Quantitative Variation, Selection and Inheritance with Fast Plants

Fast Plants are well suited to help students understand how through selection the genetic components contributing to phenotypic variation are passed on to subsequent generations. Guided over the centuries by ideas of what were desirable features in many species of organisms, humans have used selective breeding (artificial selection) to create the diversity of domestic forms of animals, plants and microbes that we use today. Charles Darwin, in developing his ideas of natural selection, drew heavily on examples of various domesticated forms, including pigeons, dogs and brassicas.

Two important concepts that contribute to understanding evolution are selection and heritability. Heritability, h^2, is a ratio of genetically caused variability to total variability of a character in a population. Essentially, h^2 is a measure or correlation bewteen genotype and phenotype. Heritability is also a measure of the genetic response to selection.

In *Brassica rapa*, Fast Plants, a suitable trait for illustrating the relationship between selection and heritability is that of hairiness on the plant. Hairs are found on many plant parts, including the true leaves, stems and occasionally sepals, cotyledons and hypocotyl. Hairs are readily observed and can be counted easily with the aid of a hand lens or low power dissecting microscope. Hairiness among individuals in most populations exhibits **continuous** variation, ranging from one to many.

Though little is known about the genetics of hair numbers and location on Rbr plants, hairiness can be examined as a quantitative trait conditioned by an unknown number of genes, each of unknown individual effect. By counting the hairs on a population of plants, selecting and intermating the hairiest, then evaluating their progeny for hairs, one can determine whether hairiness is a heritable trait.

A convenient way to quantify the response of increasing hairiness to the applied selection for increasing hairs is to follow the increase in the mean number of hairs from the original population, generation zero, to the mean number of hairs in the first generation from the selected plants (Figure 1).

Two concepts are important in understanding the relationship of selection to heritability, **selection differential** and **response to selection** with respect to hairs (Table 1).

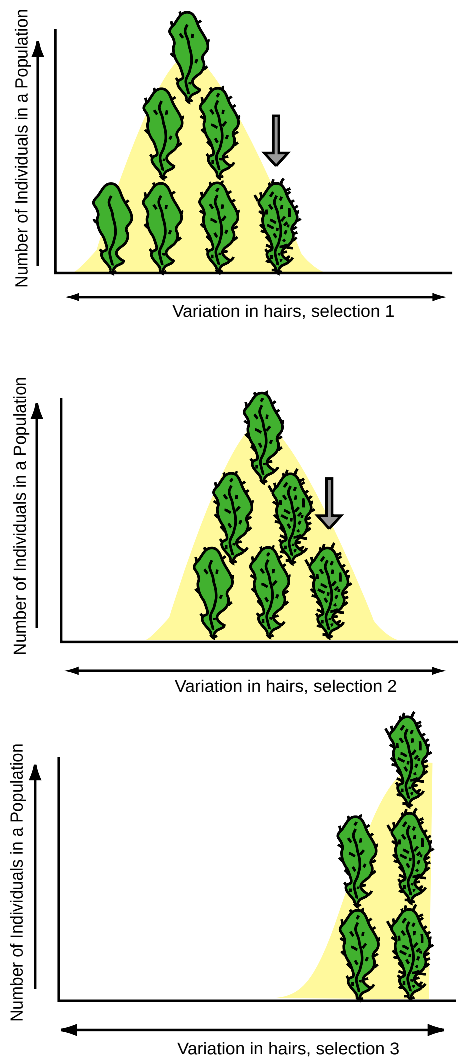

Figure 1: Depiction of directional selection, variation in the number of hairs on Fast Plant leaves, as an example. A bell-shaped curve represents the range of variation in the number of hairs on a leaf.

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Selection differential is the difference between the average number of hairs in the original population, generation zero, and average number of hairs in the selected subpopulation comprising the hairiest parents.

Response to selection is the difference between the average number of hairs among the progeny of the selected parents, gen 1, and the average number of hairs of the original population, generation zero, from which the hairiest parents plants were selected.

The **realized heritability**, h^2, for hairiness is therefore the proportion of the increase in hairiness, (response to selection), in relation to the selection differential.

$$\text{Heritability, } h^2 = \frac{\text{response to selection}}{\text{selection differential}}$$

Table 1: Summary of data needed to estimate the heritability of hairs on Fast Plants

1) Gen 0 [# hairs] n = ____ , x____ , s____ , r ____

2) Selected parents of Gen 1 [# hairs] n = ____ , x____ , s____ , r ____

3) Selection differential x ____
[2) - 1)]

4) Gen 1, # hairs n = ____ , x____ , s____ , r ____

5) Response to selection x ____ ,
[4 - 1]

6) Realized heritability (h2) = ________
[5 / 3]

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6) Realized heritability (h2) = ________
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Reference:

Fall B, Fifield S, Decker M. Evolution by artificial selection; a nine-week classroom investigation using rapid-cycling Brassica. General Biology Program, University of Minnesota