GM 30. EFFECTS OF INBREEDING AND HETEROZYGOSITY ON PREWEANING TRAITS IN A CLOSED POPULATION OF HEREFORDS

F. A. Pariacote[1], L. D. Van Vleck[2], and M. D. MacNeil[3]

[1]UNEFM, Departamento de Producción Animal, Apartado 7482, Coro 4101. [2]Roman L. Hruska U.S. Meat Animal Research Center, USDA, ARS, Lincoln, NE 68933, and [3]Livestock and Range Research Lab, USDA, ARS, Miles City, MT 59301

Resumen

Efecto de la consanguinidad y heterocigosidad sobre las características predestete en una población Hereford cerrada

Registros de cinco líneas fundadas por un sólo toro en el Livestock and Range Research Laboratory, Montana fueron usados para evaluar los efectos de consanguinidad y heterocigosis sobre peso al nacer (n = 8 065), al destete y ganancia diaria predestete (n = 7 380). Las características fueron analizadas por REML sin derivación asumiendo un modelo que incluyó los efectos fijos de sexo, combinación año x mes de nacimiento, número de parto, y los efectos lineales directos y maternos de línea, consanguinidad y heterocigosis como covariables. Como aleatorio incluyó los efectos genéticos directos y maternos y ambiental materno permanente no correlacionado. La consanguinidad y heterocigosis directa promedió 9.8 y 34.3, y la materna 7.5 y 29.4%. El peso al nacer disminuyó en 5.8 “ 1.1 y 4.7 “ 1.3, la ganancia diaria promedio en .19 “ .03 y .25 “ .04 y el peso al destete en 44.5 “ 6.6 y 56.1 “ 8.4 kg por cambios de cero a 100% de consanguinidad directa y materna, respectivamente. Los resultados sugieren que la heterosis representa la recuperación de la depresión consanguínea acumulada.
Palabras claves: Ganado de carne, consaguinidad, heterosis.
Key words: Beef cattle, inbreeding, heterosis.

Introduction

The usual plan in formation of lines has been to make genetic relationships to a desired animal as large as possible. Unfortunately, increased homozygosity has been associated with a decline in performance (Burrow, 1993). Lines have also been formed to create specific crosses that can take advantage of non additive genetic effects, under the hypothesis that heterosis is recovery of accumulated inbreeding depression (Gregory *et al.*, 1994). Within an environment, heterosis in a given trait seems to be a function of the genetic differences among lines or groups being crossed. The goal of this study was to estimate effects of inbreeding during line formation and effects of heterozygosity on preweaning traits of line crosses in a closed population of Hereford.

Material and methods

Five lines founded at Fort Keogh Livestock and Range Research Laboratory (LARRL), Miles City, Montana by single Hereford bulls were identified as Line 1, Line 4, Line 6, Line 9 and Line 10. Line 1 remained closed to outside breeding from 1934 to 1971, Line 4 from 1947 to 1975, Line 6 from 1949 to 1975, Line 9 from 1951 to 1970, and Line 10 from 1950 to 1975. The base population was defined as foundation males and females that did not have information of their own as well as other individuals from matings within that group. Any individual not related to the lines or the base population, was considered an immigrant and coded as such. Seven groups were formed, with groups 1 to 5 being Lines 1, 4, 6, 9, 10 and groups 6 and 7 being immigrants and the base population, respectively. Individuals with a composite genotype were considered to be line crosses.

Inbreeding coefficients were computed with the MTDFNRM program (Boldman *et al.*, 1995) and heterozygosity coefficients as $1\text{-}3(Sg_iDg_i)$, where Sg_i and Dg_i represent the genetic contribution of line Ai@ to sire and dam for i=1, ...,6, with the base population excluded. Direct inbreeding and heterozygosity averaged 9.8 and 34.3, and maternal inbreeding and heterozygosity 7.5 and 29.4%. Raw means for birth weight (n=8065), daily gain and weaning weight adjusted to 205 d of age (n=7380) were 34.5 “ .1, .8 “ .0 and 192.0 “ .4, respectively. Detail regarding climatic conditions and livestock husbandry at LARRL during the period of this research are given by Urick *et al.* (1966), MacNeil *et al.* (1992), and Ferreira (1996).

Traits were analyzed by derivative-free REML with the MTDFREML program (Boldman *et al.*, 1995) under the following model:

y = XB + Z_1u_1 + Z_2u_2 + Z_3u_3 + e; where: y = the vector of observations. B = vector of unobservable fixed effects. u_1 = vector of random additive direct genetic effects. u_2 = vector of random additive maternal genetic effects. u_3 = vector of random uncorrelated maternal permanent environmental effects. X = matrix that relates the elements of y to the fixed effects. Z_1 = matrix that relates the elements of y to the direct genetic effects. Z_2 = matrix that relates the elements of y to the maternal genetic effects. Z_3 = matrix that relates the elements of y to the random uncorrelated maternal effects. e = vector of residual effects.

The vector of fixed effects included sex: male, female and steer; combination of year of birth (1934-1988) with month of birth (March-June); parity of dam: 1-10 and covariates for the linear effects of direct and maternal line fractions in addition to the direct and maternal inbreeding coefficients and heterozygosity fractions.

Results and discussion

Inbreeding effects. The pooled across line regression coefficients of performance on direct and maternal inbreeding coefficients differed from zero for all traits (P < .05). Birth weight was reduced by 5.8 “ 1.1 and 4.7 “ 1.3, preweaning daily gain by .19 “ .03 and .25 “ .04, and weaning weight by 44.5 “ 6.6 and 56.1 “ 8.4 kg for a change from zero to 100% of coefficients of direct and maternal inbreeding, respectively (table 1a-c).

Table 1. Partial regression coefficients (b) and standard errors (SE) of preweaning traits on direct and maternal inbreeding and heterozygosity coefficients.

	Preweaning traits (kg)					
	Birth weight		Daily gain		Weaning weight	
Covariates	b “	SE	b “	SE	b “	SE
a) Direct genetic contribution						
Inbreeding	-5.80 “	1.14**	-0.189 “	0.003	-44.52 “	6.59
Heterozygosity	0.03 “	0.32	0.004 “	0.001	0.80 “	1.77
b) Maternal genetic contribution						
Inbreeding	-4.67 “	1.31	-0.252 “	0.004	-56.10 “	8.41
Heterozygosity	0.02 “	0.37	-0.011 “	0.001	-2.26 “	2.30

Accumulated across lines direct and maternal inbreeding depressed birth weight by .9, preweaning daily gain by .04 and weaning weight by 8.5 kg (table 2a-c), which represent 2.7, 4.8 and 4.4% of the raw means, respectively. Of this total, direct inbreeding accounted for about 62% of the depression for birth and 51% for weaning weight, which agree with previous reports (Burrow, 1993).

Table 2. Average effect of inbreeding and heterozygosity and amount of inbreeding depression recovered by heterosis.

Trait	Average effect of:		As % of raw mean:		Heterosis/Inbreeding
	Inbreeding[b]	Heterosis[c]	Inbreeding	Heterosis	
a) Direct genetic contribution					
Birth weight	-0.57	0.58	-1.65	1.68	-1.02
Daily gain	-0.02	0.02	-2.40	2.58	-1.07
Weaning weight	-4.33	4.60	-2.25	2.39	-1.06
b) Maternal genetic contribution					
Birth weight	-0.35	0.35	-1.01	1.02	-1.01
Daily gain	-0.02	0.02	-2.42	2.03	-0.83
Weaning weight	-4.14	3.51	-2.16	1.83	-0.84
c) Total					
Birth weight	-0.92	0.93	-2.66	2.70	-1.02
Daily gain	-0.04	0.04	-4.83	4.61	-0.95
Weaning weight	-8.47	8.11	-4.41	4.22	-0.95

[b]Average inbreeding effect (AIE) = b_F*F; where b_F represents the regression coefficient of trait on inbreeding, and F represents the average inbreeding. [c]Heterosis = b_H*H - AIE; where b_H represents the regression coefficient of trait on heterozygosity, and H represents average heterozygosity.

Heterozygosity. Much as expected, the regression coefficients associated with direct and maternal heterozygosity did not differ significantly from zero. Under the hypothesis of dominance, which seems to be the case for growth traits in beef cattle (Gregory *et al.*, 1994; Kress *et al.*, 1992), the theoretical expectation is for heterosis to recover effects of inbreeding depression. In this study, a negative regression coefficient associated with heterozygosity would indicate that there was not total recovery from inbreeding depression and a positive value would indicate that there was recovery above expectation.

Mean effects of direct and maternal heterozygosity for all groups were estimated as deviations of the corresponding average effect of heterozygosity from the absolute average of inbreeding depression. Results agree with previous reports (Flower *et al.*, 1963; Brinks *et al.*, 1972; Urick *et al.*, 1981; Urick *et al.*, 1983; MacNeil *et al.*, 1982). Crossing lines recovered nearly all of the effects of inbreeding depression, 1.01, .95 and .95, for birth weight, daily gain and weaning weight, respectively (table 2a-c).

Conclusion

Results support the hypothesis that inbreeding depression is due to a loss in heterozygosity that occurs in formation of lines and that heterosis is basically recovery of that depression.

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