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A COMPARISON BETWEEN BLUP AND INDEX FOR SELECTION ON LITTER SIZE

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INTRODUCTION

After the rapid development of computers, methods of selection like Best Linear Unbiased Prediction (BLUP) are being introduced in current programs of selection (HENDERSON, 1975). These methods involve large systems of equations to be solved. It would be interesting to compare BLUP with indexes to know the gain in accuracy, in order to justify whether or not BLUP should substitute them.

The accuracy of BLUP increases if information of relatives is used, but the mathematical complications increase as well. Also the compute of the inverse of the numerator relationship matrix can be considerably simplified by disregarding the inbreeding coefficient (QUAAS, 1976). It would also be interesting to know how these simplifications affect the accuracy and expected response of the selection program.

Hitherto father information has not been used in rabbit litter size selection programs (BASELGA, et al., 1984; MATHERON et POUJARDIEU, 1984). It is important to know the loss of accuracy due to the avoidance of father information in order to know how the efficiency of selection is affected.

The objective of this paper is to assess the loss in efficiency produced by simplification in the selection methods, i.e. to compare BLUP including full relatives information with other simpler BLUPs and with selection index. Also, a predicition of correlated response on

other traits based on BLUP methodology will be offered.

MATERIAL AND METHODS

Two lines of rabbit were used, both selected on litter size at weaning, line A (White New Zealand) and line V (synthetic).

The selection method was a familiar index -including individual, half sibs, full sibs and dam data-. All the animals were reared under the same conditions, but these conditions were improved little by little. Selection of line A started in 1980, selection of line V started in 1984.

Data from seven generations of selection of line A and from one of line V have been used in the analysis. Also, data from three generations of random mating of line V have been used in the analysis and data from the foundation stock.

Table 1 shows the number of animals used in the experiment.

TABLE 1

Total number of dams (D), sires (S) and parities (P), and minimal number of dams per generations (m).

LINE	D	S	P	m
A	754	143	1786	81 (A5)
V	572	198	1484	68 (V0)

The traits analised were: total litter size (LS), number of born alive (NB), number of weaned (NW) and number of animals which arrived to slaughter time (NS).

BLUP estimations of reproductive values were applied on a repeatability model (QUAAS, 1984), assuming that the only causes of correlation between data of the same animal were genetic effects and permanent environment. The model was:

$$Y_{ijkl} = l_i + E_j + a_k + p_k + e_{ijkl}$$

l_i is the parity-lactation state of the does (fixed). There are three levels, nulliparous N (i=1), lactating doe L (i=2), non nulliparous and non lactating doe NL (i=3) at the moment of mating.

E_j is the year-season in which the parity occurred (fixed). There are a maximum of 22 levels.

a_k is the additive value of the doe or the buck

p_k is the permanent non genentic effect on the doe (random).

e_{ijkl} is the temporary environmental effect on the doe.

y_{ijkl} is the litter size of the 1^{th} parity of the k^{th} doe, made in the j^{th} year-season when the parity-lactacion state of the doe was i.

The model needs the heritability (h^2) and repeatability (r) to be solved. The estimations of these parameters were calculated by pooling their estimations in random mating generations of line A which gave h^2 = 0.13, r = 0.20 (GARCIA et al., 1982).

Several kinds of BLUP were compared:

a) In lines A and V

BO: Which uses all the available information since the foundation of the lines, including consanguinity in line V.

b) In line V, disregarding consanguinity in the inverse of the numerator relationship matrix,

B1: information from the first to the fourth generation.

B2: " " " second " " " "

B3: " " " third " " " "

B4: only, information from the fourth generation.

Also the index described above was used for comparisons (IX).

Comparison can be done in different ways, three criteria were used:

1) It was calculated the average of the additive value using BO as a criterium of selection. Three pressures of selection were used: 50%, 33% and 25% of selected animals. Two cases were considered, selection based on mother predicted value and selection based on father and mother predicted values.

Using IX as a criterium of selection, it was calculated the average of the BO predictions of selected animals. As it was lower

than B0 average because B0 is a more accurate criterium, the percentage of loss due to the use of IX instead B0 was calculated; this was the criterium for efficiency.

2) Correlations between predicted additive values of B0 and B1, B2, B3, B4 and IX were calculated. This correlation was also calculated between predictors using IX and B1, B2, B3 and B4. Also correlations between ranking number of the animals were calculated in the same cases. Prediction and ranking number included males and females.
3) Using B0 as a criterium of selection on NW, it was calculated the average of B0 predictions of additive values of LS, NB and NS traits of the selected animals. Males and females were used in the criterium.

RESULTS

TABLE 2

Loss in the average predicted additive values due to the use of index (IX) instead BLUP (B0) as a criterium of selection, expressed as a percentage of B0 average prediction. Trait: number of weaned rabbits. Selection using only mother information.

Pressure	LINE	
	A	V
50%	2.5	4.4
33%	3.8	3.2
25%	5.1	5.6

Table 2 shows the loss in efficiency due to the use of index (IX) instead BLUP (B0). When selecting using only mother information BLUP and index seem to have a similar efficiency.

TABLE 3

Loss in the average of predicted additive values due to the use of mother information in selection instead father and mother information, expressed as percentage.
Trait: number of weaned rabbits. Criterium of selection: BLUP (BO) and index (IX).

Pressure	BLUP (BO)		INDEX (IX)	
	Line A	Line V	Line A	Line V
50%	21.5	23.8	28.9	28.8
33%	24.0	30.7	26.9	25.3
25%	22.6	29.4	27.9	23.8

Table 3 points out the loss in efficiency due to the use of only mother information in selecting instead father and mother information. This results has a considerable importance, since current programs do not consider sires in the criterium of selection, i.e. candidates are selected on the basis of their mother index instead of their mother + father index (MATHERON et POUJARDIEU, 1984; BASELGA et al. 1984).

Correlation between methods are shown in table 4. BO and B1 are practically the same method, which implies that much computing cost can be saved. B3 and BO seems to have almost the same consequences in selection. The loss of efficiency of index in comparison with BO or B3 is not dramatic, but it is not negligible. It depends on the actual importance of the fixed effects considered in the mixed model.

TABLE 4

Correlations between predicted additive values of BLUP, including a different amount of information and familiar index. Correlation between ranking number of the evaluated animal in the same case. B1, B2, B3 and B4: BLUP including information of 4, 3, 2 and 1 generation respectively. IX familiar index. BO: BLUP including information of 5 generations and using inbreeding coefficient. Size and dams information are considered. Line V is used.

Method	BLUP (BO)		INDEX (IX)	
	Predictions	Rankings	Predictions	Rankings
B1	1.00	1.00	0.85	0.86
B2	0.99	0.99	0.85	0.86
B3	0.96	0.96	0.88	0.89
B4	0.77	0.74	0.69	0.73
IX	0.85	0.86	-	-

TABLA 5

Loss in the average of predicted additive values on number of total born (LS), live born (NB) and slaughtered (NS) rabbits when using weaned rabbits as a criterium of selection instead on using LS, NB or NS respectively. The loss is expresed as a percentage. Mother and father information are considered in the prediction.

Pressure	Line A			Line V		
	LS	NB	NS	LS	NB	NS
50%	41.6	22.8	8.2	31.9	21.3	18.8
33%	39.2	22.7	7.5	34.7	24.5	19.7
25%	38.9	21.5	8.2	36.8	21.7	17.7

Table 5 shows the loss in the average of some traits due to selection on a correlated trait (number of weaned rabbits) in comparison with the average that these traits would have if they were directly selected. BLUP using father and mother information was the method used for comparisons (BO). When selecting on number of weaned rabbits, it can be expected a correlated response in other traits. This response can be predicted through the estimation of genetic correlations, heretabilities and phenotipic correlations. Unfortunately, standard errors of genetic correlations are very high, mainly when correlations are low. Another approach to the same problem could be to examine the average of predicted values of the selected animals using a correlated trait as a criterium of selection. It is interesting to notice that selection on number of weaned rabbits will not increase litter size (LS and NB) at birth as effectively as selecting for litter size at birth, which would be an objective if adoption is an usual practice. Also, the final economic aim, number of slaughtered rabbits, seems to have less important loses in line A than in line V.

DISCUSSION

Comparisons can be made in many ways. In order to simplify and to show as clearly as possible the results only some comparisons between methods, traits and use of information have been exposed. A full research can be found in ESTANY (1987).

It seems important to include sire information in the selection programs, and it seems to be more important if BLUP methods are used. Since this result was found, sire information is used in the current selection programs of lines A and V.

Actual and parent's information seem to be enough to predict additive values. The use of BLUP instead index depends very much on the importance of the fixed effects. They did not were high in last generations of line A and V (ESTANY, 1987), and BLUP was quite correlated with index prediction. When the population has an effective number of consanguinity large enough, calculation involving inbreeding coefficient do not improve the efficiency and cause computing troubles.

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Two strains of rabbits (A and V) selected on litter size at weaning by an index (IX) were used to study the methodology of selection on litter size.

IX was an index containing records on the doe, her mother, full sibs and half sibs. All strains were under the same conditions and reproduction was organized in separate generations.

The accuracy of selection can be improved by considering the information of relatives an by removing non genetic influences. To assess the importance of adjusting data for environmental effects, BLUP method was compared with IX. BLUP was based on a simple repeatability model which included year-season of parity and state of the female (nuliparous, lactating or non nuliparous non lactating) as fixed effects.

On average, results concerning the use of BLUP were: (I) inbreeding coefficient can be disregarded when computing the inverse of the numerator relationship matrix; (II) despite the negative first parity effect and other envorinmental fluctuations, only 6% of the predicted BLUP response was lost when IX was applied: (III) BLUP was accurate enough when only the last two generations were used for prediction; and (IV) the efficiency of selection can be improved 25% by using sire information.

COMPARACION ENTRE BLUP E INDICE PARA LA SELECCION DEL TAMAÑO DE CAMADA

A partir de dos líneas de conejos (A y V) seleccionadas por un índice (IX) sobre el tamaño de la camada al destete, se estudia la metodología de la selección del tamaño de la camada.

El índice IX se ha deducido combinando las observaciones de la hembra y las de su madre, hermanas completas y medias hermanas. Todas las líneas se han mantenido en idénticas condiciones y la reproducción se ha organizado en generaciones discretas.

La precisión de la selección puede mejorarse considerando la información de los parientes y eliminando las influencias no genéticas. Para contrastar la importancia de la correción de los datos por los efectos ambientales, se ha comparado el método BLUP con el IX. La deducción del BLUP se ha basado en un modelo de repetibilidad simple que incluye como efectos fijos el año-estación del parto y el estado de la hembra (nulípara, lactante o no nulípara no lactante).

En promedio, los resultados que se derivan de la aplicación del BLUP son: (I) se puede prescindir del coeficiente de consanguinidad al calcular la inversa de la matriz de parentesco; (II) a pesar del efecto negativo del primer parto y de las fluctuaciones ambientales, solamente se pierde un 6% de la respuesta predicha por el BLUP cuando en su lugar se aplica el índice IX; (III) es suficiente considerar las dos últimas generaciones para calcular el BLUP, y (IV) la eficacia de la selección puede mejorarse en un 25% cuando se considera la información paternal.