Lesson Plan: Climate Change and Reproductive Fitness in Red Deer

As an **Undergraduate Biological Sciences** teacher, you can use this set of computer based tools to enable students to develop a comprehensive understanding about how **vertebrate populations of red deer (*Cervus elaphus*) show evolutionary responses in terms of reproductive fitness to climate change**.

Through this lesson students can observe how warming temperatures caused by climate change can have a direct effect on advancement of parturition time or breeding time. The changed breeding time and optimum fitness may reshape selective pressure and decrease population growth and place them at risk.

Thus, the use of this lesson plan allows you to integrate the teaching of a climate science topic with a core topic in the **Biological Sciences.**

Use this Lesson Plan to help the students to understand and find answers to:

1. What is fecundity?
2. What is the role of reproductive fitness in natural selection and evolution?
3. How climate change has led to changes in reproductive fitness in animals like Red deer?

Teacher-contributed lesson plan **by Dr. Simran Jit (Assistant Professor, Miranda House, University of Delhi) and Dr. Jaspreet Kaur (Assistant Professor, Maitreyi College, University of Delhi)**

Want to know more about how to contribute? Contact us.

About the Lesson Plan

Grade Level	Undergraduate
Discipline	Biological Sciences
Topic(s) in Discipline	Evolutionary Biology, Natural Selection, Reproductive Fitness, Fecundity, Red Deer, *Cervus elaphus*
Climate Topic	Climate and the Biosphere
Location	Global
Access	Online
Language(s)	English
Approximate Time Required	55-60 min

Contents

1.	Video (2 mins)	An introductory video that discusses the example of red deer which are giving birth slightly earlier each year due to warming climate. This can be accessed here.
2.	Video (14 mins)	A video that explains the relationship between reproductive fitness and natural selection using examples. This can be accessed here.
3.	Reading (20 mins)	A research article that demonstrates how the population of Red deer, living on the Isle of Rum, on the west coast of Scotland are evolving to give birth earlier in a warming climate. This can be accessed here.
4.	Reading (5 mins)	An article provides the details about reproductive fitness and how it is linked with natural selection. This can be accessed here.
5.	Classroom/Laboratory Activity (15-20 mins)	Using the above article, help students to learn the basic concepts of natural selection and reproductive variance through a hands-on activity. This can be downloaded from here.

Step-by-step User Guide

(Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.)

1	Introduce the topic by playing a video lecture	A video titled, "Evolutionary Thinking: Natural Selection" by Yale Courses, can be used to discuss the principle of reproductive fitness and how it is related with natural selection. This video can be used to discuss the basic conditions which are required for natural selection to occur. One of these conditions include 'variation in reproductive success'. This can be accessed here.
2	Discuss the topic further by using this short article	This article titled, "The Meaning of Fitness" by Sedeer el-Showk, can be used to emphasize the role of variation in reproductive success using the article. This can be accessed here.

3	Demonstrate how it related to Climate Change through this video	The video titled “Scottish red deer 'evolving' due to climate change” by Sharjah24 News, can be used to discuss how the animals are evolving in order to cope up with climate change by giving the recent example of red deer which are giving birth slightly earlier each year due to warming climate. This can be accessed here.
4	Enhance student knowledge on impact of Climate change on Red Deers through this article	An article titled, “The role of selection and evolution in changing parturition date in a red deer population” by Timothée Bonnet et. al., can be used to further build upon the original research article, wherein the role of selection and evolution in changing parturition date in a red deer population has been discussed in detail. This can be accessed here.
5	Conduct this Classroom/Laboratory activity for hands-on experience	Now, conduct the classroom/laboratory activity to explore the topic in more detail. This activity will help students to learn the basic concepts of natural selection and reproductive variance wherein different selective pressures like climate change can change the parturition date in a red deer population. Navigate to the ‘S1 Data. Data necessary to reproduce all analysis’ under ‘Supporting Information’ of the original research article (Bonnet et al., 2019) Original article can be accessed here. Alternatively, the data files can be directly downloaded through here. Then conduct simple linear regression analysis for parturition date or offspring birth date (in days) over the 45-year study period (from 1972 to 2016). The steps are given below: 1. Open the link and download the zipped folder. 2. The folder contains data files. Import ‘Birth_fit_data.txt’ file in MS Excel. 3. Use the two columns ‘OffspBirthYear &; OffspBirthDate’ and sort the OffBirthYear in ascending order. 4. Use the sorted data (from 1972 to 2016) for linear regression analysis by adding the trendline and displaying R-equation on the chart. 5. You will observe the trend line with negative slope (goes down and right). Statistically, this implies that as x increases, y decreases. In other words, the OffSpBirthDate decreases with increasing OffspBirthYear. Thus, this activity uses the *original research data* to deduce the statistical inference about decreased parturition date with respect to changing climate conditions during the 45-year study period (from 1972 to 2016).

Learning Outcomes:

The tools in this lesson plan will enable students to:

1. understand the concept of reproductive fitness in animals
2. find out how reproductive fitness is related to natural selection
3. differentiate between phenotypic plasticity and evolutionary responses
4. decipher the role of climate change in affecting reproductive fitness in animals
5. find out some recent evidence/examples where reproductive fitness has been affected in animals due to climate change

Additional Resources

(If you or your students would like to explore the topic further, these additional resources will be useful.)

1.	Video	(From 0 to 7:00 min) Fitness and Natural Selection This can be accessed here.
2.	Reading	This article provides the details about reproductive fitness and how it is linked with natural selection. This can be accessed here.

Credits / Copyrights:

1.	Video, “Scottish red deer 'evolving' due to climate change”	by Sharjah24 News, Youtube.
2.	Video, “Fitness and fecundity”	by Ross Firestone, Khan Academy Channel, Youtube
3.	Video, “Fitness and Natural Selection”	by Wilson Biology Lab Channel, Youtube.
4.	Reading and activity, “The role of selection and evolution in changing parturition date in a red deer population”	Bonnet, T., Morrissey, M. B., Morris, A., Morris, S., Clutton-Brock, T. H., Pemberton, J. M., & Kruuk, L. E. B. (2019). The role of selection and evolution in changing parturition date in a red deer population. PLOS Biology, 17(11), e3000493
5.	Reading, “The Meaning of Fitness”	by Sedeer el-Showk, Nature Education,