EVALUATION OF COMPETITION AND ITS APPLICATION TO BREEDING PROGRAMS

Evaluation de la competition et ses applications aux programmes d'élévage

Valoración de la competencia y sus aplicaciones a los programas de cría animal

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Selection by the breeder of livestocks is aimed, as a rule, at improving the efficiency of converting external resources, particularly feed, into marketable products (meat, milk, eggs, wool, etc.), produced by crowded animals that compete for limited resources. These conditions of crowding and competition may be defined as the *commercial environment*. The genotype (g_c) to be improved, namely, efficiency of utilization of external resources under commercial environment, cannot be selected directly by mass selection. The only way for its *direct* selection is to stock whole families, each in a separate pen, and to use the family mean as the unit of selection. Under conditions of family selection, competition may considerably increase the intra-pen variability, while having only a small effect on the pen's mean (JONSSON, 1959). The relationship of the genotype (g_j) selected by mass selection under competition situation (environment) j, to the genotype to be improved (g_c) can be expressed as,

$$g_j = (1 + \alpha_j)\ g_c + I_j \qquad [1]$$

when α and I are the two competition factors. The first is amplifying differences of g_c while the second is a genetically independent competition factor. The two terms $\alpha_j\, g_c$ plus I_j make up the genotype × environment interaction component in the traditional «mean effects plus interactions» model (for detailed description of the relationship between the two models see MOAV and WOHLFARTH, 1974).

The phenotype P_j exposed to competition and to mass selection can be presented as,

$$P_j = g_j + e_j = (1 + \alpha_j)\ g_c + I_j + (1 + s_j)\ e_c \qquad [2]$$

When $(1 + s_j)$ measures the scale relationship of the environmental effects in the

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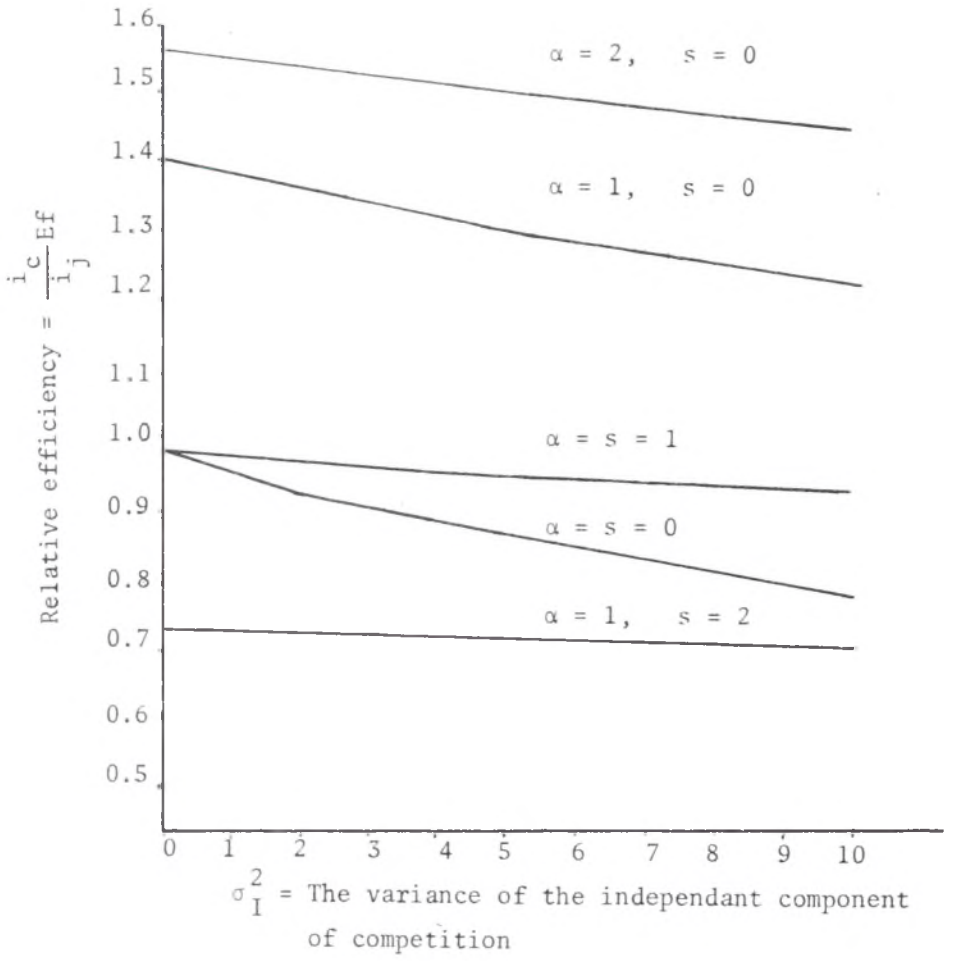

FIGURE 1. The relative efficiency of selection under competition as a function of σ^2_I, for five combinations of α and s. (Hypothetical parameters: $\sigma^2_{g_c} = 5$, $\sigma^2_e = 10$. See text for details.)

selection environment (e_j) to those of the *commercial environment* (e_c) (for simplicity, $g \times e$ interactions have been omitted). Note that the components g_e and e_e have non-analogous interpretations. Consider two individuals having identical genotypes, if one is raised in environment 1 and the other in environment 2, their phenotypic expressions can be presented, respectively, as $P_{11} = g_{11} + e_{11}$ and $P_{12} = g_{12} + e_{12}$. Here $g_{11} = g_{12}$, while $E(e_{11}) = E(e_{12})$ and $E(e_{11}\, e_{12}) = 0$. That is, while g_{11} is identical to g_{12}, e_{11} and e_{12} are two independent random variates drawn from a single distribution.

The phenotypic variance is,

$$\sigma^2_{P_j} = \sigma^2_{g_j} + \sigma^2_{e_j} = (1 + \alpha_j)^2 \sigma^2_{g_c} + \sigma^2_I + (1 + s_I)^2 \sigma^2_{e_c} =$$
$$(\sigma^2_{g_c} + \sigma^2_{e_c}) + [(2\alpha_I + \alpha^2_I) \sigma^2_{g_e} + (2s_I + s^2_I) \sigma^2_{I_j}] \quad [3]$$

The competition parameters are α, σ^2_I and s, and the square brackets contain the extra variance due to competition.

The coefficient of genetic correlation between a selected genotype g_I and the genotype to be improved g_c is,

$$r_g = \left[\frac{(1 + \alpha_j)^2 \sigma^2_{g_c}}{(1 + \alpha_j)^2 \sigma^2_{g_c} + \sigma^2_I} \right]^{1/2} \quad [4]$$

Note that when $\sigma^2_I = 0$ then $r_g = 1$.

The fundamental biological difference between the two genetic parameters α [or $(2\alpha + \alpha^2)\ \sigma^2_{g_c}$] and σ^2_I is shown by their different contributions to r_g. As a rule, both respond to competition by increased variability. However, α does not change the rankings of the different genotypes, while I, which may be controlled by a different set of genes, reduces the correlation.

The efficiency (Ef) of selection under competition environment j relative to direct selection of g_c (possible only by family selection, as explained earlier) can be measured by the followig equation (FALCONER, 1960),

$$Ef = \left(\frac{i_j}{i_c} \right) r_g \left(\frac{h_j}{h_c} \right) \quad [5]$$

When i is the standardized selection differential, and h is the square root of heritability. In order to emphasize the role of competition beyond the usual factors affecting relative efficiency of mass versus family selection (heritability, pen effect, potential selection differentials, costs, etc.), the following simplifying assumptions have been made: I) complete additivity of the genetic components, II) in the direct selection each «family» consists of a single individual grown in a separate pen, III) absence of pen effects, and IV) absence of genetic variance for resistance (or susceptibility) to loneliness when animals are grown in separate pens. Under these assumptions the heritability ratio is,

$$\frac{h^2_j}{h^2_c} = \frac{[(1 + \alpha)^2 \sigma^2_{g_c} + \sigma^2_I]\ (\sigma^2_{g_c} + \sigma^2_{e_c})}{\sigma^2_{g_c}\ [(1 + \alpha)^2 \sigma^2_{g_c} + (1 + s)^2 \sigma^2_{e_c} + \sigma^2_I]} \quad [6]$$

Substituting the square root of the last equation and equation 4 into equation 5 results in,

$$Ef = \frac{i_j}{i_c} \left[\frac{(1 + \alpha)^2\ (\sigma^2_{g_c} + \sigma^2_{e_c})}{(1 + \alpha)^2 \sigma^2_{g_c} + (1 + s)^2 \sigma^2_{e_c} + \sigma^2_I} \right]^{1/2} \quad [7]$$

Since i_c is related to family selection and i_j to mass selection, obviously, per unit cost, i_j will be considerable higher than i_c. Figure 1 shows how Ef changes as a function of σ^2_I for a given ratio (i_j/i_c), for arbitrarily chosen values of σ^2_{gc} and σ^2_e and for five combinations of α and s.

SUMMARY

The relationship of the genotype (g_j) selected by mass selection under competition situation j, to the genotype to be improved (g_c) can be expressed as,

$$g_j = (1 + \alpha_j)\, g_c + I_j$$

when α and I are the two competition factors. The first is amplifying differences of g_c while the second is a genetically independant competition factor. An equation that describes the relative effeciency of selection under competition was derived, and its dependance on the various parameters was illustrated.

RESUME

La relation existante entre le génotype (g_j), sélectionné par sélection massale sous situation compétitive j, et le génotype qui doit être amélioré (g_c), peut être exprimée ainsi:

$$g_j = (1 + \alpha_j)\, g_c + I_j$$

où α et I sont les deux facteurs de compétition. Le premier est un amplificateur des différences de g_c, tandis que le deuxième est un facteur compétitif génétiquement indépendant. D'après ceci, on a déduit une équation qui décrit l'efficacité relative de la sélection sous compétition, tout en exposant sa dépendence quant aux divers paramètres.

RESUMEN

La relación entre el genotipo (g_j) seleccionado por selección masal bajo situación competitiva de j, con el genotipo que debe ser mejorado (g_c), puede expresarse así:

$$g_j = (1 + \alpha_j)\, g_c + I_j$$

en donde α y I son los dos factores de competicin. El primero es amplificador de las diferencias de g_c, mientras que el segundo es un factor competitivo genéticamente independiente. De ello se ha deducido una ecuación que describe la eficiencia relativa de la selección bajo competición, exponiéndose su dependencia en relación con los diversos parámetros.

LITERATURE CITED

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