

Lab 9

Evolution and Adaptation: Using Woolly Worms and Other Creatures to Simulate Natural Selection

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Correlation

Miller 14th edition Chapter 5, Chapter 8, and Chapter 9
Acorn Book–Topic Outline in the APES Course

- II. The Living World
- D. Natural Ecosystem Change

Purpose

By completing this lab activity, students will become familiar with specific adaptations such as cryptic coloration and the ways some organisms breed more than others and whose genes can eventually dominate the gene pool of the population. Further, students begin to understand how this change in gene frequency could help or hinder a population's survival.

Objectives

1. Make predictions about the ability of certain organisms to fit in their given environment and their chances of survival.
2. Give examples of specific adaptations which determine which members of a population are more likely to contribute their genes to the next generation.
3. Describe natural selection as an ongoing process in nature, and describe it as the single most significant factor that disrupts genetic equilibrium.
4. List the environmental conditions which may cause a change in gene frequencies and cause evolution to take place.
5. Describe the causes of variation in a population.
6. Collect and process data and relate interpretations to the natural selection process.
7. Use a step-by-step procedure for testing a hypothesis and calculating a Chi-square test.

Background Information

Woolly worms are pieces of yarn of various colors distributed in a random manner over a designated area of your school yard. You will simulate the feeding by predators who like woolly worms as part of their diets. Your teacher will have you and a partner feed (collect) as many worms in a timed session as you can. The collected yarn is counted and recorded and a Chi-square test is used to determine if the yarn pieces were collected randomly or by a selection process.

Since worms of certain colors are best fitted to survive in their environment, certain variations are more favorable to the individual and the species than others. These favorable variations are termed adaptations. Adaptations increase an organism's chances of survival and subsequent ability to reproduce and pass on its traits (favorable genes) to its offspring. An example of adaptation is cryptic coloration, whereby an organism blends into its environment so well that it is difficult to detect. Cryptic coloration can help animals escape predators or capture unsuspecting prey. This "survival of the fittest" concept is supported by Darwin's Theory of Natural Selection.

As with many other worms, the wooly worms in this lab activity represent or simulate insect larvae in a natural habitat. They will complete their metamorphoses into adult insects, so long as they survive. Predation places a selection pressure on certain colors of wooly worms; those who exhibit favorable adaptations (i.e. remain hidden by their cryptic appearance and thus escape predation) are positively selected for. Those who contrast with their surroundings are easy prey for the predatory birds, and are said to be selected against. The gene frequencies for wooly worm coloration will change – such changes illustrate the dynamics of natural selection. Drastic and sudden changes in the environment may lead to extinction, but this is not common in nature.

Background on Random Numbers and Selection:

The different colors of yarn distributed randomly on school grounds represent the different color varieties of wooly worm. If these yarn pieces are collected randomly, the number of worms of each color should be nearly equal. If, however, the data does not support this hypothesis, then selection of certain colors must have occurred. A null hypothesis is proposed for these circumstances, something to the effect that the color of the wooly worms will have no effect on the numbers of each color collected. If you can reasonably show that this is not the case through a statistical process, then selection must have occurred. The Chi-square test is used to test the null hypothesis by comparing the expected number of worms of each color against the observed numbers actually collected. A variance between the expected and the observed numbers is likely in any chance event. The Chi-square test will determine if this variance is within acceptable statistical limits to support the original null hypothesis. The Chi-square test will reveal how likely it is that the worms were collected randomly.

Materials

Yarn of 8-14 different colors
Master chart of yarn colors
Chi Square Probability Table
Chi Square Calculations Table
Calculator

Procedure

Before activity:

1. After your teacher has explained the scenario, develop the Null Hypothesis for the activity.
2. Divide yourselves into pairs. This will be your “hunting” partner.

During Activity:

1. At your teacher’s signal, engage in a feeding frenzy for 5-10 minutes. Collect as many worms as you can.
2. After the feeding period, return to the classroom with your collected yarn. Refer to the Master Chart up on the board, and determine the number of each color of worm you and your partner collected.

After Activity:

1. Collect all class data, and transfer this data to your Chi-Square Calculations Table. This information should be placed into your table in the column labeled, “Observed number.”

Data

Chi-square Calculations Table

Color	A. Observed	B. Expected	C. Obs. - Exp.	D. (Obs. -Exp.) ²	E. (Obs. -Exp.) ² /Exp
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
	Total = χ^2 =				

1. Fill in the Chi Square table using the following information.

A. Class Observed Data

B. The “expected number” for each color is determined with your calculator by dividing the total number observed by the number of different colors:

$$\frac{\text{Total number observed}}{\text{Number of different colors}} = \text{Expected number for each color}$$

C. Subtract the expected number from the observed number. Answers may be either positive or negative.

D. Square the number obtained immediately above. (Negative numbers will now be positive.)

E. Divide the answer immediately above by the expected Exp number.

Repeat the calculations for each of the colors observed during the feeding period.

Determine the Chi-square value based on the following equation:

$$\chi^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

Add up all the final figures (column E) for each color to get the sum of Chi-square.

- Determine the degrees of freedom to be used. The degrees of freedom to use will always be one less than the total events (colors) observed. For example, if 12 colors were observed, then 11 degrees of freedom will be used.
- Determine the probability that the Chi-square value you obtained is caused by chance factors or by selection. The columns with the decimals - .99, .95, .50, .05, .01, and .001 refer to probability levels of the Chi-square numbers illustrated. If you obtained a Chi-square value of 10.339, then you could conclude that the observed numbers you obtained did vary from the expected but such a variance is likely 50% of the time. Therefore, chance alone could cause such a variance. The null hypothesis would be supported. However, if a Chi-square value of 19.675 or higher was obtained (at or below the .05 level of probability), then we would have to conclude that chance factors are not likely to cause the variance we observed. The null hypothesis would be rejected. Selection of certain colors over others must have occurred.

Degrees of Freedom (df)	<u>Probability (p)</u>										
	0.95	0.90	0.80	0.70	0.50	0.30	0.20	0.10	0.05	0.01	0.001
1	0.004	0.02	0.06	0.15	0.46	1.07	1.64	2.71	3.84	6.64	10.83
2	0.10	0.21	0.45	0.71	1.39	2.41	3.22	4.60	5.99	9.21	13.82
3	0.35	0.58	1.01	1.42	2.37	3.66	4.64	6.25	7.82	11.34	16.27
4	0.71	1.06	1.65	2.20	3.36	4.88	5.99	7.78	9.49	13.28	18.47
5	1.14	1.61	2.34	3.00	4.35	6.06	7.29	9.24	11.07	15.09	20.52
6	1.63	2.20	3.07	3.83	5.35	7.23	8.56	10.64	12.59	16.81	22.46
7	2.17	2.83	3.82	4.67	6.35	8.38	9.80	12.02	14.07	18.48	24.32
8	2.73	3.49	4.59	5.53	7.34	9.52	11.03	13.36	15.51	20.09	26.12
9	3.32	4.17	5.38	6.39	8.34	10.66	12.24	14.68	16.92	21.67	27.88
10	3.94	4.86	6.18	7.27	9.34	11.78	13.44	15.99	18.31	23.21	29.59
11	5.58	5.58	6.99	8.15	10.34	12.90	24.73	17.28	19.68	24.73	31.26
12	6.30	6.30	7.81	9.03	11.34	14.01	26.22	18.55	21.03	26.22	32.91
13	7.04	7.04	8.63	9.93	12.34	15.12	27.69	19.81	22.36	22.69	34.53
14	7.79	7.79	9.47	10.82	13.34	16.22	29.14	21.06	23.69	29.14	36.12
	<u>Nonsignificant</u>									<u>Significant</u>	

Data Analysis

Analyze your data by answering the following questions:

1. Do you think that the null hypothesis is acceptable or unacceptable? What factors influenced your decision?
2. Which colors of worms were subjected to a positive selection pressure? Which colors of worms were subjected to a negative selection pressure? Explain.
3. Consider feeding times, feeding habits, ability to see color, vision acuity, and other possible characteristics of predatory birds in nature. How might such characteristics determine selection of certain colors?
4. Consider the school grounds upon which you “fed” on your wooly worms. If this particular environment remained unchanged over a very long period of time, how would gene frequencies be affected in future generations?
5. Suppose the school grounds upon which you “fed” experienced an increase in rain over a very long period of time. What might happen to the gene frequency of the different colors of the wooly worm population in the future?
6. Explain the connection between Darwin’s Theory of Natural Selection and gene frequencies.
7. (Extension) While some of the wooly worms we studied tend to blend in or camouflage themselves against their background, some animals actually stand out or contrast boldly with their background. Why are some animals colored brightly and by what means do they survive? Describe several examples.

B. For Extra Practice and Reinforcement: Your teacher may ask you to use the Chi-square test to complete two additional activities titled “Toads and Natural Selection” and “Vulnerability of Wildebeest”. These two activities are based on real-life events.

Important Terms

adaptation	gene frequency
camouflage	Hardy-Weinberg
Chi-square	mimicry
cryptic coloration	natural selection,
Darwin	selection pressure
evolution	

Additional Resources and References

Information about the adaptive value of cryptic coloration

users.rcn.com/jkimball.ma.ultranet/BiologyPages/M/Mimicry.html

www.accessexcellence.org/AE/AEPC/WWC/1995/mimicry.html

www.britannica.com/eb/article-25421

eppserver.ag.utk.edu:81/courses/EPP321/INSECTPROTectLEC.pdf

www.sirinet.net/~jgjohnso/apbio24quiz.html