | 109 | 0.251 |
| 6 | 76 | 0.99 |
| 7 | 43 | 0.95 |
| 8 | 32 | 0.71 |
| 9 | 19 | 0.49 |
| 10 | 9 | 0.27 |
| 11 | 9 | 0.27 |
| 12 | 9 | 0.27 |
| 13 | 0 | 0 |

Q4. The government is planning to reintroduce 10 Namibian cheetahs to Madhya Pradesh's Gandhi Sagar Wildlife Sanctuary in January 2025. At the same time, they plan to introduce 30 Sangai deers from Manipur into the sanctuary as prey. No further introduction of either prey or the predator is planned. The government has decided to celebrate the introduction after a few years through a major celebration in the park inviting many world leaders. Park authorities have determined that the optimal viewing densities for the dignitaries would be 15 cheetahs and 18 sangais in the park. They have also determined that the cheetah-sangai system can be modelled as a Lotka-Volterra prey-predator system

$$\frac{\mathrm{d}N}{\mathrm{d}t} = r_1 N - CNP$$

$$\frac{\mathrm{d}P}{\mathrm{d}t} = -d_2 P + gCNP$$

where N and P denote the prey and the predator population respectively, and the other constants have their usual meaning as per the Lotka-Volterra prey-predator model. As per data from the scientists, the yearly rates are $r_1$= 1.05, C = 0.1, $d_2$=0.6 and g = 0.45. Based on this information, in which year will the celebratory event happen for the first time? Assume that all the assumptions of the Lotka-Volterra continuous prey-predator model are true for this system, and one needs to have both the cheetah's and the sangai's numbers to be simultaneously as per specifications. **(3 marks)**