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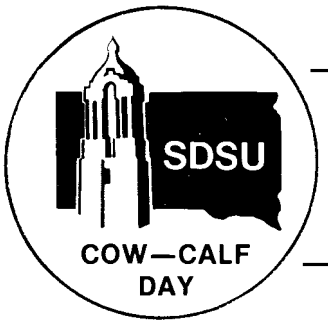

AN EVALUATION OF HETEROSIS AND MATING SYSTEMS IN HEREFORD CATTLE

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Summary

Four mating systems, inbreeding, linecrossing, topcrossing and outbreeding (control) were compared for preweaning traits. Significant differences among these mating systems were found for fertility, birth weight of male calves, weaning weight of female calves and pounds of calf weaned per cow exposed in the breeding pasture. Nonsignificant differences were found for calf livability of both sexes, birth weight of female calves and weaning weight of male calves. Although the topcross and control groups generally outproduced the inbred and linecross groups, there were specific individual linecrosses that were equal or superior to these two groups.

Introduction

The objective of this project was to evaluate the effectiveness of inbreeding in furthering the improvement of beef cattle. Results obtained with other species, notably corn, have led to similar research projects with farm animals.

Procedures

Four inbred lines of registered Hereford cattle were established in 1952, and in 1955 a control line was formed by breeding available foundation cows from the inbred lines to line bulls from unrelated lines. Inbred lines were carried as single sire lines and the control line as a four-sire line through 1968. Linecross matings were made in 1969, 1971, 1972, 1973 and 1974. In 1970, inbred calves were again produced to provide sufficient replacements to carry on the linecrossing program. In addition to the 5 years of linecross tests carried on at the Antelope Range Livestock Station, limited crossing of the lines had been carried on at the Cottonwood Range Field Station during the period 1963 through 1969.

Matings were made between related inbred animals to produce the inbred cattle, while matings of unrelated inbred cattle produced the linecrosses. Topcrosses were produced by mating an inbred bull to control line females and the control group was continued by mating control line bulls to control line cows. The inbred, linecross and topcross calves were produced by mating a bull to related inbred cows, unrelated inbred cows and control line cows, respectively, so that bull differences were essentially eliminated in these comparisons. The control line was maintained over the years to enable an evaluation of what might have been obtained in a commercial herd through the usual selection of unrelated bulls and thus allow an evaluation of the effects of inbreeding and linecrossing relative to usual commercial

production. This was made possible through use of four sires in the control line and a very minimal increase of 3 or 4% in the level of inbreeding during the 15 years of its existence.

Results and Conclusions

Comparisons among the four mating systems (table 1) allow an evaluation of heterosis in the technical sense by comparing the linecross to the inbred and the more practical comparison of heterosis by comparing the linecross to the control. Since the same selection pressure was applied to all four groups, mating system benefits would be reflected by superiority over the control group.

Mating of inbred bulls to noninbred cows (topcross) resulted in higher fertility than that found in the inbred or linecross groups but not significantly different from the control group. The control group did not differ significantly from the inbred and linecross. Differences in calf livability, either male or female, were not large enough to expect them to be repeatable.

The four mating systems did not differ in birth weight of heifer calves. However, bull calves in the linecross group were significantly heavier than those in the inbred group. Other differences in birth weight of bull calves were not important. For weaning weight, the situation was reversed with respect to sex, with no significant differences among breeding groups for bull calves but important differences for heifer calves between inbred and linecross and between linecross and both topcross and control groups. The topcross and control groups were essentially equal. The last trait in the table, weaning weight of calf per cow exposed, combines the important traits of fertility, livability and average weaning weight. Indications are that the topcross and control groups are highest in this trait and are essentially equal. In spite of the 37-pound advantage for the control group over the linecross, the analysis indicates this difference was not significant. The linecross did have a significant 29-pound advantage over the inbred group.

Since preweaning traits are subject to maternal environment, the results in table 1 are highly influenced by the inbred mothers in the inbred and linecross groups as compared to the noninbred mothers in the topcross and control groups. This is an important consideration in planning the utilization of inbreeding in a commercial cow operation. Further evidence in this regard will be forthcoming from results of an experiment at the U.S. Meat Animal Research Center at Clay Center, Nebraska. The heifer calves born in this project were transferred at weaning to Clay Center and their performance as mother cows is being measured there.

While the performance of the four mating systems discussed above is of interest, commercial utilization of inbred linecrosses will depend more on the performance of individual crosses rather than the average of all linecrosses as presented in table 1. For example, if one were to look at a similar table for corn where the maternal effect is not as important, theoretical expectation would be that the average of all linecrosses would equal the control. The advantage that hybrid corn has had in recent history stems from the fact that there are individual crosses that exceed this

average substantially and because of the high level of inbreeding can be depended on to produce this advantage uniformly. With beef cattle, our expectations are reduced because of the depressing effect of inbreeding on maternal abilities as already discussed and also because the extreme uniformity obtained with inbred lines of corn will not be available in cattle due to the lower levels of inbreeding. These lower levels of inbreeding result because beef cattle cannot be self-fertilized, they have a low reproductive rate and they have a long generation interval as compared to corn. Table 2 indicates the average level of inbreeding of the dams and sires of the calves used in this analysis. In comparison, lines of corn that are routinely crossed would be very nearly 100% inbred. There is interest, though, in examining the performance of the individual crosses to see the extent to which the best crosses exceed the control. Perhaps even with a more variable response, there might still be sufficient advantage to warrant further consideration.

Table 3 is included to illustrate differences in specific combining ability among crosses of these lines for weaning weight of calf per cow exposed in the breeding pasture. Individual performance of the control line, topcross, inbred and single cross matings can be found in the inner cells of the table. The average performance of a line as a dam line or as a sire line can be found in the side margin or in the bottom margin, respectively. Line 2 and line 8 are the two best inbred lines when evaluated on average sire line and average dam line performance. They approach but do not equal the control line performance. On this basis, crosses of lines 2 and 8 would be expected to do well and this is borne out where line 8 is used as a sire line and line 2 is used as a dam line but not where the cross is made the other way. This emphasizes the importance of considering the maternal abilities of the lines in planning crosses. On the other hand, line 3 is next to the lowest in dam line performance and line 2 is the lowest in sire line performance. From this, crosses of line 3 with line 2 would be expected to be lower, particularly when line 2 is the sire line, but they are not. In fact, they are surpassed only by line 8 sires crossed on line 2 dams. This ability for a particular cross to perform far different from expectation based on average performance over all crosses is what is commonly called specific combining ability. The identification and propagation of lines that have high specific combining ability have contributed in a large part to the success of hybrid corn. The average superiority of crosses of lines 2 and 3 above the average of their inbred performance (heterosis) is 67%, but with respect to control line performance it is zero, since they are equal. The only cross showing heterosis with respect to the control line is line 8 males crossed on line 2 females and it amounts to 8%.

These results may not appear encouraging to the use of inbreeding and linecrossing in the production of commercial beef. Although the levels of heterosis indicated here are not greatly different from levels of heterosis found in crosses of inbred lines of corn, one must consider that only four inbred lines have been evaluated here, where hundreds of lines of inbred corn have been used to find the very highest performing individual crosses.

Duplicating this procedure with beef cattle would be extremely expensive and, as indicated earlier, would not produce the uniformity of product due to the lower level of inbreeding. Improved technology in the areas of increased reproductive rate, sex control, synchronization of estrus, non-surgical ova transplant and self-fertilization could make the procedure more useful and practical.

Table 1. Mating System Preweaning Performance+

	Fertility	Calf livability		Birth weight		Weaning weight		Weaning weight per cow exposed
		Male	Female	Male	Female	Male	Female	
	%	%		lb		lb		lb
Inbred	79[a]	93[a]	87[a]	74[b]	68[a]	399[a]	351[c]	269[a]
Linecross	83[a]	92[a]	91[a]	78[a]	69[a]	414[a]	375[b]	298[ab]
Topcross	91[b]	90[a]	96[a]	77[ab]	71[a]	426[a]	399[a]	337[c]
Control	88[ab]	99[a]	93[a]	76[ab]	71[a]	426[a]	401[a]	335[bc]

+ Means with the same superscript are not significantly different.

Table 2. Average Inbreeding of Dam and Sire

Line	Inbreeding of dam %	Inbreeding of sire %
1	28	34
2	30	32
3	31	31
8	19	20
Control	4	3

Table 3. Individual Line and Linecross Performance for Weaning Weight Per Cow Exposed (Lb)

Line of dam	Line of sire 1	2	3	8	Control	Line of dam avg
1	264 (56)[a]	234 (14)	272 (26)	299 (40)		267 (136)
2	309 (18)	277 (26)	336 (16)	360 (14)		320 (74)
3	304 (27)	331 (19)	223 (30)	267 (23)		281 (99)
8	290 (46)	234 (21)	331 (27)	309 (63)		291 (157)
Control	373 (80)	328 (30)	302 (32)	344 (71)	334 (92)	336 (305)
Line of sire avg	308 (227)	281 (110)	293 (131)	316 (211)	334 (92)	

[a] Numbers in parentheses are number of observations.