EcologyConnections

connecting ecology research and education

POPULATION ECOLOGY
Population Genetics – Education Connections

Alberta
INNOVATION AND SCIENCE

KANANASKIS FIELD STATIONS

UNIVERSITY OF CALGARY

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Population Genetics – Education Connections

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Education Connections
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Revised: May 2004

1. TEACHING CONNECTIONS

RESEARCH CONNECTION 1

Genotype Frequencies and Hardy-Weinberg Equilibrium in Cats.

Example 1: Estimating genotype frequencies with Incomplete Dominance

Calculate the proportion of dominant (S) and recessive (s) alleles in the population of cats, starting with dominant (**S**) alleles:

*Number of dominant (**S**) alleles in population*

Homozygous Dominant = **SS** = 2 alleles x ________ (# of >50% white fur cats) =	A
Heterozygous Dominant = **S**s = 1 allele x ________ (# of <50% white fur cats) =	B
Homozygous Recessive = ss = 0 alleles x ________ (# of no white fur cats) =	C
Total number of Dominant (**S**) alleles in the population = A + B + C =	D

Total number of alleles (S and s) in entire population

Total # of cats x 2 alleles per cat = ________ x 2 =	E

*Proportion of Dominant (**S**) alleles in population (**p**)*

p = D/E =	F

*Proportion of Recessive (**s**) alleles in the population (**q**)*

Knowing that **p** + **q** = 1.00, then **q** = 1.00 – **p** or, **q** = 1.00 – F _____ =	G

<u>Answer</u>:
*We find that 30% of the alleles in the population are dominant (**S**), while 70% are recessive (**s**).*

1. TEACHING CONNECTIONS

RESEARCH CONNECTION 1

Example 2: Testing for the Hardy-Weinberg Equilibrium

1) Calculate the expected number of cats of each genotype (SS, Ss and ss), Knowing that $p = 0.30$ (S) and $q = 0.70$ (s) and $p^2+2pq+q^2=1.00$ for a population in equilibrium.

		# Expected	# Observed
SS	Total cats in pop x p^2 = 231 x _______ =	A	B 18
Ss	Total cats in pop x 2pq = 231 x 2_______ =	C	D 104
ss	Total cats in pop x q^2 = 231 x _______ =	E	F 109

<u>Answer</u>:

We find the expected number of SS, Ss and ss cats to be 21, 98 and 112 respectively.

2) Calculate the chi-square, where:

$$\chi^2 = \Sigma \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$$

$\chi^2 = (B-A)^2/A + (D-C)^2/C + (F-E)^2/E$ = ______ + ______ + ______ =	

<u>Answer</u>:

We find a chi-squared value of 1.075

3) Find the χ^2 value in the table below, to determine statistical significance.

Table 1.1. Condensed Chi-square (χ^2) Values Table.

No. of Classes	**χ^2 Values**							
2	0.0002	0.0040	0.4550	1.0740	1.6420	2.7060	3.8410	6.6350
3	0.0200	***0.1030***	***1.3860***	2.4080	3.2190	4.6050	5.9910	9.2100
4	0.1150	0.3520	2.3660	3.6650	4.6420	6.2510	7.8150	11.3450
Probability	0.99	***0.95***	***0.50***	0.30	0.20	0.10	0.05	0.01

<u>Answer</u>:

The value is not significant. Differences between observed and expected values are due to chance. The population is in equilibrium.

1. TEACHING CONNECTIONS

RESEARCH CONNECTION 2

Artificial Sexual Selection and Hardy-Weinberg Equilibrium

Table 2.1. Mean observed (Het-Obs) and expected (Het-Exp) heterozygosity with chi-square values for 19 gene loci in three dog breeds. All three chi-square values are statistically significant. *(Adapted with permission from: Table 1, Pg 183. Zajc et al. (1997). © Springer-Verlag.)*

	Labradors n = 53			
Locus	# of alleles	Het-Obs	Het-Exp	χ^2
Mean	3.3	0.352	0.481	***3.812***
	German Shepherds n =53			
Locus	# of alleles	Het-Obs	Het-Exp	χ^2
Mean	3.3	0.310	0.431	***4.177***
	Greyhounds n =52			
Locus	# of alleles	Het-Obs	Het-Exp	χ^2
Mean	2.5	0.333	0.357	***0.235***

Q. What does a significant Chi-square value mean?

Answer:

Observed heterozygosity in each dog species is significantly different than expected heterozygosity. This difference is greater than would be expected by chance alone. Therefore, some process is likely acting on these populations to cause the allele frequencies to deviate from Hardy Weinberg Equilibrium.

Q. What might account for this deviation from equilibrium? (Hint: refer to the assumptions of Hardy-Weinberg equilibrium).

Answer:

Mating is non-random, as most of these species are bred for particular characters. This is called artificial sexual selection.

1. TEACHING CONNECTIONS

RESEARCH CONNECTION 3:
Natural Selection and Genetic Drift in Granary Mice

Table 3. 1 Percentage of mutant mice in populations before, during and after introduction of cats. *(Adapted with permission from Table 1, Pg 463. Brown (1965). © American Society of Mammalogists.)*

Event	Date	No. of mice trapped	No. of mutant mice	% of population mutants	% of population normal
Before Cats	April 1962	32	9	28.1	71.9
	August 1962	44	18	40.1	59.9
	December 1962	58	27	46.6	53.4
Cats Introduced	April 1963	22	0	0	100
	August 1963	29	0	0	100
Cats Removed	December 1963	37	2	5.4	94.6

Q. Mutant mice made up what proportion of the population prior to the introduction of cats?
Answer:
Somewhere between 28-47%

Q. In such as small population, what might account for such a high frequency of recessive alleles?
Answer:
Genetic drift

Q. Mutant phenotype mice disappeared from the population when cats were introduced. After the removal of cats from the granary, the mutant alleles re-appeared in the population. Where did they come from?
Answer:
Recessive alleles can remain “hidden” in the genotypes of some mice and not appear in the phenotype.

1. TEACHING CONNECTIONS

RESEARCH CONNECTION 4:

Gene Flow, Genetic Drift and Geographic Isolation in Alpine Butterflies

Table 4. 1 Genetic variation within each sampling site. For each site, the number of alleles and the heterozygosity values (expected and observed) were averaged across four loci. In most cases, observed heterozygosity was significantly different from expected heterozygosity. *(Adapted with permission from: Table 2, Pg 1487. Keyghobadi et al. (1999). © Blackwell Science Ltd.)*

Site	Sample Size (N)	Mean No. of Alleles	Mean Expected H_e	Mean Observed H_o
D	43	6.50	0.6439	0.2555
E	40	7.25	0.6942	0.2118
F	41	7.25	0.7571	0.2838
G1	40	6.50	0.6914	0.2381
G2	40	7.00	0.7169	0.2630
I	21	6.00	0.7110	0.2722
J	31	6.25	0.6959	0.2686
K	40	6.50	0.7110	0.2542
L	40	7.00	0.7466	0.2782
M	38	6.75	0.6878	0.2638
O	12	6.00	0.7569	0.3225
P	39	6.75	0.7158	0.2768
Q	40	7.25	0.7005	0.3007
R	24	6.50	0.7129	0.2951
S	14	5.25	0.6392	0.2655
Y	13	5.50	0.7441	0.3295
Z	41	6.25	0.6895	0.2687

Q. Was observed heterozygosity within each population greater or less than expected heterozygosity? What does this indicate?
Answer: Less, indicating genetic variability is depressed in most populations.

1. TEACHING CONNECTIONS

RESEARCH CONNECTION 4:
Gene Flow, Genetic Drift and Geographic Isolation in Alpine Butterflies

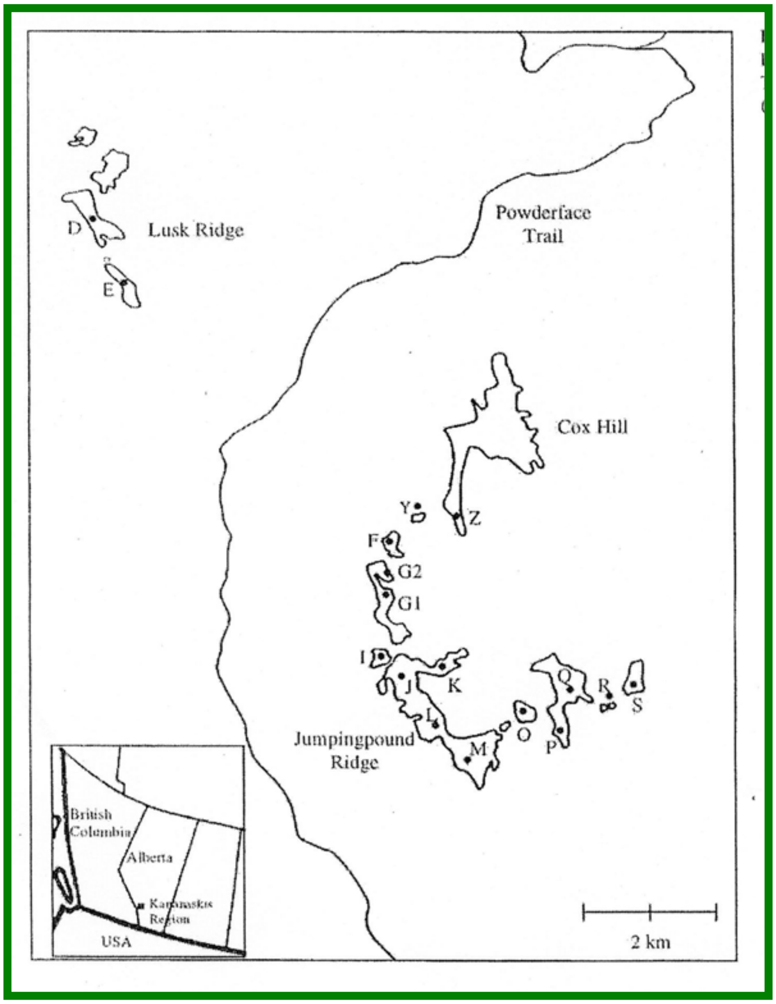

Figure 4.1 Locations of the sampling sites. A different letter identifies each site and the outlined areas denote high-altitude (>2000m) meadow habitat. *(Adapted with permission from: Figure 1, Pg 1483. Keyghobadi (1999). © Blackwell Science Ltd.)*

Q. The genetic difference <u>between</u> populations increased with increasing distance. What does this suggest about the results of the study?

<u>Answer</u>:

Geographically isolated populations have lower dispersal and therefore less genetic mixing (i.e. gene flow).

1. TEACHING CONNECTIONS

RESEARCH CONNECTION 5:

Natural Selection and Mutation in a Pathogenic Yeast

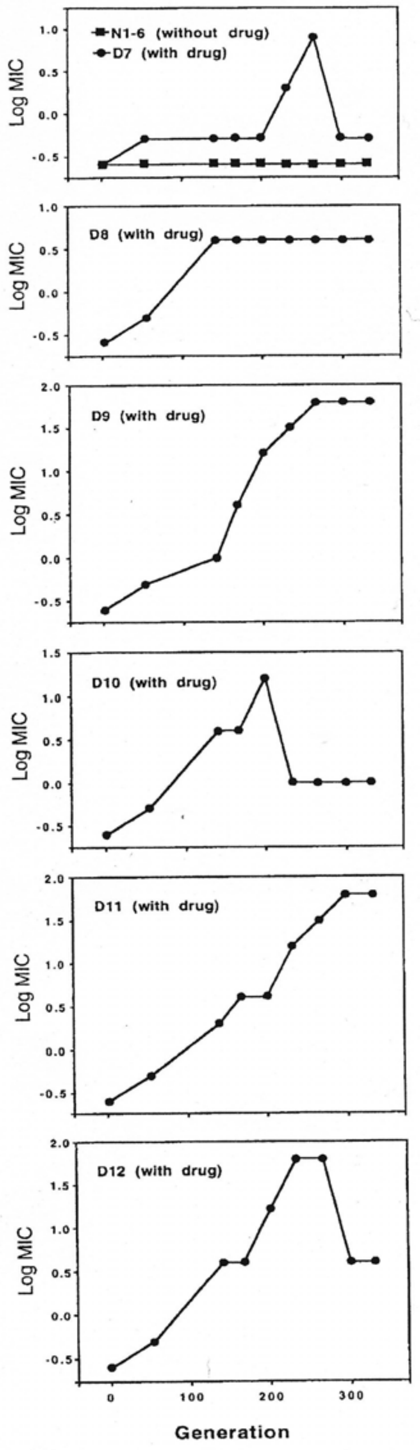

Figure 5.1. Adaptation of *C. albicans* to fluconazole in 12 experimental populations: N1-6 grown without drug and D7-12 grown in drug. *(Adapted with permission from: Figure 1, Pg 1518. Cowen et al. (2000). © American Society for Microbiology.)*

Q. Did the control population develop resistance to Azole?
<u>Answer</u>: No.

Q. Did all test populations develop resistance in the same manner?
<u>Answer</u>: No, each population developed resistance at different Azole concentrations and generation times.

Q. Given the large, genetically identical populations tested, what processes might account for the results?
<u>Answer</u>: Mutation and natural selection.

2. WEBSITE CONNECTIONS – Population Genetics

A. Genetics Society of America [http://www.genetics-gsa.org/]

- ***Paper and Lesson Plan:*** Christensen, A.C. 2000. Cats as an aid to teaching genetics. Genetics **155**: 999-1004. [http://www.genetics.org/cgi/content/full/155/3/999]

B. Ecological Society of America EcoEdNet [http://www.ecoed.net/index.php]

- ***Follow Links under*:** Evolution >> Population Genetics (Natural Selection)

C. AAAS Science Netlinks [http://www.sciencenetlinks.com/]

- ***Insight:*** Introduction to Natural Selection [http://www.sciencenetlinks.com/lessons.cfm?BenchmarkID=5&DocID=99]

D. Actionbioscience.org [http://www.actionbioscience.org/]

- ***Paper:*** Bull, J.J. 2000. Evolutionary biology: Technology for the 21st century. Actionbioscience.org. [http://www.actionbioscience.org/newfrontiers/bull.html]
- ***Lesson Plan:*** Brock, D. 2003. Applied evolution: How will we get there from here? Actionbioscience.org Lesson. [http://www.actionbioscience.org/newfrontiers/lessons/bulllessons.pdf]
- ***Paper:*** Meade-Callahan, M. 2001. Microbes: What they do & how antibiotics change them. Actionbioscience.org [http://www.actionbioscience.org/evolution/meade_callahan.html#educatorresources]
- ***Lesson Plan:*** Deichstetter, P. 2002. Microbes: Too smart for antibiotics? Actionbioscience.org Lesson. [http://www.actionbioscience.org/evolution/lessons/meade_callahanlessons.pdf]

E. Other Websites of Interest

3. LESSON PLAN CONNECTIONS