GENETIC TRENDS DUE TO BULL SELECTION AND DIFFERENTIAL USAGE IN THE SIMMENTAL POPULATION[1]

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ABSTRACT

Records for calving ease and weight traits from 839,292 Simmental calves were used to obtain expected progeny differences of 11,130 Simmental bulls. Yearly weighted and unweighted means of the bulls' expected progeny differences for both direct and maternal effects were computed. These were used to study the trends in availability and bull usage between 1973 and 1984. The traits considered were first-parity calving ease, birth weight, weaning weight and yearling weight. The trends for both the weighted and unweighted means of the sire direct effects were positive for first-parity calving ease, weaning weight and yearling weight, but negative for birth weight. Trends in the unweighted means for direct effects for bulls represented as maternal grandsires were similar to that observed in the sires. Trends in the maternal effects were positive for first-parity calving ease and birth weight but showed almost no change for weaning weight. In each year bulls used on heifers had a higher first-parity calving ease and lower birth weight, weaning weight and yearling weight expected progeny difference means than those used on cows. Similarly the expected progeny differences of bulls mated to base dams were higher for first-parity calving ease and lower for birth weight, weaning weight and yearling weight than the predicted differences of bulls used on Simmental females. This indicates that selection of sires differed depending on the age and percent Simmental of the cow to be bred.
(Key Words: Genetic Trend, Growth, Dystocia, Maternal Effects.)

Introduction

The Simmental breed in the United States has been established through a grading-up process beginning with the availability of semen in the late 1960s. Since then, information on various productive and reproductive traits have been recorded. Beginning in 1971 these data were used for sire evaluations. Table 1 shows the traits reported by the American Simmental Association (ASA) in each year's sire summary. Producers had available information on bulls to aid in selection decisions shortly after the breed's introduction into the United States.

The ASA required the use of bulls designated as reference sires for information to be included in the sire evaluation to insure that data from different contemporary groups were connected. This requirement promoted the continued use of artificial insemination and resulted in many well-evaluated bulls being available to producers. The question that arises is, have breeders made use of the published sire evaluations to choose bulls? One way to answer this question is by studying the changes in bull usage over time. Thus, the objectives of this research were to examine the trends in sire usage from 1973 to 1984 for first-parity calving ease, birth weight, weaning weight and yearling weight, and to compare sire usage in Simmental and non-Simmental heifers and cows. Information will also be presented on bulls as sires of dams (i.e., maternal grandsires).

Materials and Methods

Data on calving ease (CE) and weight (WT) traits from 839,292 calves born between 1966 and 1985 were used to obtain predicted differences for 11,130 Simmental bulls. Separate evaluations were carried out for the CE and WT traits using multiple trait mixed model procedures (Henderson, 1976; Henderson and Quaas, 1976; Quaas and Pollak, 1980). The CE traits were first-parity CE (CE1) and second and later parities CE (CE2). Although the CE data were expressed in scores from 1 to 4 (1 = unassisted birth, 2 = easy pull, 3 = hard pull, 4 = cesarean),

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TABLE 1. WEIGHT AND CALVING EASE TRAITS FOR WHICH THE AMERICAN SIMMENTAL ASSOCIATION PUBLISHED BULL EVALUATIONS BY YEAR

	Trait[a]											
Year	BWD	BWG	GBD	WWD	WWM	WWG	GWD	YWD	CE1D	CE1G	CE2D	CE1X[b]
1972				+				+				
1973	+			+				+	+		+	
1974	+			+		+		+	+	+		+
1975	+	+		+		+		+	+	+	+	+
1976	+	+		+		+		+	+	+	+	+
1977	+	+	+	+		+	+	+	+	+	+	+
1978	+	+	+	+		+	+	+	+	+	+	+
1979	+	+	+	+		+	+	+	+	+	+	+
1980/81[c]	+	+	+	+		+	+	+	+	+	+	+
1982	+	+	+	+		+	+	+	+	+	+	+
1983	+	+		+		+		+	+	+	+	+
1984	+	+		+		+		+	+	+	+	+
1985	+	+		+		+		+	+	+	+	+
1986	+			+	+	+		+	+	+		

[a]BWD = Birth weight direct; BWG = birth weight maternal grandsire; GBD = weight gain direct from birth to weaning; WWD = weaning weight direct; WWM = weaning weight maternal; WWG = weaning weight maternal grandsire; GWD = weight gain direct from weaning to yearling; YWD = yearling weight direct; CE1D = first-parity calving ease direct; CE1G = first-parity calving ease maternal grandsire; CE2D = second and later parities calving ease direct; CE1X = calving ease index.

[b]$$\text{CE1X} = \frac{.4(\text{trait ratio CE1D}) + .6(\text{trait ratio CE2D}) + 1.2(\text{trait ratio BWD})}{2.2}$$

[c]Only one evaluation was published in this 2-yr period.

they were treated as continuous variables in the evaluation. The WT traits were birth weight (BW), weaning weight (WW) and weight gain from weaning to yearling (GW). The model for each trait included age of dam within sex and percent Simmental subclass, contemporary group, genetic group of the sire and genetic group of the maternal grandsire as fixed effects. The random effects were sire, maternal grandsire and residual. Maternal grandsire (MGS) effects contained direct and maternal effects in all traits, except for GW, where maternal effects were assumed to be negligible. Genetic groups of sires and MGS were obtained by first considering the pedigree information that was available on a bull (i.e., whether neither, either or both his sire and MGS were known) and by groups of approximately 100 bulls sorted by registration number with pedigree category. Predicted differences of bulls as sires and as maternal grandsires were computed for yearling weight (YW). The YW evaluations were obtained by adding the WW and the GW predicted differences. In addition, bulls' maternal grandsire effects for each trait were separated into their direct (MGD) and maternal (MGM) components. The MGD of a bull was calculated as one-half of that bull's sire direct (SID) effect and his MGM effect was obtained by subtracting the MGD effect from the maternal grandsire effect (i.e., the solution to the equations for maternal grandsires).

The set of mixed model equations used to compute the bull evaluations included the complete relationship matrix among males in the Simmental population. Females were assumed to be unrelated except through males. Yearly weighted and unweighted means of SID, MGD and MGM effects were computed to study the trends in the Simmental population. The weights for the weighted means of the SID effects were the numbers of progeny per bull each year and for the MGD and MGM effects the number of daughters with progeny per bull each year. The unweighted means are averages of SID, MGD and MGM effects for bulls represented as sires and MGS in each year. The unweighted means indicated the value of the males used (hence, available) each year for the various traits and effects. The weighted means, on the other hand, indicated how these males were used.

The weighted means and the unweighted means were computed within percent Simmental of dam x calving category subclass. The percent Simmental of dam subclasses were base (0% Simmental), F_1 (50% Simmental) and Simmental (greater than or equal to 75% Simmental). The breed of each base dam was unavailable. However, it is known (ASA National Sire Summary, 1973) that there are at least 23 base breeds represented in the base dam subpopulation, e.g., Hereford, Polled Hereford, Angus, Shorthorn, Belted Galloway, Brahman, Charolais, Limousin, Holstein. The calving categories were first-parity females (heifers) and second-parity and older females (cows).

Table 2 shows the distribution of calves by percent Simmental of dam x calving category subclass from 1973 to 1984. The calves out of base females were required to have the sire identified. The progeny of the F_1 and the Simmental females were required to have both the sire and the maternal grandsire identified. Thus, the F_1 calves provided information on sire usage, whereas the Simmental calves provide information on both sire and maternal grandsire usage.

Table 2 illustrates the grading-up process in the Simmental population. The calves from base dams constituted 75.1% of the data in 1973, but only 12.4% of all calves in 1984. Conversely, the Simmental calves increased from .1% in 1973 to 70.2% in 1984.

Table 3 shows the yearly distribution of bulls used on base, F_1 and Simmental heifers and cows from 1973 to 1984. Table 3 also contains the numbers of bulls represented as sires of F_1 and Simmental heifers and cows each year. As expected, given the grading-up mating scheme of the Simmental population, there was an increase in the number of sires used and maternal grandsires represented each year between 1973 and 1984.

The additive genetic correlations and the ratios of the additive genetic variances to the phenotypic variances used in the analysis of the WT traits are presented in table 4. The values of the genetic parameters used in the CE1 analysis were .07 and .10 (for the ratios of the direct and the maternal additive genetic variances to the phenotypic variances, respectively), and −.62 for the genetic correlation between direct and maternal CE1 effects.

Results and Discussion

Trends in Means of Sire Additive Effects. There were positive trends for the SID weighted and unweighted means between 1973 and 1984 for CE1, WW and YW, and negative trends for BW for bulls mated to heifers and cows from all percentage dam categories (tables 5 and 6). For instance, the unweighted SID means of the bulls used on Simmental heifers increased for CE1 (.0708 points), WW (1.81 kg) and YW (2.64 kg), and decreased for BW (−.63 kg) in the weighted SID means of the bulls mated to Simmental heifers (table 6), i.e., CE1, WW and YW increased (.0722 points, 2.03 and 3.59 kg,

TABLE 2. DISTRIBUTION OF CALVES PER YEAR BY BREED GROUP OF DAM AND CALVING CATEGORY

	No. of calves					
	Base		F_1		Simmental	
Year	Heifers	Cows	Heifers	Cows	Heifers	Cows
1973	1,805	33,569	8,363	3,311	53	7
1974	2,305	40,128	11,513	11,620	656	78
1975	2,505	36,790	10,273	20,548	2,571	866
1976	724	19,181	8,430	22,652	4,928	2,977
1977	749	11,325	7,049	23,031	7,071	7,120
1978	745	8,985	3,205	21,773	7,531	12,283
1979	439	7,981	2,185	21,393	9,200	18,315
1980	675	9,237	1,895	21,258	9,831	25,688
1981	661	10,208	1,626	18,276	10,914	30,956
1982	732	10,590	1,688	15,563	12,023	35,505
1983	421	9,553	1,666	12,784	11,651	37,207
1984	392	6,484	1,379	8,229	9,214	29,588

TABLE 3. NUMBER OF BULLS USED AS SIRES AND REPRESENTED AS MATERNAL GRANDSIRES (MGS) BY BREED GROUP OF DAM

	No. of bulls									
	Base dams		F_1 dams				Simmental dams			
	Heifers	Cows	Heifers		Cows		Heifers		Cows	
Year	Sires	Sires	Sires	MGS	Sires	MGS	Sires	MGS	Sires	MGS
1974	224	366	301	140	325	75	149	100	44	28
1975	215	497	385	211	530	149	314	224	226	111
1976	166	530	459	361	731	238	594	434	516	121
1977	151	538	533	448	980	318	860	666	1,024	482
1978	138	550	425	449	1,186	476	1,102	922	1,690	806
1979	140	698	382	430	1,545	563	1,498	1,362	2,569	1,231
1980	192	916	375	400	1,848	778	1,798	1,829	3,630	1,793
1981	180	1,011	361	474	1,943	799	1,970	2,273	4,322	2,552
1982	190	1,257	411	572	1,888	943	2,044	2,726	472	3,449
1983	170	1,287	404	591	1,813	1,191	2,019	2,774	507	4,386
1984	157	971	345	532	1,332	1,074	1,626	2,300	4,049	4,110

respectively), whereas BW decreased (−.64 kg). An increase in calving ease score implies a decrease in mean calving difficulty score on the actual scale reported from 1973 to 1984 (table 5).

Figures 1 to 4 depict the trends in the standardized yearly weighted means of the SID effects of bulls used on Simmental females. The standardized weighted means were obtained by dividing the weighted means by one-half the genetic standard deviation for each trait. The genetic standard deviations for the SID genetic effects were .086 score points for CE1, 2.28 kg for BW, 9.59 kg for WW and 19.43 for YW. The upward trends for CE1, WW and YW and the downward trends for BW between 1973 and 1984 show themselves unambiguously in these figures. The shape of the trends of the SID effects of bulls used on base and on F_1 females followed similar patterns to those shown in figures 1 to 4 for the weighted and the unweighted means in all traits. Because these graphs are in relative values (i.e., as fractions of the genetic standard deviations of each trait), comparisons across traits are possible. Notice the sharp upward trends found in CE1 (figure 1) and the fast downward trends in BW (figure 2) between 1973 and 1980. Also, notice that WW (figure 3) and YW (figure 4) changed very little during this period. These two facts suggest that until 1980 breeders chose bulls based mainly on their CE1 and BW predicted values, or the calving

TABLE 4. ADDITIVE GENETIC PARAMETERS FOR WEIGHT TRAITS IN THE SIMMENTAL POPULATION[a]

Trait[b]	BW (D)	WW (D)	YW (D)	BW (M)	WW (M)
BW (D)	.19				
WW (D)	.43	.14			
YW (D)	.47	.83	.27		
BW (M)	−.48	−.06	−.03	.07	
WW (M)	−.07	−.08	.10	.29	.11

[a]Diagonal = ratios of additive genetic variances to phenotypic variances; below diagonal = additive genetic correlations.

[b](D) = direct genetic effects; (M) = maternal genetic effects; BW = birth weight; WW = weaning weight; YW = yearling weight.

TABLE 5. YEARLY UNWEIGHTED GENETIC MEANS OF SIRE DIRECT GENETIC EFFECTS OF SIRES USED ON SIMMENTAL HEIFERS

Year	Unweighted means[a]			
	CE1, X 100	BW, kg	WW, kg	YW, kg
1973	−8.83	.63	−1.04	−.80
1974	−6.53	.31	−1.36	−1.99
1975	−4.13	.17	−1.76	−2.34
1976	−2.62	.12	−1.47	−1.88
1977	−2.33	.10	−1.04	−1.29
1978	−2.40	.02	−.98	−1.09
1979	−1.60	−.06	−.96	−1.03
1980	−2.00	−.08	−.74	−.96
1981	−2.39	−.07	−.56	−.62
1982	−2.21	−.08	−.31	−.37
1983	−1.45	−.08	.21	.45
1984	−1.75	.00	.77	1.84

[a]CE1 = first-parity calving ease; BW = birth weight; WW = weaning weight; YW = yearling weight.

ease index published in the Simmental sire summary (table 1). Among the bulls selected based on CE1 and BW, breeders probably chose those with the highest WW and YW evaluations. If no attention had been paid at all to WW and YW, it would be expected that these traits would have declined over this period as BW did, given the positive genetic correlations shown in table 4. From 1981 to 1984, there was little change in the CE1 means (figure 1) and the BW means began to go upward, especially in bulls used on cows (figure 2). In addition, there were large upward changes in the WW (figure 3) and YW (figure 4) means. Thus, the strategy to choose bulls as mates seems to have been reversed. After 1980 it appears that breeders chose bulls using mainly their growth traits (WW and YW) evaluations. However, breeders still considered CE1 to be important as evidenced by the slight upward trend shown in figure 1.

Thus, in the early years breeders must have looked for those bulls with low BW and high CE1 as well as average or better WW and YW proofs. In later years (after 1980), having

TABLE 6. YEARLY WEIGHTED GENETIC MEANS OF SIRE DIRECT GENETIC EFFECTS OF SIRES USED ON SIMMENTAL HEIFERS

Year	Weighted means[a]			
	CE1, X 100	BW, kg	WW, kg	YW, kg
1973	−8.27	.58	−.57	.16
1974	−8.09	.45	−.50	−.16
1975	−6.88	.43	−.34	.85
1976	−4.40	.18	−.31	1.34
1977	−3.21	.12	.06	1.72
1978	−2.72	.05	−.20	1.65
1979	−1.97	−.08	−.32	1.26
1980	−1.77	−.11	−.17	1.32
1981	−1.86	−.16	−.12	.90
1982	−1.97	−.11	.34	1.77
1983	−1.39	−.12	.78	2.12
1984	−1.05	−.06	1.46	3.75

[a]CE1 = first-parity calving ease; BW = birth weight; WW = weaning weight; YW = yearling weight.

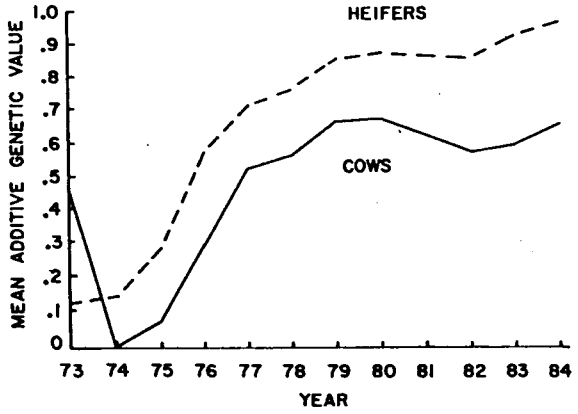

Figure 1. Standardized means of sire direct effects for first-parity calving ease.

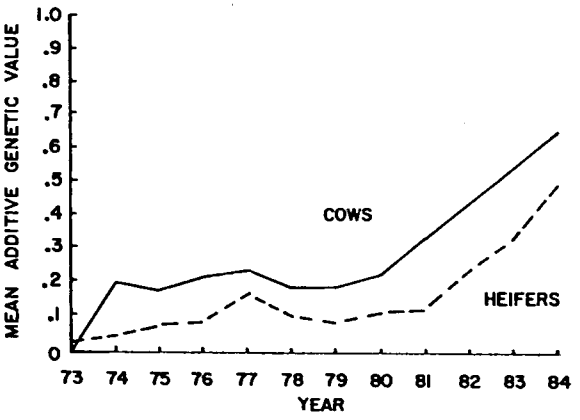

Figure 3. Standardized means of sire direct effects for weaning weight.

achieved a certain level of calving ease in the population, breeders apparently looked for bulls with high WW and YW proofs with above-average CE1 proofs. Probably because BW is not the only factor influencing CE1, the SID means for BW and CE1 have both increased in recent years. In both time periods, breeders appeared to have attempted to select bulls that were exceptions to the expected based on the correlation of traits.

Trends in the Means of the Maternal Grandsire (Direct and Maternal) Effects. Upward trends were found for the maternal grandsire direct means of CE1, WW and YW and downward trends for BW. These trends were, as expected, in the same direction as the trend of the SID means. This occurred in the weighted and the unweighted means of the MGD effects of the sires of F_1 and Simmental heifers and cows. For instance, in the sires of Simmental heifers (table 7), the weighted MGD means for CE1, WW and YW increased by .0179 points, 2.23 kg and 4.23 kg, respectively, between 1973 and 1984. Conversely, during the same period of time, the weighted mean for BW decreased .16 kg.

The trends for the MGM effects were somewhat more complex. The MGM means for CE1 and for BW increased over time. On the other hand, the MGM means for WW increased for a while (until a year between 1979 and 1982 depending on the breed and age group of the female) and then decreased. Again, these trends occurred in the MGM of the sires of F_1 and of Simmental heifers and cows. As GWD was assumed not to be affected by maternal effects, the MGM means for YW are the same as those for WW. Table 7 presents the MGM means for CE1, BW, WW and YW (which is equal to the MGM for WW because no MGM effect was

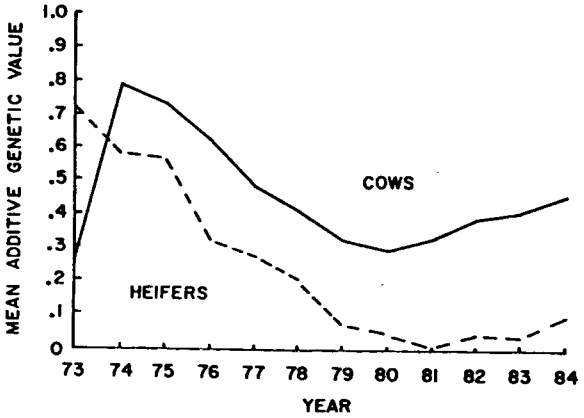

Figure 2. Standardized means of sire direct effects for birth weight.

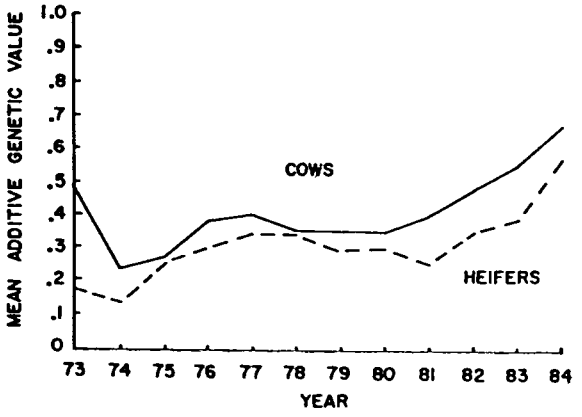

Figure 4. Standardized means of sire direct effects for yearling weight.

TABLE 7. YEARLY WEIGHTED GENETIC MEANS OF MATERNAL GRANDSIRE DIRECT AND MATERNAL OF THE SIRES OF SIMMENTAL HEIFERS

	Weighted means							
	CE1 (X 100)[a]		BW (kg)		WW (kg)		YW (kg)	
Year	MGD[b]	MGM[c]	MGD	MGM	MGD	MGM	MGD	MGM
1973	−3.92	−6.62	.26	−.29	−1.45	−.41	−2.37	−.41
1974	−4.18	−4.52	.25	−.28	−1.04	−.34	−1.42	−.34
1975	−4.23	.83	.19	−.29	−.66	.22	−.49	.22
1976	−3.99	2.78	.19	−.31	−.42	.25	−.23	.25
1977	−3.86	3.57	.21	−.27	−.22	.51	.29	.51
1978	−3.09	3.20	.18	−.20	−.08	.81	.59	.81
1979	−2.46	3.29	.16	−.17	.18	1.06	1.01	1.06
1980	−2.14	3.64	.13	−.13	.14	.86	1.01	.86
1981	−1.74	3.65	.07	−.08	.09	.49	.98	.49
1982	−1.73	3.98	.07	−.05	.24	.22	1.20	.22
1983	−1.87	4.50	.07	−.03	.44	.09	1.33	.09
1984	−2.13	5.07	.10	−.02	.78	−.17	1.86	−.17

[a]CE1 = first-parity calving ease; BW = birth weight; WW = weaning weight; YW = yearling weight.

[b]Maternal grandsire direct.

[c]Maternal grandsire maternal.

considered for postweaning gain) for the sires of Simmental heifers. The MGM means for CE1 and BW increased by .1169 points and by .27 kg from 1973 to 1984. The MGM means for WW, however, increased only until 1979 (1.47 kg), then they decreased (−1.23 kg). Thus, the mean MGM in 1984 (−.17 kg) was only slightly higher than that in 1973 (−.41 kg). This was true for the sires of heifers regardless of their Simmental fraction. In the sires of cows, the MGM means declined less than in the sires of heifers. For instance, after an initial increase of .60 kg from 1973 to 1981, the MGM mean of the sires of cows decreased only .32 kg between 1981 and 1984. This difference between the MGM means of the sires of heifers and the MGM of the sires of cows was due to the differential representation of bulls as sires of heifers and as sires of cows (as might occur with selection).

The trends of the MGD means and the MGM means suggest that breeders wanted to obtain females with better calving ease ability combined with an adequate WW maternal ability for their production systems. Hence, the decrease in the MGM means since 1979. These females tended also to be born more easily (upward trend in the MGD means for CE1), to be smaller at birth (downward trend in the MGD means for BW) and larger at weaning and yearling (upward trends in the MGD for WW and YW) in 1984 than in 1973.

Bull Usage by Calving Category of the Female. Bulls were used differently in heifers than in cows. The bulls mated to heifers were those that had, on the average, higher CE1 and lower BW, WW and YW additive genetic values than those used on cows. This differential mating occurred in base, F_1 and Simmental females throughout the 1973 to 1984 period with very few exceptions. For instance, figures 1 to 4 show the trends of the SID means for CE1, BW, WW and YW for sires used on Simmental heifers. Except for 1973 in CE1, BW and WW, the upper line in figure 1 (CE1) and the lower line in figures 2 (BW), 3 (WW) and 4 (YW) correspond to the SID means of the sires mated to heifers. Furthermore, the contrast between the SID means of sires used on heifers and on cows has tended to increase over the years. This is more evident for CE1 (figure 1) and BW (figure 2) than for WW and YW (figures 3 and 4).

Bull Usage by Simmental Fraction of Females. Bulls were used differently depending on the proportion of Simmental of the female. The SID means tended to be the highest for CE1 and the lowest for BW, WW and YW in the sires used on base dams. The opposite occurred with the sires used on Simmental females, i.e., their SID means were usually the lowest for CE1 and the highest for BW, WW and YW. The SID means of the sires used on F_1 dams had generally intermediate values between those of the sires

TABLE 8. AVERAGES OF WEIGHTED MEANS OF DIRECT GENETIC EFFECTS FROM SIRES USED ON BASE AND ON SIMMENTAL FEMALES IN TWO TIME PERIODS

Item	Trait[b]	Avg of sire direct genetic effects yearly means[a]		
		Base females	Simmental females	Difference (Simmental-base)
1974–1976				
Heifers	CE1	−4.60	−6.46	−1.86
Heifers	BW	−.03	.35	.38
Heifers	WW	−2.14	−.38	1.76
Heifers	YW	−2.69	.68	3.37
Cows	CE1	−7.84	−8.24	−.40
Cows	BW	.45	.58	.13
Cows	WW	−.85	.17	1.02
Cows	YW	−.33	1.27	1.60
1982–1984				
Heifers	CE1	1.35	−1.47	−2.28
Heifers	BW	−.42	−.10	.32
Heifers	WW	−.21	.86	1.07
Heifers	YW	.43	2.55	2.12
Cows	CE1	−3.31	−4.09	−.78
Cows	BW	.19	.28	.09
Cows	WW	1.52	1.72	.20
Cows	YW	3.11	3.69	.58

[a]Average of genetic means for 1974, 1975 and 1976 and average of genetic means for 1982, 1983 and 1984.

[b]CE1 = first-parity calving ease score (× 100); BW = birth weight (kg); WW = weaning weight (kg); YW = yearling weight (kg).

used on base and Simmental females. Table 8 shows averages of SID means for all traits in two periods for sires used on base and on Simmental heifers and cows. Table 8 also shows the difference between these averages for each trait. For instance, the SID average means of the sires used on Simmental heifers in the first period (1974 to 1976) were lower for CE1 (−.0186 points) and higher for BW (.38 kg), WW (1.76 kg) and YW (3.37 kg) than those of the sires used on base heifers. The same pattern was found for the SID average mean differences of the sires mated to cows in the first period, and to both heifers and cows in the second period (1982 to 1984). Thus, breeders used bulls with the highest proofs for CE1 and the lowest proofs for BW, WW and YW on base females. In fact, it was found that breeders tended to use the bulls with the highest CE1 and the lowest BW, WW and YW proofs on base heifers. Also, the higher the Simmental fraction and the older the females were, the more relaxed the constraints of choosing bulls with very high CE1 and very low BW proofs apparently became. Consequently, the sires used on Simmental cows had the lowest CE1 and the highest BW, WW and YW proofs of all sires in the Simmental population.

Conclusions

The study of the weighted and unweighted means revealed that 1) the SID genetic means had positive trends for CE1, WW and YW but negative trends for BW; 2) the MGD genetic means showed trends in the same direction as the SID effects; 3) the MGM genetic means had upward trends for CE1 and BW; 4) the genetic means for WW had positive trends only for the first 7 yr, then they steadily decreased until 1984; and 5) bulls mated to base heifers had the highest CE1 and the lowest BW, WW and YW evaluations of all bulls used in the Simmental population. The opposite occurred with the Simmental cows.

The trends in the weighted and unweighted means of the traits and effects analyzed in this study suggest that breeders made use of the bull evaluations published by the ASA as a selection tool. The differences in the unweighted means and particularly the weighted means between bulls used on heifers vs cows, or between bulls used on base, F_1 and Simmental females,

reflected the utilization of the sire summary as a management tool. Breeders tried to avoid calving difficulties by mating heifers and small cows to bulls whose CE1 evaluations were high and whose BW evaluations were low. Hence, the factors breeders considered to choose bulls as sires were probably as follows: 1) whether the female was heifer or a cow and 2) breed group (base, F_1, Simmental) of the female. Until 1980 they chose bulls mainly for CE1 and(or) BW within the group of bulls considered appropriate for the type of female to be inseminated. Since 1981 they chose bulls based primarily on WW and YW, again within the bulls preselected for a particular female type.

The effects of the Simmental breeders' selection and genetic management practices were to make calving easier and to increase their cattle's ability to grow. Calving was made easier due to increments in the direct and maternal CE1 effects, and because direct BW effects decreased. The ability of the animals to grow increased because both direct and maternal WW and YW effects increased over the years.

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