DESIRED IMPROVEMENT IN RELATION TO SELECTION INDICES[1]

Index selection is the most efficient method of improving several quantitative traits simultaneously. However, the problem of assigning relative economic weights to the traits limits the use of selection index principles. Few breeders are prepared to assign "relative economic weights" to traits but most would be willing to specify the amount of gain they would like to see in each trait in a given selection program. These "desired gains" are really a form of economic weights, and we have modified current index selection theory to substitute desired gains for relative economic weights in the calculation of selection indices.

In the following derivation, the assumptions and the matrix notation will be essentially those of Finney (1). The relevant notation is summarized below, where bold letters indicate matrices.

$\mathbf{a}$ — column vector of relative economic weights of traits
$\mathbf{b}$ — column vector of index coefficients
$\mathbf{g}$ — column vector of expected genetic gains
$\hat{\mathbf{g}}$ — column vector of desired genetic gains
i — subscript having the range 1, 2, . . . n
n — number of traits considered
P — fraction of the whole population to be selected
$\mathbf{V}$ — genetic variance-covariance matrix
$\mathbf{W}$ — phenotypic variance-covariance matrix
$\mathbf{y}$ — column vector of phenotypic values
Z — ordinate of the standardized normal curve for truncation area P
I — selection index ($I = \sum_i b_i y_i$)

To use the proposed modification, two types of information are required: (*a*) the genetic variance-covariance matrix from the population in which selection is to be practiced, and (*b*) the vector of desired gains of the n traits.

Conventional theory of index selection (1) states that the expected genetic response to index selection is given by the formula

$$\mathbf{g} = \frac{\mathbf{V}\,\mathbf{b}}{\sqrt{\mathbf{b}'\,\mathbf{W}\,\mathbf{b}}} \cdot \frac{Z}{P} \qquad [1]$$

where the vector $\mathbf{b}$ is the solution to the set of linear equations $\mathbf{Wb} = \mathbf{Va}$. We propose to substitute $\hat{\mathbf{g}}$, the vector of desired gains, for $\mathbf{g}$ in equation [1] and solve for $\mathbf{b}$. Premultiplying both sides of equation [1] by $\mathbf{V}^{-1} \cdot \frac{P}{Z}$ and substituting $\hat{\mathbf{g}}$ for $\mathbf{g}$, we obtain

$$\hat{\mathbf{b}} = \frac{\mathbf{b}}{\sqrt{\mathbf{b}'\,\mathbf{W}\,\mathbf{b}}} = \left(\mathbf{V}^{-1}\hat{\mathbf{g}}\right) \cdot \frac{P}{Z} \qquad [2]$$

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The vector $\hat{\mathbf{b}}$ will result in a selection index, $I = \hat{\mathbf{b}}'\mathbf{y}$, which will maximize the expected response to index selection in proportion to the desired response.

Thus, it is possible to calculate index coefficients without assigning relative economic weights to each trait as required in conventional index selection theory. Rather, the index coefficients are calculated in consideration of desired gains. As such, the index coefficients will result in maximum gains in each trait according to the relative importance assigned by the breeder in his specification of desired gains, and subject to the restrictions imposed by the phenotypic and genetic constitution of the initial population. This modification of index selection theory is more suited to the needs of practical breeders than the unmodified theory.

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