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Kappa-Casein and Beta-Lactoglobulin Genotype Effects on Milk Production and Maternal Calf Growth Traits in Crossbred Beef Cattle[1]

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Summary

Cows were genotyped at the kappa-casein and beta-lactoglobulin loci and evaluated for milk yield, calf birth weight, weaning weight, and average daily gain from birth to 109 days and from birth to 211 days of age. The interaction of breed-group with genotype was significant for milk yield at both loci. Cow genotype and additive allelic effects were significant or approached significance for both measures of calf average daily gain and weaning weight at the kappa-casein locus. Cow genotype and additive allelic effects were significant for calf average daily gain to 109 days at the beta-lactoglobulin locus. Cow genotype approached significance for calf average daily gain to 211 days at the beta-lactoglobulin locus. The quadratic effect of number of A alleles in the cow's genotype (i.e., 0, 1, or 2) was significant or approached significance for several measures of calf growth, suggesting possible dominance effects.

Key Words: Beef cattle, Genotype, Milk, Growth

Introduction

Marker-assisted selection has received increasing interest as DNA technologies have developed. Potential benefits of marker-assisted selection include 1) a reduction in generation interval since superior animals can be identified at an early age, even before birth and 2) the accuracy of predicted performance (heritability, h^2) increases when DNA marker information is combined with performance information of the individual and(or) its relatives. A number of DNA markers have been located, but the actual effects of such loci are mostly unknown to date. Candidate genes may have a direct influence on production traits, and can serve as linkage markers to other genes affecting traits of interest. Kappa-casein and beta-lactoglobulin have been suggested as candidate genes for possible effects on milk yield, milk composition, and calf preweaning growth. The objective of this study was to evaluate the effect of cow genotype at the kappa-casein and beta-lactoglobulin loci on milk production and preweaning calf growth in a beef herd.

Materials and Methods

Production data for this study were collected from 1991 to 1995 at the Beef Breeding Unit at South Dakota State University in Brookings, South Dakota. The cows were 3 to 10 years old and maintained in one of three two-breed rotational crossbred groups: Tarentaise-Hereford cross, Angus-Hereford cross, or Simmental-Hereford cross. Traits measured include estimated cumulative milk yield, calf birth weight, calf average daily gain from birth to 109 days and 211 days, and calf weaning weight. Cumulative milk yield was estimated by nonlinear regression procedures using weigh-suckle-weigh measurements taken on six or seven dates each year.

DNA was extracted from blood samples of each cow. Genotyping procedures included amplification of a portion of the target gene by the polymerase chain reaction (PCR), followed

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by restriction enzyme digestion of the amplified DNA into fragments and gel electrophoresis to separate the DNA fragments. The genotype of a particular cow is determined from the banding pattern of the DNA fragments. Each locus was assumed to have two alleles, designated A and B, segregating in these beef populations. Thus, the possible genotypes for a given locus in a particular cow were AA, AB, or BB.

Mixed-model statistical analyses were conducted to calculate least squares means by genotype. In a second analysis, linear and quadratic covariates for the number of copies of allele A (i.e. 0, 1, or 2) in a cow's genotype were included in the model. Separate analyses were conducted for the kappa-casein and beta-lactoglobulin loci. Variance components were estimated for use in the mixed-model analysis, and the resulting heritability values are presented in Table 1.

Table 1. Number of records (n) and heritability values by trait

Trait	n	Heritability
Estimated milk yield	231	.38
Calf birth weight	223	.37
Calf ADG to 109 days	226	.46
Calf ADG to 211 days	222	.44
Calf weaning weight	222	.40

Results and Discussion

For estimated milk yield, a breed-group by genotype interaction was significant for both kappa-casein and beta-lactoglobulin (Table 2). For both loci, genotype rankings within Tarentaise-Hereford cows were different as compared to the other two breed-groups. At the kappa-casein locus, milk yields for the BB genotype was lower than for the other two genotypes among Simmental-Hereford and Angus-Hereford cows, whereas the AA genotype was associated with the lowest milk yield in the Tarentaise-Hereford cows. At the beta-lactoglobulin locus, the AA genotype was associated with lower milk yield among Simmental-Hereford and Angus-Hereford cows, but with the most milk among Tarentaise-Hereford cows. These interactions suggest the possible existence of additional genes affecting milk yield that are linked to (i.e., located near) the kappa-casein and beta-lactoglobulin loci.

Table 3 shows least-squares means by cow genotype for calf growth traits. The effect of cow genotype on birth weight was not significant at either locus. At the kappa-casein locus, average daily gains and weaning weight were similar for calves from AA versus AB cow genotypes, whereas calves from BB cows gained less and weighed 21 lb less at weaning than calves from AA cows. At the beta-lactoglobulin locus, average daily gain to 211 days and weaning weight were similar for calves from AB and BB cows, whereas calves from AA cows gained slower and weighed 26 lb less at weaning than calves from BB cows.

It is interesting to note the number of weaning records for the two loci in Table 3. The fewest cows exist for the genotype least favoring calf growth, that being BB for kappa-casein and AA for beta-lactoglobulin. This raises speculation that perhaps previous selection for increased calf growth has resulted in increased frequency of the A allele of kappa-casein and B allele of beta-lactoglobulin in these populations.

Table 2. Least-squares means by genotype and breed-group for estimated cumulative milk yield (lb)

Item	Simmental-Hereford	Angus-Hereford	Tarentaise-Hereford
Kappa-casein genotype			
AA	3411	3385	3177
AB	3614	3329	3502
BB	2772	3114	3529
Beta-lactoglobulin genotype			
AA	3051	2360	4091
AB	3509	3235	3431
BB	3541	3398	3257

Table 3. Least-squares means (± standard error) by genotype and breed-group for calf growth traits

	Genotype					
	AA		AB		BB	
Item	Mean	s.e.	Mean	s.e.	Mean	s.e.
	Kappa-casein					
No. weaning records	129		77		38	
Birth wt, lb	107	1.5	103	1.8	105	2.4
ADG to 109 days, lb/day	1.78	.03	1.81	.03	1.66	.05
ADG to 211 days, lb/day	2.04	.03	2.05	.03	1.93	.04
Weaning wt, lb	532	5.6	534	6.9	511	9.1
	Beta-lactoglobulin					
No. weaning records	13		83		148	
Birth wt, lb	109	3.5	105	1.7	105	1.5
ADG birth to 109 days, lb/day	1.69	.06	1.75	.03	1.81	.03
ADG birth to 211 days, lb/day	1.89	.06	2.03	.03	2.03	.03
Weaning wt, lb	504	13.4	529	6.5	530	5.7

Linear and quadratic effects of the number of A alleles in the cow's genotype are shown in Table 4. Linear values are analogous to additive allele effects, sometimes called the effect of allele substitution. They represent an estimate of the average change in a production trait for each additional A allele in the cow genotype. Quadratic values measure non-linearity of the regression and might be indicative of dominance effects at the locus. Linear or quadratic effects were not significant for calf birth weight at either locus in this study. Linear and quadratic effects at both loci were significant or approached significance for several of the measures of calf growth after birth. In general, the significant linear (additive) values suggest a positive association with calf growth for cows having the A allele at the kappa-casein locus and the B allele at the beta-lactoglobulin locus. However, calves of heterozygous cows had similar preweaning growth to calves from cows with two copies of the favorable allele, sometimes resulting in a significant quadratic effect, and indicating a possible dominance effect.

Table 4. Linear and quadratic values for regression on the number of A alleles in the cow's genotype

	Linear effect[a]	s.e.	Quadratic effect[a]	s.e.
	Kappa casein			
Birth wt, lb	1.5	1.19	2.54	1.9
ADG to 109 days, lb/day	.04*	.02	-.09**	.03
ADG to 211 days, lb/day	.04†	.02	-.07*	.03
Weaning wt, lb	7.5†	4.45	-12.7†	7.1
	Beta lactoglobulin			
Birth wt, lb	1.2	1.39	1.8	2.29
ADG to 109 days, lb/day	-.12**	.03	-.10	.04
ADG to 211 days, lb/day	-.04	.02	-.07†	.04
Weaning wt, lb	-7.6	5.20	-12.0	8.77

[a]Linear values are in actual units of the trait; quadratic values are in units^2.
†P<.10; *P<.05; **P<.01.

Implications

These data indicate possible associations of cow genotype with milk yield and calf preweaning growth at the kappa-casein and beta-lactoglobulin loci. Such associations could possibly result from a direct influence of these genes, or from the linkage of these genes to other genes affecting the traits evaluated, or from a combination of both.