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Crossbreeding Holstein-Friesian with Ethiopian Boran cattle in a tropical highland environment: preliminary estimates of additive and heterotic effects on milk production traits

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Introduction

The Boran cattle breed is a zebu type that originated in the southern lowlands of Ethiopia. It is widely used for milk, meat, draught power and manure production (Albero & Hailemariam, 1982). It has been crossed with the milk-producing Holstein-Friesian breed with the aim of combining productivity and adaptability in the progeny. The objective of the current study was to estimate additive and heterotic effects for total lactation milk yield (LMY), daily milk yield (DMY) and lactation length (LL) in crosses involving Holstein-Friesian and Boran cattle.

Material and methods

The data for this study were obtained from a long-term crossbreeding project of the Ethiopian Agricultural Research Organization, conducted at the Holetta Research Center. The Center is located at 38.2^o E longitude and 8.6^o N latitude at an altitude of 2400 m and receives an average annual rainfall of 1200 mm. A total of 1095 lactation records, collected over a period of 21 years, from 1978 to 1998 were used. Imported Holstein-Friesian semen was used on purebred Holstein-Friesian (H) and Boran (B) dams to produce purebred Holstein-Friesian, F_1s and backcrosses. The F_1's were mated *interse* to produce two-bred synthetic or F_2 's. Contemporary purebreds were also produced. Thus, the six genotypes used in the current analysis were F_1, F_2, B_1 (5/8H3/8B), B_2 (3/4H1/4HB), and purebreds H and B. Similar management protocols, such as feeding based on grazing with some concentrate supplementation, hand milking and bucket-feeding of unweaned calves were followed for all genetic groups.

A two step method was used to estimate the crossbreeding parameters. In the first step, all traits were analyzed by fitting a fixed effect model using the least-squares procedure of the generalized linear model (GLM), of Statistical Analysis Systems (1994). The fixed effects included in the analyses were genotype, year of calving, season of calving, and parity. All fixed effects were highly significant ($P < 0.001$). In the second step the least-squares means and associated standard errors of the genotypes were used in estimating weighted least square crossbreeding parameters, based on the Kinghorn (1987) model, using a Universal Program for Estimating Crossbreeding Effects (Wolf, 1996). Additive genetic effects for the Holstein-Friesian breed were estimated as deviations from the Boran.

Results and discussion

The least-square means for genotypes are presented in Table 1. In an average lactation, the purebred Holstein-Friesian cattle produced 4.5 times more milk than Boran and nearly 1000 kg more milk than the best producing B_2 crossbred cattle ($P < 0.01$). All the crossbred groups produced at least three times more milk per lactation than the Boran ($P < 0.01$). The yield difference per day followed a similar pattern to that of total lactation yield. The Boran had the lowest ($P < 0.01$) lactation length while the rest of the genotypes had more or less similar lactation lengths. The values obtained in this study on lactation performance for both crosses and purebreds were within the intervals reported for indigenous, crosses and exotic dairy breeds evaluated under tropical environments (Rege, 1998).

Results for the estimated individual crossbreeding effects for LMY, DMY and LL are presented in Table 2. The direct genetic effect of the Holstein-Friesian significantly ($P < 0.01$) influenced LMY, DMY and LL. Crossbreeding Holstein-Friesians with Borans resulted in desirable ($P < 0.01$) direct individual heterosis for LMY, DMY and LL. The individual heterotic advantages of the crosses were 51%, 21% and 27% above the average of both B and H for LMY, DMY and LL, respectively. On the other hand, there was a significant ($P < 0.01$) negative direct epistatic effects on LMY and DMY. This was due to the lowered performance observed on both the F_2's and backcrosses. The genetic explanation for this could be that Holstein-Friesians through generations of selection for increased milk yield might have accumulated favorable epistatic interactions between genes at different loci, in addition to positively acting additive genes. Therefore, by crossing Holstein-Friesian with Boran (unselected for milk), the epistatic interaction genes might have been lost due to the free recombination process during meiosis. Similar negative recombination effects on milk yield were reported even for crossing between two *B. taurus* breeds namely, Holstein-Friesian and Jersey (Grosshans *et al*. 1994).

Table 1 Least-squares means (± SE) for lactation and daily milk yields and lactation length for Holstein-Friesian and Boran breeds and their crosses

Breed group [1]	N	Lactation milk yield (kg)	Daily milk yield (kg)	Lactation length (days)
Overall mean	1095	2521±27	7.3±0.1	342±3
Boran (B)	108	771±99	3.4±0.2	198±11
Holstein-Friesian (H)	601	3311±76	9.8±0.2	335±9 [b2]
F_1	213	2278±65[b2]	6.2±0.1[ab]	374±8[a]
F_2	91	1947±110[a]	5.6±0.2[a]	348±13[ab]
B_1	32	2194±178[ab]	6.3±0.4[ab]	339±21[ab]
B_2	50	2312±135[b]	6.9±0.3[b]	348±16[ab]

[1] B, Boran; H, Holstein-Friesian; F1, H x B; F2, HB x HB; B_1, 5/8H3/8B; B_2, 3/4H1/4B; breed of sire is identified by first symbol in crosses; [2] Means followed by similar superscript letters were not significantly different (P > 0.05)

Table 2. Estimates and standard errors of individual crossbreeding effects for milk traits [a]

Parameters[b]	LMY (kg)	DMY(kg)	LL(days)
m	783±101**	3.4±0.21**	197±11**
g^I_H	2417±123**	6.3±0.25**	129±14**
h^I_{HB}	846±232**	1.4±0.25**	71±28**
e^I_{HB}	-1147±417**	-1.7±0.88**	81±49

[a] LMY, total lactation milk yield; DMY, daily milk yield; LL, lactation length; [b] m, estimated mean value for Boran; g^I_H, direct Individual additive effects of Holstein-Friesian; h^I_{HB} and e^I_{HB}, direct individual heterosis and epistatic effects, respectively; ** P < 0.01

Conclusions

The preliminary estimates of crossbreeding parameters obtained in this study showed the importance of Holstein-Friesian genes and heterosis on milk production traits. Using the parameter estimates, the predicted performance of tested and untested crosses showed that maximum yield increase was for F_1's and thereafter it increased at a decreasing rate for other crosses with a higher proportion of Holstein-Friesian genes. In general, the findings of this study show that using pure Holstein-Friesian's for milk production would be more profitable, if reproduction and survival rate is not significantly lower.

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