Quantitative Genetics

Variance Components of a Quantitative Trait

As we discussed earlier, the metric value (or phenotypic value) for a specific individual, is the result of genetic factors, environmental factors, and the environmental factors that interact with the genetic factors. The sum of these factors in a popul ation of individuals segregating fora quantitative trait contributes to the variance of that population. Thus the total variance can be partitioned in the following manner.

$$\mathbf{V_P = V_G + V_E + V_{GE}}$$

V_P = total phenotypic variation of the segregating population
V_G = genetic variation that contributes to the total phenotypic variation
V_E = environmental contribution to the total phenotypic variation
V_{GE} = variation associated with the genetic and environmental factor interactions

The genetic variation can be further subdivided into three components. The first component is called the **additive genetic variation**. Some alleles may contribute a fixed value to the metric value of quantitative value. For example, if genes A and B control corn yield (it is actually controlled by many genes), and each allele c ontributes differently to yield in the following manner:

A = 4 bu/aca = 2 bu/acB = 6 bu/acb = 3 bu/ac

Then the AABB genotype will have a yield of 20 (4+4+6+6) bu/ac and the AaBb genotype will yield 15 (4+2+6+3) bu/ac. Genes that act in this manner are additive, and they contribute to the **additive genetic variance (V_A)**.

In addition to genes which have an additive effect on the quantitative trait, other genes may exhibit a dominant gene action which will mask the contribution of the recessive alleles at the locus. For example, if the two genes just mentioned exhibited dominance the metric value of the AaBb heterozygote would be 20 bu/ac. This value equals the homozygous dominant genotype in the example where the alleles were acting additively. This source of variability is attributed to the **dominance genetic variance (V_D)**.

The final type of genetic variance is associated with the interactions between genes. The genetic basis of this variance is epistasis, and it is called the **interaction genetic variance (V_I)**.

The total genetic variance can be partitioned into the three forms of variance

$$V_G = V_A + V_D + V_I$$

and the total phenotypic variance can be rewritten as

$$V_P = V_A + V_D + V_I + V_E + V_{GE}$$

By performing specific experiments quantitative geneticists can estimate the proportion of the total variance that is attributable to the total genetic variance and the environmental genetic variance. If geneticists are trying to improve a specific quantitative trait (such as crop yield or weight gain of an animal), estimates of the proportion of these variances to the total variance provide direction to their research. If a large portion of the variance is genetic, then gains can be made from selecting individuals with the metric value you wish to obtain. On the other hand if the genetic variance is low, which implies that the envi ronmental variance is high, more success would be obtained if the environmental conditions under which the individual will be grown are optimized.