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Genetic Components for Milk Production of Tarentaise, Hereford, and Tarentaise × Hereford Cows¹

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ABSTRACT: The objective of this study was to estimate genetic components for milk production of Hereford (HH), Tarentaise (TT), and Hereford × Tarentaise or Tarentaise × Hereford (HT) cows under range conditions at the Northern Agricultural Research Center, Havre, MT. Milk production of 494 cow-calf pairs was estimated by the weigh-suckle-weigh procedure from 1989 to 1994. Milk production and cow and calf weights were measured at 40 d (early) and 120 d (late) of lactation. The mating scheme was a 3 × 3 design in which HH, HT, and TT cows were mated with HH, HT, and TT sires, producing calves that were varying percentages of Hereford and Tarentaise. Data were analyzed by least squares procedures according to a model that included year, age of cow, sex of calf, linear regression on calf age, and linear regressions on coefficients that coded for various genetic components. These genetic components were breed individual, breed maternal, breed

grand maternal, individual heterosis (calf heterosis), and maternal heterosis (cow heterosis). Coefficients for genetic components were such that breed effects estimated TT – HH and regressions on heterosis values estimated the full effect of heterosis. The breed individual genetic component was significant only for calf early and late weights; Tarentaise calves were lighter. Breed maternal was significant for most traits, and these effects were positive for milk production (2.16 and 3.77 kg/d for early and late, respectively) and calf weights but negative for cow weights. Individual heterosis was not significant for early milk production but was significant for late milk production (1.05 kg/d) and calf weights (2.3 and 8.1 kg for early and late, respectively). Maternal heterosis was significant for most traits and increased early milk production (1.25 kg/d), calf weights (4.5 and 5.8 kg for early and late, respectively), and cow weights (18.1 and 6.0 kg for early and late, respectively).

Key Words: Beef Cattle, Milk Production, Heterosis

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Introduction

Tarentaise cattle are a moderate-framed breed noted for calving ease, hardiness, and maternal characteristics (Briggs and Briggs, 1980), but few reports have been published comparing Tarentaise to other breeds in the United States (Long, 1980; Kress et al., 1995). If Tarentaise cattle are to be used as a maternal breed, it is important that their maternal characteristics be identified relative to established breeds such as Hereford. The primary objective of this study was to estimate genetic components (breed effects and heterosis) for milk production of Hereford, Tarentaise, and Hereford × Tarentaise or Tarentaise × Hereford cows under range conditions.

Materials and Methods

Cattle were located at the Northern Agricultural Research Center near Havre, MT, and all breed combinations were managed together. Supplemental feeding was practiced during the winter (late December to 1st wk of May) with 9 kg of alfalfa hay or its energy equivalent fed per day per cow before calving and increased to 14 kg/d per cow after calving. Cows were placed on a crested wheatgrass pasture the 1st wk of May and then moved to a foothill bunchgrass type of summer pasture the last week of May. The summer pasture averaged 480 mm of annual precipitation and 1,200 m in altitude. Vegetation of the summer pasture included rough fescue, Idaho fescue, and bluebunch wheatgrass with interspersed areas of ponderosa pine. Terrain varied from level to very steep areas and the stocking rate was 1.1 ha per animal-unit-month.

Foundation Hereford (85) and Tarentaise (77) dams were mated to Hereford (17) and Tarentaise

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Table 1. Design to produce Phase II calves^a from Phase I dams and sires, number of observations, and coefficients for individual heterosis

Breed of sire	Breed of dam			Total
	HH	HT	TT	
HH	1H1H 93 ^b 0 ^c	3H1T 80 .5	1H1T 17 1.0	190
HT	3H1T 35 .5	1H1T,F ₂ 44 .5	1H3T 33 .5	112
TT	1H1T 41 1.0	1H3T 57 .5	1T1T 94 0	192
Total	169	181	144	494

^aBorn in 1989, 1990, 1991, 1992, 1993, and 1994. H = Hereford and T = Tarentaise.

^bNumber of observations for milk production.

^cCoefficient for individual heterosis.

(16) sires to produce Phase I Hereford (**HH**), Hereford × Tarentaise or Tarentaise × Hereford (**HT**), and Tarentaise (**TT**) progeny. These Phase I HH, HT, and TT sires were mated at random to Phase I HH, HT, and TT dams in a 3 × 3 design (Table 1) to produce the Phase II calves of the present study. Two Phase I sires from each breed group were selected for breeding each year based on an index (365-d weight minus 3.2 times adjusted birth weight) from Dickerson et al. (1974), with the limitation that no sire could have an adjusted birth weight greater than 45.5 kg. Semen was collected on each sire and each sire was used for breeding for 1 yr. The resulting Phase II calves varied in percentage of Hereford and Tarentaise breeding (0, 25, 50, 75, and 100%). Breed group of sire (and individual sire within breed group) for individual cows changed from year to year in a random manner.

Cows 2 yr old and older were bred by AI during a 45-d season starting the 1st wk of June. Heifers were

bred by natural service to one sire selected at random from each breed group each year. Calves were born from early March to late April and were weaned at an average age of 6 mo during the 1st wk of October. Male calves were retained as bulls. There was no creep feeding.

The weigh-suckle-weigh technique, as described by Williams et al. (1979), was used to measure milk production. The separation interval was 6 h at 40 d (early) and varied from 6 to 10 h at 120 d (late) of lactation. The technique was performed once at each point in lactation. Age of calf varied from 20 to 61 d for early and from 87 to 155 d for late milk production. All estimates of milk production were converted to a 24-h basis. Calf and cow weights were measured each time milk production was measured.

Traits were analyzed by least squares analysis of variance procedures (SAS, 1985) assuming a model with fixed effects of year, age of dam (2, 3, 4, and 5+ yr), sex, linear regression on day of birth, and linear

Table 2. Probability values from ANOVA

Source ^a	Milk production		Calf weight		Cow weight	
	Early ^b	Late	Early	Late	Early	Late
Year	.00	.02	.00	.00	.00	.00
Age of dam (AOD)	.00	.00	.00	.00	.00	.00
Sex of calf	.57	.52	.00	.00	.02	.02
BI	.74	.53	.01	.08	—	—
BM	.00	.00	.24	.00	.00	.00
BGM	.10	.62	.04	.84	.79	.72
HI	.95	.05	.02	.00	—	—
HM	.00	.69	.00	.00	.00	.00
AOD × HM	—	—	—	—	—	.03
Sex × HM	—	—	.01	—	—	—
Calf age	.22	.97	.00	.00	.00	.48

^aBI = breed individual, BM = breed maternal, BGM = breed grand maternal, HI = individual heterosis, and HM = maternal heterosis.

^bEarly = 40 d, Late = 120 d following parturition.

Table 3. Least squares means for fixed effects

Item	Milk production, kg/d		Calf weight, kg		Cow weight, kg	
	Early ^a	Late	Early	Late	Early	Late
Age of dam, yr						
2	7.8 ^b ± .27	7.5 ^b ± .36	59 ^b ± .64	139 ^b ± 1.4	413 ^b ± 4.5	446 ^b ± 4.3
3	9.0 ^c ± .27	8.0 ^b ± .35	65 ^c ± .62	146 ^c ± 1.3	468 ^c ± 4.5	511 ^c ± 4.1
4	10.8 ^d ± .30	9.9 ^c ± .39	73 ^d ± .70	160 ^d ± 1.5	511 ^d ± 5.0	541 ^d ± 4.6
5+	11.3 ^d ± .36	10.6 ^c ± .45	76 ^e ± .82	165 ^e ± 1.7	563 ^e ± 5.9	568 ^e ± 5.3
Sex						
Heifer	9.8 ^b ± .20	9.1 ^b ± .25	66 ^b ± .46	147 ^b ± .96	493 ^b ± 3.3	521 ^b ± 3.0
Bull	9.6 ^b ± .20	8.9 ^b ± .25	70 ^c ± .46	158 ^c ± .95	484 ^c ± 3.3	512 ^c ± 2.9
Regression on calf age	.026 ± .02	.001 ± .01	81* ± .05	.91* ± .06	-1.08* ± .25	-.12 ± .17

^aEarly = 40 d, Late = 120 d following parturition.

^{b,c,d,e}Means with different superscripts within classification differ ($P < .05$).

* $P < .05$.

regressions on coefficients for various genetic components. These genetic components were **BI** = breed individual, **BM** = breed maternal, **BGM** = breed grand maternal, **HI** = individual heterosis (calf heterosis), and **HM** = maternal heterosis (cow heterosis). Estimates of genetic components were based on the genetic model described in detail by Robison et al. (1981). Coefficients were such that breed effects estimated TT - HH and regressions on heterosis values estimated the full effect of heterosis. Coefficients for individual heterosis for each type of Phase II calf are presented in Table 1. Percentage individual heterosis was calculated by dividing HI × 100 by the average of the least squares means for HH and TT dams raising straightbred calves, and percentage maternal heterosis was calculated by dividing HM × 100 by the average of the least squares means for HH and TT dams raising F₁ calves.

Results and Discussion

Table 2 shows probability values from analyses of variance for early (40-d) and late (120-d) milk production and corresponding calf and cow weights. In general, fixed effects of year, age of dam, sex, and regression on calf age were significant, except that sex and calf age were not important ($P > .05$) for either measure of milk production. Interactions were not significant except for HM interacting with age of dam for late cow weight and with sex of calf for early calf weight. The significant age of dam × HM interaction for late cow weight was due to more maternal heterosis (16.3 kg) in 2-yr-old dams. The significant sex × HM interaction for early calf weight indicated that maternal heterosis was 3.4 kg greater for bull calves.

Least squares means for age of dam and sex are presented in Table 3. Age of dam means indicated that older dams produced more milk and heavier calves and had larger weights. These results agree with those from Simmental and Hereford-cross cows at the same location (Kress et al., 1990). Bull calves were heavier and their dams were lighter. One might suspect that these differences would be due to bull calves stimulating greater milk production, but milk production for dams raising heifer and bull calves was not significantly different.

Table 3 also shows the regression of each trait on calf age (which is confounded with the effects of stage of lactation and time of year born), which was important ($P < .01$) for calf weights and early cow weight. Early cow weight decreased as calf age increased and was at about the same rate as the increase in calf weights as calf age increased.

Estimates of genetic components are presented in Table 4. Values for daily milk production indicated that calf breed effects were not important but that

Table 4. Estimates of genetic components

Component ^a	Milk production, kg/d		Calf weight, kg		Cow weight, kg	
	Early ^b	Late	Early	Late	Early	Late
BI	-.22	-.51	-3.74*	-5.51	—	—
BM	2.16*	3.77*	1.99	14.51*	-34.90*	-33.76*
BGM	-.71	-.27	2.03*	.40	-1.87	-2.32
HI	.02 (.2) ^c	1.05* (12.1)	2.30* (3.5)	8.10* (5.5)	—	—
HM	1.25* (13.4)	.15 (1.5)	4.52* (6.6)	5.83* (3.7)	18.14* (3.8)	6.04* (1.2)

^aBI = breed individual, BM = breed maternal, BGM = breed grand maternal, HI = individual heterosis, and HM = maternal heterosis; all breed effects are Tarentaise minus Hereford.

^bEarly = 40 d, Late = 120 d following parturition.

^cValues in parentheses are percentage heterosis.

* $P < .05$.

Tarentaise dams produced more milk (average of 3.0 kg/d) than Hereford dams. Cundiff et al. (1981) reported that Tarentaise-cross dams produced 3.6 kg/d more milk (averaged over three milk estimates as 3-yr-olds) than Hereford \times Angus and Angus \times Hereford dams. Fiss and Wilton (1992) showed a smaller advantage of 2.5 kg/d for Tarentaise-sired dams over straight Hereford dams. Breed grand maternal effects were not significant for milk production. Genetic components indicated that the Tarentaise straightbreds and crossbreds of the present study surpassed the milk production of straightbred Hereford cows to about the same degree as Simmental crossbreds in an earlier study (Kress et al., 1990) at the same location.

There was positive individual heterosis for late milk production (12.1%) and positive maternal heterosis (13.4%) for early milk production, indicating that maternal heterosis was more important early in lactation and that individual heterosis was more important late in lactation. Perhaps crossbred calves were able to stimulate their dams to produce more milk in late (4 mo and older) lactation. However, we did not observe significant individual heterosis for late milk production when foundation Hereford and Tarentaise dams raised F₁ calves (Kress et al., 1995).

Values of genetic components for calf weights (Table 4) showed that breed individual genetic effects were negative whereas breed maternal and grand maternal effects tended to be positive. Weaning weights presented by Fiss and Wilton (1993) were 179 kg for Herefords and 185 kg for Tarentaise-sired calves. Notter and Cundiff (1991) showed net maternal effects on weaning weight for Hereford and Tarentaise breed of maternal grandsire of -6.1 and 9.8 kg, respectively, in agreement with the present 14.51 kg breed maternal effect. Our 14.51-kg breed maternal effect is in agreement with Cundiff et al. (1981), who reported that Tarentaise \times Hereford and Tarentaise \times Angus dams weaned calves that were 21.8 kg heavier than calves from Angus \times Hereford and Hereford \times Angus dams.

Both individual and maternal heterosis (Table 4) were important factors that increased calf weights. Maternal heterosis tended to be larger for early calf weight (6.6 vs 3.5%) and individual heterosis larger for late calf weight (5.5 vs 3.7%). This is in agreement with a larger individual heterosis (16.81 kg) than maternal heterosis (2.91 kg) for weaning weight reported by Newman et al. (1993) from a composite that was 1/4 Tarentaise.

Genetic components for cow weights (Table 4) indicated that Tarentaise cows were lighter than Herefords, in agreement with our results from the foundation cows (Kress et al., 1995). These results are in disagreement with Hereford (500 kg) and Tarentaise (519 kg) mature cow weights (simple means) reported by Jenkins et al. (1991). Maternal heterosis was positive for both early and late (3.8 and 1.2%, respectively) cow weight but was about three times larger for early cow weight when most cows were producing more milk and not gaining in weight.

Genetic components (Table 4) were used to construct mean values for each dam breed group (Table 5) in order to show actual levels of productivity by

Table 5. Means for dam breed group constructed from genetic components^a

Trait	Dam breed group		
	HH	HT	TT
Milk production, kg/d			
Early ^b	8.8	10.8	10.6
Late	8.1	10.0	11.6
Calf weight, kg			
Early	66	73	70
Late	148	162	163
Cow weight, kg			
Early	500	500	463
Late	528	516	492

^aAssuming that all dam breed groups were suckling 1H1T calves.

^bEarly = 40 d, Late = 120 d following parturition.

combining appropriate direct and heterotic effects. It was assumed that each type of dam was raising 1H1T F₁ calves, and the mean values also represent dam breed group differences if they were all bred to a third breed of sire. Hereford × Tarentaise and Tarentaise dams produced more milk and raised heavier calves, and Hereford and Hereford × Tarentaise were heavier cows. Straightbred Tarentaise cows demonstrated the ability to maintain or increase milk production from early to late lactation, in agreement with results from foundation cows at the same location (Kress et al., 1995).

Implications

Tarentaise dams produced more milk than Hereford dams, raised heavier calves, and had lighter cow weights. Hereford × Tarentaise F₁ dams had milk production and calf weights similar to straightbred Tarentaise but cow weight similar to straightbred Hereford cows. Comparisons of maternal heterosis to individual heterosis indicate that it is more important to use crossbred cows than crossbred calves. Crossbreeding systems that use Hereford and Tarentaise cattle will produce moderate-sized cows with improved milk production and larger calf weaning weights due to both individual and maternal heterosis.

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