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Crossbreeding of Holstein Friesian, Brown Swiss and Sanga breeds in Zaire. I. Milk production

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Une expérience de croisement de bovins de races Holstein Frisonne, Brown Swiss et Ankole a été réalisée durant les années 1978-1988 dans l'élevage de Lushebere dans la région de Masisi, Kivu-Nord, Zaïre. Des effets additifs de la race Holstein Frisonne supérieure et des effets d'hétérosis individuels du croisement Holstein Frisonne x Ankole ont été trouvés en ce qui concerne les rendements laitiers. Les effets d'hétérosis individuels du croisement Brown Swiss x Ankole ont contribués à l'augmentation de la production laitière. Le coefficient d'héritabilité s'est révélé faible (0,14) pour le rendement laitier, correspondant au caractère le plus important économiquement. Les raisons principales pourraient être liées à la sélection à long terme du phénotype, en particulier en ce qui concerne la race Ankole, mais également aux possibilités limitées, pour les races européennes, d'exprimer leur potentiel génétique en raison de l'absence d'alimentation à base de concentrés. En ayant pour objectif la réalisation d'un croisement à long terme, reposant sur la simulation de races synthétiques nouvelles, on a montré qu'il convenait de poursuivre les croisements avec des proportions de race Holstein Frisonne comprises entre 77,5 et 80 p.100 et de race Ankole comprises entre 20 et 22,5 p.100.

Mots clés : Bovin - Croisement - Hétérosis - Production laitière - Zaïre.

INTRODUCTION

In a crossbreeding programme, a breeder normally has a long-term goal for genetic improvement, a short-term goal for maximizing the expected immediate return, or both. For the long term breeding goal, the breeding value or additive effects of sires and dams should be emphasized. To maximize the short term commercial return, a high predicted total genetic value (additive plus non additive genetic effects) should be chosen. For the design of a flexible crossbreeding mating plan, the sire's proof should be obtained. The sire's proof contains the additive breeding value and the non-additive sire group and dam group interaction or crossbreeding effects expressed in the offspring generation.

The genetic parameters are of interest as a quantitative summary of inheritance of traits. These parameters also indicate whether there is enough genetic variation in a trait to make selection effective or whether to choose an alternative selection scheme. A reliable estimate of the heritability is needed to decide which breeding plan is likely to be the most effective (1).

The crossbreeding experiment between Holstein Friesian*, Brown Swiss** and Ankole*** was conducted during the years 1978-1988 on the Lushebere farm in the Masisi zone, North-Kivu in the Republic of Zaire. It was found that the crossbreds were better adapted to specific environmental conditions than the purebred Holstein Friesian and Brown Swiss breeds. As compared with local breeds, crossbreds gave higher milk yields.

In this study, more precise information about crossbreeding effects and heritability was estimated from available milk production data. This information can be helpful to establish crossbreeding programmes in the future.

MATERIALS AND METHODS

Data

The data were collected from a crossbreeding experiment between Holstein Friesian (H), Brown Swiss (B) and Ankole (local breed Z) that had been conducted over the years 1978 to 1988 on the Lushebere farm in the Masisi zone in North-Kivu, Zaire. First lactation records were used to estimate the milk yield which was recorded monthly. The total milk yields of cows with suckling calves were corrected. Approximately, 760 l were used by a single calf and 1,500 l by twins. The correction was based on an estimated requirement of 10 l of milk per kg growth prior to weaning. The crossbreeding groups could be separated by male and female parent breed proportions. The genetic proportions for the offspring generation of the crossbreeding groups were based on DICKERSON's work (2). If the number of daughters per sire was less than 5, the observations were deleted in order to estimate breeding values for sires. The observations grouped in sire and daughter groups are presented in table I.

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* Holstein Friesian stands for the Black and White cattle from the Netherlands and Belgium.

** Brown Swiss from Switzerland.

*** Ankole is a local breed belonging to the Sanga group of breeds of Eastern Africa.

TABLE I Distribution of the original data.

Sire group 1 (100 % H)		Sire group 2 (100 % B)		Sire group 3 (75 % H 25 % B)	
DG	Number daughters	DG	Number daughters	DG	Number daughters
1	23	12	48	24	27
2	13	13	23	25	5
3	17	14	19	26	10
4	18	15	46	27	17
5	21	16	52	28	23
6	18	17	21	29	6
7	18	18	14	30	3
8	2	19	5	31	10
9	10	20	10	32	2
10	4	21	10	33	4
11	7	22	17	34	6
		23	19	35	4

DG = a daughter group, based on the breed proportions.
H : Holstein Friesian ; B : Brown Swiss.

Methods

To estimate the crossbreeding parameters the number of breeds involved was relatively small. Therefore, crossbreeding effects were considered as fixed effects. The crossbreeding parameters were obtained from the means of the least square groups. The mixed model has also been used to estimate crossbreeding parameters by several authors (3, 4, 7, 8). The sire breeding values were estimated with a mixed model.

Estimation of crossbreeding parameters

The general linear genetic model can be formulated as :

$$[1]\ \hat{d} = X\beta + e$$

where d = the vector of the least square means of each combination ; β = the vector of the crossbreeding parameters ; X = the matrix relating the crossbreeding parameters to the least square means of the groups ; e = random error (NID, 0, σ_e^2).

The least square means of the groups and their variance-covariance-matrix are used in the second step of the analysis.

$$[2]\ \begin{vmatrix} \hat{d} \\ 0 \end{vmatrix} = \begin{vmatrix} X \\ R \end{vmatrix} \beta$$

where matrix X is the design matrix of the particular model and matrix R the corresponding matrix of the restrictions. ß is the parameter vector of the model and d the vector of group mean estimates with Var(e)= $V\sigma^2$. The least square solutions are :

$$[3]\ \hat{\beta} = (X'V^{-1}X)^{-1} X'V^{-1} \hat{d}$$

where V is the variance-covariance matrix of $\hat{d}$.

Because the least square means have been calculated from groups with different numbers of observations, a weighted least square procedure was used (12).

Crossbreeding parameter estimations were used in a simulation programme (5) to search for optimal synthetic breeds.

Least square means of the groups, genetic parameters

In a crossbreeding experiment, sires are normally nested within sire groups and offspring groups are often nested within the sire groups. Therefore, sire groups should be considered as fixed effects in the mixed model to estimate the least square means of groups and sire breeding values. The "genetic group" term (10) is introduced to construct this model. The mixed model is :

$$[4]\ Y_{ijklm} = X_i\alpha_i + Q_jf_j + Q_{jk}d_{jk} + Z_{jl}a_{jl} + e_{ijklm}$$

where Y_{ijklm} = the observation vector ; X_i = a known incidence matrix relating observations to environmental fixed effects ; Q_j = a known incidence matrix relating observations to sire groups ; Q_{jk} = a known incidence matrix relating observations to daughter groups nested within the sire groups ; Z_{jl} = a known incidence matrix relating observations to sire effects ; α_i = a vector of fixed environmental effects ; f_j = a vector of sire group effects; d_{jk} = a vector of daughter group effects ; a_{jl} = a vector of sire additive genetic effects ; e_{ijklm} = a vector of residual effects; $\sigma(Y) = \sigma(Za + e)$.

The genetic variances were estimated by REML (Restricted Maximum Likelyhood Estimation) (11).

The heritability estimates of milk yield were calculated by parental half-sib analysis.

RESULTS AND DISCUSSION

The estimated crossbreeding parameters are presented in table II and figure 1. Most estimates are not significant because of the limited number of observations per daughter group. The additive effect of the Holstein Friesian breed was superior to the additive effects of the Brown Swiss and the local breed. It was also found that, in this specific environment, the crosses of the European breeds with Ankole show higher heterosis effects. These results are similar to those observed by CUNNINGHAM (1). In this experiment, a negative heterosis was found for the cross between the two European breeds. It might be concluded that a higher immediate commercial return from milk production in the Masisi area is dependent of the high heterosis effects between the two European breeds and the Ankole breed, and also of the superior additive effect of the Holstein Friesian breed. Obviously,

TABLE II Least square estimates of crossbreeding effects for milk yield.

Effects	Constants (liter)	Percentage
overall mean	1 379.6	
add H	95.7	6.8
add B	– 19.0	– 1.4
add Z	– 76.7	– 5.5
het HB	– 26.2	– 1.9
het HZ	156.8	11.8
het BZ	265.3	18.3

add : additive effect ; het : heterosis effect.
H : Holstein Friesian ; B : Brown Swiss ; Z : Ankole.

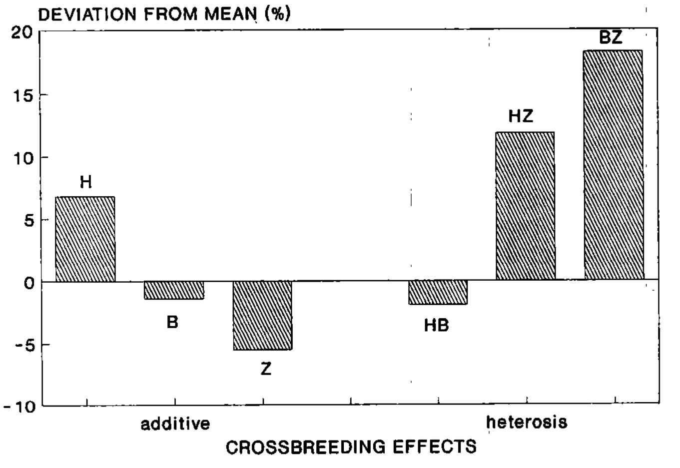

Fig. 1 : The crossbreeding parameters for milk yeld. (H : Holstein Friesian ; B : Brown Swiss ; Z : Ankole)

the crossbred cows with higher additive proportions from the two European breeds and a lower proportion of the Ankole breed produced more milk than the local pure breeds. The crossbred between the European and the Ankole breeds can maximally exploit HZ an BZ individual heterosis.

A heritability estimate of 0.14 was obtained after 3 iterations (table III). The random effect of the interaction between sire and dam groups might be important (3). Certain causes for the sire x group-of-dam interaction variances may be found in heterogeneous genetic variances (9) or non-additive variances. Here, the non-additive genetic variance was included in the fixed effect of the daughter groups. This model can also be extended to an animal model and use the indirect iteration method to solve large data sets. The relatively low heritability of milk yield might be caused by environmental conditions specific to the Masisi area, and by the limited possibilities to express the genetic potential of the European breeds caused by suboptimal feeding for milk production.

TABLE III Variance and heritability estimates.

	σ^2_s	σ^2_e	h^2
Iteration 1	5 270.57	142 369	0.14279
Iteration 2	5 268.36	142 371	0.14273
Iteration 3	5 266.27	142 372	0.14268

Table IV shows the milk yield for the three best synthetic breeds, the breed proportion and breed heterozygosity. Theoretically, for long-term breeding, the proportion of heterosis in a synthetic breed is not large. Additive effects play a more important role. The best three synthetic breeds contain between 77.5 and 80 % Holstein Friesian, between 20 and 22.5 % Ankole and no Brown Swiss. The predicted milk yield of these synthetic breeds is around 1,491 l per year. The breed heterozygosity is 35 %.

TABLE IV Milk yield and breed proportions of the best 3 synthetic breeds.

% H	% B	% Z	milk yield (kg)
80.0	0.0	20.0	1 491.0
77.0	0.0	23.0	1 491.2
77.5	0.0	22.5	1 491.2

H : Holstein Friesian ; B : Brown Swiss ; Z : Ankole.

CONCLUSION

A low heritability was found for milk yield (0.14), economically the most important trait. The main reasons might be the long-term phenotypic selection in the Ankole breed, the limited data per sire and the limited possibilities for the European breeds to express their genetic potential due to the abscence of concentrate feeding for economic reasons. Under unconstrained conditions, crossbreds may have a considerable advantage. The combination with higher milk yield may tend to a higher Holstein Friesian proportion. For the long-term breeding goal, resulting from the new synthetic breed simulation, breed proportions between 77.5 and 80 % Holstein Friesian and between 20 and 22.5 % Ankole can be advised. Normally, a crossbreeding programme can be carried out to enhance the genetic improvement in the population by using the superior purebred and the heterosis effects. However, this practice must compete with the selection programme currently underway within the population, and an optimal balance or complementarity between these two policies must be sought (6). The crossbreeding programme in Lushebere tends to achieve balance.

For the long-term breeding goal, a new synthetic breed adapted to the constrained conditions must be constructed, while the limited possibilities, such as the lack of concentrates, should be changed in order to express the European breeds' genetic potential for milk yield. For the short-term, the individual heterosis between European breeds and local breeds should be used for obtaining immediate returns.

The Masisi area has a great natural milk production potential because of favourable climatological conditions. To release its potential, the milk-concentrate price ratio has to be increased. This is an essential condition to make use of the genetic potential of the European breeds.

The importance of the local Ankole breed in crossbreeding schemes should not be neglected. For milk yield, our analysis of field data and our simulation work indicate an optimal proportion of 20 to 22.5 %.

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A crossbreeding experiment between Holstein Friesian, Brown Swiss and Ankole cattle was conducted during the years 1978 - 1988 on the Lushebere farm in the Masisi zone, North-Kivu in the Republic of Zaire. Superior Holstein Friesian breed additive effects and Holstein Friesian x Ankole individual heterosis effects were found for milk yield. Brown Swiss x Ankole individual heterosis contributed positively to milk production. A low heritability was found for milk yield (0.14), economically the most important trait. The main reasons might be the long-term phenotypic selection, particularly for the Ankole breed, and further the limited possibilities for European breeds to express their genetic potential due to the absence of concentrate feeding. Considering a long-term breeding goal, based on the simulation of new synthetic breeds, it was shown that the breed proportions between 77.5 and 80 % Holstein Friesian and between 20 and 22.5 % Ankole should be pursued. *Key words* : Cattle - Crossbreeding - Heterosis - Milk production - Zaire.

WANG (N.), VANDEPITTE (W.), NOUWEN (J.), CARBONEZ (R.). Cruzamiento de las razas Holstein Frisia, Pardo Suizo y Sanga en Zaire. I. Producción láctea. *Revue Élev. Méd. vét. Pays trop.*, 1992, **45** (3-4) : 349-352

Entre 1978 y 1988, se llevaron a cabo cruzamientos experimentales entre las razas Holstein Frisia, Pardo Suizo y Ankole en la finca Lushebere en la zona Masisi, Kivú del Norte, República de Zaire. Los efectos aditivos de la raza Holstein Frisia y de la heterosis individual del cruce Holstein Frisia x Ankole, se reflejaron en la producción láctea. El cruce Pardo Suizo x Ankole contribuyó en forma positiva a la producción láctea. La heredabilidad de la producción láctea (0,14) fue baja, constituyendo característica de mayor importancia económica. Como principales razones, se pueden citar la larga duración de la selección fenotípica, principalmente para el ganado Ankole y la limitación de las razas europeas para desarrollar su potencial genético en ausencia de alimento concentrado. Como meta a largo plazo, basada en la simulación de nuevas razas sintéticas, se debe continuar con proporciones de 77,5 y 80 p. 100 Holstein Frisia y 20 a 22,5 p. 100 Ankole. *Palabras claves :* Bovino - Cruzamiento - Heterosis - Producción láctea - Zaire.

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