

HERITABILITY ESTIMATES FOR CALVING DATE
IN SIMMENTAL CATTLE

by

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INTRODUCTION

Reproductive efficiency is a fundamental goal of beef cattle producers. Historically, variation in reproductive efficiency has been primarily associated with variation in management and nutrition because heritabilities of reproductive traits have been low (0 to .1; Milagres et al., 1979; Janson, 1980). However, use of more beef sires through artificial insemination (AI) has increased progeny numbers from these sires. This increased volume of information improved the accuracy of sire evaluation and allowed sires to be ranked for lowly heritable traits. The addition of characterizations of sires for reproductive traits of their daughters to existing sire summary parameters would allow a more complete assessment of overall genetic merit.

All beef cattle breed associations have performance programs which include various breeding value estimates for an individual's growth potential and (or) maternal ability (BIF, 1986). In addition, the American Simmental Association (ASA) has also provides breeding value estimates for calving ease as a reproductive fitness trait in its Sire Selector (ASA, 1986). This information enables the producer to select bulls to sire progeny with optimum size and growth potential to meet individual production goals. The inclusion

of additional reproductive traits in performance programs would assist in identifying bulls that would sire progeny with superior growth performance as well as daughters that conceive quickly and rebreed easily. It is important however, that these reproductive traits be easily obtained and accurately recorded to be used by breed associations in sire summaries.

With this goal in mind, a project was begun using data obtained from ASA. The objectives were to estimate the amount of genetic variation among sires' daughters for calving date and calving interval and to evaluate the accessibility of these data in ASA performance records for potential inclusion of one or both traits in future sire summaries.

REVIEW OF LITURATURE

Genetic variation for reproductive traits. When evaluating any characteristic of a population, the focus is on the nature of the population variance. To properly evaluate the variance, it must be partitioned into components which can be attributed to different causes; because it is the relative magnitude of the individual components that determines the resemblance among relatives. The total or phenotypic variance (V_P) is the sum of the variation attributable to genetic factors and the variation attributable to environmental factors (V_E). The genetic variation may be further divided into additive genetic variation (V_A) and nonadditive genetic variation which is primarily due to dominance (V_D) and epistatic interactions (V_I). Thus:

$$V_P = V_A + V_D + V_I + V_E$$

Heritability is the proportion of the total phenotypic variation caused by genetic differences among the members of a population. It is often more specifically defined as the proportion of the phenotypic variance that is due to additive genetic differences (V_A/V_P). Heritability describes the degree of resemblance among relatives and is therefore important in breeding and selection programs

(Wallace, 1981; Falconer, 1981).

Fisher's fundamental theorem (Price, 1972) states that the rate of increase in fitness of a population equals the additive genetic variance for fitness. An obvious implication of this theorem is that little or no additive genetic variation for fitness would be found in most populations because it would have been exhausted by natural selection. Natural selection increases the frequency of alleles which are advantageous to reproduction and survival (animals of low fertility produce fewer offspring), thereby depleting the additive genetic variation for these fitness traits. However, heritable variation has been shown to exist in many traits associated with sexual behavior and reproduction such as mating speed in *Drosophila* (Parsons, 1974), egg size and offspring number in red grouse chicks (Moss et al., 1981), and sex ratio in fish (Koswig, 1964). These moderate to highly heritable traits may be important in determining fitness (Cade, 1984). These results suggest the existence of opposing forces acting on these populations such as migration, mutation, and (or) artificial selection which are maintaining additive genetic variance.

In domestic populations, selection for individual traits is common. For example, in recent history the trends of selection in beef cattle populations have been

towards growth, frame size and muscling; whereas, selection in dairy cattle populations has been focused on milk production. However, some studies have shown antagonistic genetic correlations between reproductive traits and growth traits in beef cattle (Nelson et al., 1986), between reproductive traits and milk production in dairy cattle (Maijala, 1978; Philipson, 1981) and between reproductive traits and wool production in sheep (Mullaney et al., 1969). The antagonistic relationship between natural selection for fitness and artificial selection for size and production may explain the measurable amounts of additive genetic variation which remain in domestic populations.

Measures of reproductive efficiency. In beef cattle, the evaluation of genetic variation in fitness traits has been based on analysis of performance records. Traditionally, reproductive traits of primary importance to the beef cattle producer have included age at first calving, services per conception, postpartum interval, calving ease, gestation length, calving date and calving interval. The genetic and phenotypic correlations among these traits are also valuable tools for interpretation of the suitability of these traits in sire selection.

Bourdon and Brinks (1982) found that the heritability estimate for age at first calving was low ($.07 \pm .09$) in data

from Red Angus and Hereford herds. Genetic correlations between age at first calving and growth traits were consistently negative. This indicated a favorable relationship between superior breeding values for growth traits and earlier reproduction.

The heritability estimate for age at first farrowing was determined by Irgang and Robison (1984) from data on three commercial herds of swine. Heritability estimates of $.49 \pm .26$ and $.49 \pm .35$ were determined for paternal and maternal half-sibs, respectively. It was suggested that if sows were kept for more than one farrowing, age at first farrowing would be an important factor in increasing annual sow productivity by improving the number of pigs per sow per year.

Services per conception is a trait which measures the number of inseminations required for conception. Published estimates of the mean number of services per conception in cattle range from 1.27 from a computer simulated beef cattle data set (Hepp, 1982) to 2.02 for dairy cows (Everett et al., 1966). In general, the services required per conception in dairy cattle decreases as the days from parturition to first breeding increase toward 100 to 120 d, at which time the number of services per conception reaches a minimum (Meland, 1984). Heritability estimates for

services per conception were reviewed by Maijala (1964) for studies conducted from 1931 to 1957. The weighted average heritability was .03. In subsequent studies, heritability estimates of services per conception in dairy data were generally reported to be less than .07 (Meland, 1984). Slama et al. (1976) found that services per conception was a major factor affecting calving intervals in dairy herds.

The postpartum interval is a measure of the ability of cows to recover following parturition to rebreed. This measure is available for all cows which are rebred following calving, regardless of whether they conceive or not. Many environmental factors influence the postpartum interval such as the plane of nutrition, duration and intensity of suckling, and calving difficulty. Mean postpartum intervals range from 51.2 d for beef cows (Bellows and Short, 1978) to 77 d for dairy cows (Everett et al., 1966). Heritabilities of .02 to .04 for this trait were given by Meland (1984) from various studies with dairy herds. Postpartum interval was another measure (along with services per conception) that had a major effect on calving interval (Slama et al., 1976).

Calving ease (dystocia) is an important economic trait to the cow-calf producer. The ASA uses this trait in their evaluation of bulls to assist producers in selecting bulls which sire calves with less dystocia. Burfening et al.

(1981) reported a heritability estimate for the maternal effect on calving ease of .20. Although the heritability of this trait was low, they found that the frequency of assisted births in bulls with 100 or more progeny ranged from 24 to 69% in bulls that were used as sires of calves and from 35 to 70% for bulls that were used as maternal grandsires. The authors found an antagonism between direct and maternal effects for traits related to dystocia; therefore selection methods will require modification for effective reduction of dystocia (Burfening et al., 1981).

Selection for shorter gestation lengths is being studied as a method for reducing birth weights and thereby reducing calving difficulty. Mean gestation lengths ranged from 272.8 d for Aberdeen Angus to 291.5 d for Brown Swiss and birth weights ranged from 19.1 kg for Sindhi to 47.9 kg for Charolais cattle (Anderson and Plum, 1965). Heritability estimates for gestation length of .36, .42 and .37 were reported by Wheat and Riggs (1958), Anderson and Plum (1965) and Bourdon and Brinks (1982), respectively. Heritabilities for birth weight of .29 (Anderson and Plum, 1965) and .39 (Bourdon and Brinks, 1982) have been reported for beef cattle. The genetic correlation between gestation length and birth weight of .24 (Bourdon and Brinks, 1982) confirms the positive relationship between long gestation lengths and heavier birth weights.

Even though shorter gestation lengths seem to induce lower birth weights, gestation length was negatively correlated with all other traits related to growth. Genetic correlations with gestation lengths of $-.19$, $-.22$, $-.25$, $-.18$, $-.20$, and $-.33$ were reported for prenatal gain, weaning weight, gain to weaning, yearling weight, gain to yearling and postweaning gain, respectively (Bourdon and Brinks, 1982). The authors concluded that continued response to selection for growth without inordinate gains in birth weight is possible. Therefore, selection for rapid growth with moderate birth weights would be more effective than simultaneous selection for shorter gestation and rapid growth.

Calving date versus calving interval. Calving date may be defined as the date on which a cow calves within a given calving season, while calving interval is the number of days between successive parturitions. Calving date and calving interval are measures of reproductive efficiency that have been suggested for use by beef producers. Calving interval has been more widely accepted due to the all-inclusive nature of the trait. Calving interval includes the intermittent steps of calving, rebreeding, gestating and calving again the following year. However, a major disadvantage of calving interval as a measure of reproductive

efficiency is the possible misinterpretation of the end result. In a herd with more than one distinct calving season, a cow which does not conceive to calve again in the same season the following year, may be given another opportunity to conceive in the following breeding season. For example, a cow which calves in the spring and is then exposed to rebreeding but fails to conceive, may be given another opportunity to conceive the following fall. This process of moving an open female to another breeding season, may add up to 182 d to the calving interval, thereby biasing results if the record is not detected and removed before analysis or interpretation.

The mean calving interval reported in dairy herds is approximately 384 d (Dunbar and Henderson, 1953; Everett et al., 1966; Slama et al., 1976) with a standard deviation of 57 d (Slama et al., 1976). Morris (1984) reported a mean and standard deviation for calving interval of 369 and 20 d, respectively, for Angus and Hereford herds in New Zealand. Morris also found that the calving interval for 2-yr-old cows was 12 d longer than that of older cows. This result could be due, however, to the earlier calving date at 2 yr of age associated with the common practice of breeding heifers before the cow herd. Heritability estimates for calving interval from studies utilizing dairy cows of 0, .08 \pm .02, and .06 have been reported by Dunbar and Henderson

(1953), Everett et al. (1966), and Hansen (1979), respectively. Lindley et al., (1958) reported a heritability estimate of .07 and a repeatability of .06 for calving interval in Hereford cattle. Additionally, the heritability of farrowing interval in three commercial herds of swine was studied and estimated to be $.27 \pm .34$ (Irgang and Robison, 1984). These studies suggest the existence of low levels of genetic variation for calving interval.

Beef cattle are normally bred within a limited breeding season to subsequently calve within a limited calving season. The practice of limiting the breeding season restricts the expression of additive genetic variation for calving interval and makes the interpretation of such data difficult. This situation has caused beef producers and animal scientists to reevaluate the use of calving interval as a measure of reproductive fitness. Consequently, calving date is now being evaluated for its potential to estimate reproductive fitness of cattle bred in a limited season. Data compiled from 2,411 records on purebred beef herds during the years 1969 through 1976 were used in a study by Bourdon and Brinks (1983). Calving interval had a strong, undesirable relationship with first calving date. After adjusting the data for first calving date in order to fix the starting point for calving interval, the measures of calving interval and second calving date were highly correlat-

ed with a residual correlation of .978. The authors concluded that the strong dependence of calving interval on first calving date, coupled with the fact that calving interval and second calving date were essentially the same trait after adjustment for first calving date, suggests that calving date is superior to calving interval as a measure of reproductive efficiency.

In a New Zealand study, 35,890 Angus and 22,397 Hereford records were used to evaluate calving dates and subsequent calving intervals (Morris, 1984). The statistical model used to evaluate these data included the effects of district, herd, year and cow age. The relationship of each calving interval to its associated calving date was analyzed. Calving interval averaged 369 d and the regression analysis revealed that as the initial calving date used to calculate the calving interval increased, the calving interval was reduced. Calving intervals were 6.2 d longer for cows that calved 10 d before the average of the herd. These findings suggest that selection for shorter calving intervals may result in selection for cows which take longer to conceive the first time.

In another study, calving dates from Meat and Livestock Commission records of 56,000 cows from 575 herds were analyzed by Kilkenny (1978). Cows which calved late in a

designated season had longer calving intervals than average for that herd in the subsequent year. These two studies again reemphasize the strong dependent relationship between first calving date and calving interval and the positive covariance between first and second calving dates.

The effect of calving date on subsequent calving performance over a 7 yr period was studied by utilizing the records of the Beef Cattle Research Station at Front Royal, Virginia (Burris and Priode, 1958). Angus, Hereford, and Shorthorn breeds were represented and the breeding season was limited to 90 d. Cows which calved late in one year tended to either calve late or not at all in the following year. The correlation between the percentage of cows failing to calve and the previous calving date was .95 ($P < .01$). Also, 6.1% more cows failed to calve for each 20 d delay in previous calving date. Previous calving dates of cows that failed to calve in a given year averaged 14.4 d later than the calving dates of the rest of the herd. A regression analysis in a study by Bourdon and Brinks (1983) also revealed a delay in the current calving date of $.11 \pm .02$ d for each 1 d delay in previous calving date.

In addition to the effect of calving date on subsequent calving rates, there was a significant positive correlation (.39) between calving dates in successive

years. Burris and Priode (1958) concluded that the correlation between calving dates in successive years and the correlation between calving date and calving percentage in the following year indicated that selection of cows for early calving should result in higher calving percentages and earlier calving dates in the following year.

Selection for calving date allows identification of cows which calve earlier in a fixed calving season. These cows usually are those which conceived at their first estrus after the start of breeding. An earlier calving date allows calves to be older, and therefore, heavier at weaning than contemporaries weaned on the same date (Burris and Priode, 1958; Morris, 1984). In addition to the obvious advantage of weaning a heavier calf, the cows that calve early will also have more days from calving to the start of the next breeding.

MATERIALS AND METHODS

Data. Data obtained from ASA included records collected between 1969 and 1982 on 65,331 calvings in 12 herds. Herds were chosen after consultation with ASA personnel and choice was based on the perceived accuracy and completeness of the data. Seven of the herds calved only in spring; five herds had both spring and fall calving seasons. Initial edits retained only cows that had at least 50% Simmental breeding, that calved first at 2 yr of age, and that were born and subsequently calved in the same herd and season. In order to minimize effects of culling on estimates of genetic variation in reproductive traits, only first and second calving records were used. Contemporary groups were formed within each herd and season and included cows that differed by no more than 60 d in birth date. A minimum of two sires of cows was required within each contemporary group and each sire was required to have a minimum of five daughters at first calving.

The initial data set (65,331 calving records) was processed through several edits to obtain the final data set which was used to estimate genetic parameters. The following is the list of conditions which were prescribed for each edit and the number of records remaining after each step.

Stage I (65,331 records)

1. Dam born and subsequently calved in the same herd
2. Minimum of 50 % Simmental breeding in dam

Stage II (30,717 records)

1. Dam calved first at 2 yr of age
2. Distinct calving seasons (spring or fall)

Stage III (8,720 records)

1. Complete data
2. Single births (no twins or embryo transfers)
3. At least five daughters per sire

Stage IV (5,096 records)

1. Contemporary groups - dams born within 60 d

Final Data Set

1. First calving records - 4,300
2. Second calving records - 2,570

The final data set (table 1) utilized spring calving data from seven herds and spring and fall calving data from one herd and consisted of 4,300 first calving records and 2,570 second calving records. Second calving records

included all cows that calved first at 2 yr of age and returned to calve in the same herd and season as 3-yr-olds. Traits analyzed were first and second calving dates, first calving interval and percentage of cows returning to calve as 3-yr-olds.

Statistical Analysis. Preliminary analyses were used to estimate the effects of percentage of Simmental breeding of the cow on reproductive traits and the effects of calving difficulty at first calving on subsequent calving performance. Cows were categorized as 50% (50 to 62.5%), 75% (62.6 to 87.5%) or 100% (>87.5%) Simmental. Cows were categorized at first calving as requiring no assistance, an easy pull, a hard pull or a Cesarean section. Premature births or those involving an abnormal presentation were excluded from all analyses. Births that required a Cesarean section were included in preliminary analyses but excluded from subsequent analyses for estimation of genetic parameters. Effects of percentage Simmental and of first-calf calving ease were estimated within contemporary group and sire of cow and pooled to obtain additive adjustment factors for these effects. Within-sire regressions of first calving date on age at the start of breeding and on actual yearling weight were also tested in preliminary analyses. All significant effects were used to adjust the data before final analysis to obtain heritability estimates.

Heritability estimates for reproductive traits (Y) were obtained from adjusted data using the following nested model:

$$Y_{ijklmn} = u + H_i + P_{ij} + Y_{ijk} + G_{ijkl} + S_{ijklm} + e_{ijklmn}$$

where Y_{ijklmn} is the observation on the n th cow produced by the m th sire (S) within the l th contemporary group (G), k th cow birth year (Y), j th season (P) and i th herd (H) and u is a fixed effect common to all observations. Effects of sires and of residual error (e) were assumed random and uncorrelated with means of zero and variances of σ_S^2 and σ_e^2 , respectively. All other effects were assumed fixed. Variance and covariance components for random effects were obtained by equating mean squares to their expectations in the nested analysis. Calculations were performed using the nested analysis of variance procedure of the Statistical Analysis System (SAS, 1982). Heritabilities (h^2) were calculated as $h^2 = 4\sigma_S^2 / (\sigma_S^2 + \sigma_e^2)$. Genetic correlations (r_G) were calculated from sire components of variance and covariance. Standard errors of h^2 and r_G were calculated using the approximate procedure of Dickerson (1969).

RESULTS AND DISCUSSION

Means and standard deviations for reproductive traits in each herd are contained in table 1. Herd 3a was the only fall-calving herd, had a mean first calving date of d of yr 249 (September 6) and a mean calving interval of 373 d. First calving intervals for the nine herds ranged from 373 to 384 d and averaged 379 d. The average calving interval exceeded 365 d in part because heifers in most herds were bred in advance of the rest of the cow herd. Slama et al. (1976) reported a mean and standard deviation for calving interval of 394 and 57 d, respectively, in dairy cattle and Morris (1984) reported comparable values of 369 and 20 d for calving interval in New Zealand beef herds. The percentage of cows that calved as 2-yr-olds and returned to calve as 3-yr-olds in the same herd and season (percent return) ranged from 48 to 86% and averaged only 66%. During the beginning years of this data set, the Simmental breed was in an expansion phase in the United States. Therefore, producers that were rapidly upgrading their herds may have heavily culled crossbred cows to replace them with heifers with a higher percentage of Simmental breeding. In addition, producers that were expanding their herds may have been more forgiving to those cows which did not conceive in a given breeding season, and therefore more likely to retain

the cow until the next breeding season. The variable percent return also includes cows which were sold, traded or died. Percent return is a complex trait in field data including both voluntary and involuntary culling as well as movement to other calving seasons. Thus results involving this trait must be interpreted cautiously.

Effects of percentage Simmental breeding and of first-calf calving ease score are shown in table 2. Percentage Simmental did not affect first calving date or percent return, but 50% Simmental cows had earlier second calving dates and shorter calving intervals than 75 or 100% Simmental cows. This effect may be related to the greater heterosis that is expected in the 50% Simmental cow. Alternatively, the higher milk production that is expected in 75 and 100% Simmental cows may have increased energy demands with attendant negative effects on cow condition and time to rebreeding.

All measures of reproduction were associated ($P < .001$) with first-calf calving ease score. At first calving, calves that required manual assistance were born an average of 5.3 d earlier than calves that did not require assistance, and calves that required a Cesarean section were born an average of 11.1 d earlier. These differences were not expected. The heifers which calved earlier may have been

bred artificially in the beginning of the breeding season. The AI bulls that were used at the time may have been larger framed and therefore more likely to sire heavier calves than clean-up bulls used to breed remaining open heifers at the end of the breeding season.

Cows whose calves required an easy pull did not differ in percent return or second calving date from cows whose calves were born without assistance. Cows requiring an easy pull had a 4.9-d-longer mean calving interval. Cows that experienced hard pulls as 2-yr-olds recorded second calving dates which did not differ from those of cows that calved without assistance, but 9% fewer of cows experiencing hard pulls returned to calve as 3-yr-olds and their average calving interval was 6.5 d longer. For cows that received a Cesarean section, 23% fewer returned to calve as 3-yr-olds, the average calving interval of those that did calve was increased by 19.6 d and their average second calving date was increased by 9.4 d. Brinks et al. (1973) also reported that cows that experienced calving difficulty had longer calving intervals and later subsequent calving dates. Large framed, heavily muscled cattle such as Simmental are more liable to be associated with dystocia. The obvious economic impact of calving difficulties emphasizes the need to select bulls with higher breeding values for calving ease to avoid the losses associated with dystocia. The use of breeding values

for calving ease in the Simmental Sire Selector supplies producers with a tool to alleviate this problem.

First calving date was not affected ($P > .10$) by age at the start of breeding or by actual yearling weight. Regression coefficients (pooled across herds) were $-.62 \pm .62$ d/d for age and $-.05 \pm .03$ d/kg for yearling weight. Thus calving dates were not adjusted for these effects. This result was not surprising since the heifers were restricted to contemporary groups for comparison, and a contemporary group was defined as those heifers born within 60 d of one another.

Heritability estimates are shown in table 3. When estimates were pooled across herds, resulting values were $.17 \pm .04$ for first calving date, $.07 \pm .06$ for second calving date, $.04 \pm .05$ for calving interval and $.11 \pm .04$ for percent return. The heritability estimate for first calving date was more consistent among herds. The heritability of first calving date of .17 in these herds is somewhat larger than the estimate of $.08 \pm .03$ reported by Burfening et al. (1979) for calving ease score in Simmental cattle and approximates the heritability of .162 reported by Quaas et al. (1985) for birth weight using all available Simmental field data. Thus, first calving date may serve as a useful measure of genetic differences in reproductive fitness.

The lower heritability of second calving date may reflect culling of open cows before the second calving or real changes in the magnitude of genetic and (or) environmental variation. Variation in first calving date may include genetic variation in age at puberty that would not be operative at second calving. However, the nonsignificant phenotypic relationships between first calving date and either age at breeding or actual yearling weight would suggest that variation associated with puberty did not have a large effect on first calving date in these data.

Calving interval had a lower heritability than either first or second calving date. As noted by Bourdon and Brinks (1983), calving interval is a less satisfactory measure of reproductive performance than is calving date because a short calving interval may be obtained by a cow that calves late in one year and early in the next. Genetic correlations between calving interval and first and second calving dates in these data were $-.83 \pm .37$ and $-.09 \pm .88$, respectively (table 4), suggesting that simultaneous genetic improvement in calving date and calving interval would be difficult. In contrast, the estimated genetic correlation between first and second calving dates was $.66 \pm .41$. The negative genetic correlation between second calving date and

calving interval was surprising in light of the definition of calving interval (calving interval = second calving date - first calving date) and the large positive phenotypic correlation of .63 between second calving date and calving interval. Because calving interval is a linear function of first calving date and second calving date, the genetic covariance between second calving date and calving interval is given by:

$$\sigma_{\text{second calving, calving interval}}^2 = \sigma_{\text{second calving}}^2 + \sigma_{\text{first calving, second calving}}$$

where σ_{second}^2 and $\sigma_{\text{first, second}}$ are the genetic variance and covariance, respectively. It appears that the large positive genetic covariance between first calving date and second calving date leads to a negative genetic relationship between calving interval and both first and second calving dates.

The heritability estimate of $.11 \pm .04$ for percent return suggests that differences existed among sires in the proportion of their daughters that returned to calve as 3-yr-olds. However, these differences may in part reflect voluntary culling decisions and are of indeterminate biological significance.

When considering one of these traits for inclusion in a breed performance program, one must address the question of practicality for collecting data from the field. For

example, it may be unreasonable to require a producer to maintain a daily record of estrus cycles of individual females in the herd; and these records would be required to separate genetic variation for postpartum interval from genetic variation for second calving date and calving interval. Another loss of genetic information concerning second calving date and calving interval stems from unrecorded cullings of cows before their second calving. In the final data set the number of records dropped from 4,300 for first calving to 2,570 for second calving. These females may have been culled for reproductive inefficiencies or may have been sold for unrelated purposes. This culling reduces the genetic base from which to draw accurate conclusions concerning genetic merit for reproductive efficiency among these females and their sires.

Traditionally, recording of data to be used in sire evaluation begins when a cow calves, or, in many cases, when she weans her first calf. Therefore, there is no record of those cows which did not conceive or may have been culled for other reproductive inefficiencies. With some effort on the part of the producer, breed performance programs may be able to capture data on all heifers entered into the breeding herd and, if they were culled, obtain reasons for culling. Records to be used to estimate genetic merit for reproductive traits should include: 1.) all heifers which

had the opportunity to enter the breeding herd, 2.) reasons for culling and 3.) stage of reproduction at which the female was culled. These additions to the performance programs of the breed associations would enable recording of early reproductive performance and evaluation of differences among sires' daughters.

Useful levels of genetic variation appear to exist for first calving date ($h = .17 \pm .04$) in the nine herds examined. Combining use of this trait with the restructuring of performance programs to capture the early culling information on heifers is recommended in order to expand sire summaries to include reproductive performance traits.

TABLE 1. NUMBERS OF OBSERVATIONS AND MEANS AND STANDARD DEVIATIONS (SD) FOR REPRODUCTIVE TRAITS BY HERD

Herd	Location	Calving season	Number of records at:		First calving ¹ date, d of yr		Second calving date, d of yr		Calving interval, d		Percent return, % ²	
			First calving	Second calving	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	Montana	Spring	178	106	74	22	90	21	379	25	65	28
2	Montana	Spring	262	123	79	17	92	15	379	18	48	39
3a	Iowa	Fall	473	175	249	12	258	11	373	14	49	33
3b	Iowa	Spring	859	467	98	14	109	13	377	18	69	34
4	South Dakota	Spring	1,222	812	111	14	122	17	377	20	68	35
5	North Dakota	Spring	150	110	114	21	125	21	375	24	86	33
6	Oregon	Spring	731	471	61	26	76	22	383	26	72	39
7	Wisconsin	Spring	285	206	84	13	101	16	383	20	74	34
8	Iowa	Spring	140	100	70	20	90	19	384	22	79	29
Total			4,300	2,570	Average				379	21	66	35

¹ Day of the year² Percentage of cows returning to calve as 3-yr-olds that first calved at 2 yr of age

TABLE 2. EFFECTS OF PERCENTAGE SIMMENTAL AND FIRST-CALF CALVING EASE ON REPRODUCTIVE TRAITS

Item	Level	First calving date, d	Second calving date, d	Calving interval, d	Percent return, %
Percentage Simmental ^a	50%	- .4 ± 1.0	-5.1 ± 1.4*	-5.9 ± 1.7*	+ .7 ± 2.0
	75%	0 ± .8	-1.7 ± 1.2	-1.7 ± 1.4	-.8 ± 1.6
	100%	0	0	0	0
First-calf ^b calving ease	No assistance	0	0	0	0
	Easy pull	- 4.9 ± .7*	+ .1 ± .9	+ 4.9 ± 1.0*	- 1.7 ± 1.4
	Hard pull	- 5.7 ± 1.0*	+2.1 ± 1.4	+ 6.5 ± 1.6*	- 9.0 ± 2.1*
	Cesarean	-11.1 ± 1.2*	+9.4 ± 2.0*	+19.6 ± 2.4*	-23.1 ± 2.5*

^aEffect is expressed relative to the 100% Simmental.^bEffect is expressed relative to cows that calved without assistance.

* P < .001.

TABLE 3. HERITABILITY ESTIMATES FOR REPRODUCTIVE TRAITS

Herd	Heritability of:			
	First calving date	Second calving date	Calving interval	Percent return
1	$-.19 \pm .16$	$.06 \pm .33$	$.53 \pm .54$	$.66 \pm .47$
2	$.24 \pm .23$	$-.53 \pm .14$	$-.28 \pm .19$	$-.04 \pm .14$
3a	$-.05 \pm .09$	$-.52 \pm .14$	$.09 \pm .27$	$.54 \pm .23$
3b	$.08 \pm .08$	$.30 \pm .17$	$-.02 \pm .11$	$-.03 \pm .06$
4	$.19 \pm .08$	$.15 \pm .09$	$.07 \pm .07$	$.11 \pm .06$
5	$-.11 \pm .24$	$-.57 \pm .21$	$-.01 \pm .37$	$.40 \pm .44$
6	$.13 \pm .12$	$.07 \pm .14$	$-.08 \pm .12$	$-.04 \pm .09$
7	$.39 \pm .32$	$-.21 \pm .09$	$.03 \pm .19$	$.17 \pm .21$
8	$.12 \pm .29$	$.30 \pm .43$	$.40 \pm .48$	$-.12 \pm .19$
Pooled	$.17 \pm .04$	$.07 \pm .06$	$.04 \pm .05$	$.11 \pm .04$

TABLE 4. ESTIMATES OF PHENOTYPIC AND GENETIC CORRELATIONS^a

	First calving date	Second calving date	Calving interval
First calving date	1.00	.25	-.58
Second calving date	.66 ± .41	1.00	.63
Calving interval	-.83 ± .37	-.09 ± .88	1.00

^aPhenotypic correlations are above the diagonal; genetic correlations are below the diagonal. Phenotypic correlations in excess of .08 are significant ($P < .01$).

SUMMARY AND CONCLUSIONS

Genetic variation among sires' daughters for reproductive performance was analyzed using data on 4,300 cows from nine herds obtained from the American Simmental Association. Traits analyzed included first and second calving dates, calving interval and the percentage of cows that returned to calve in the same season as 3-yr-olds.

Characterization of sires for reproductive traits of their daughters is of importance and deserves more consideration in sire selection programs. This would enable the producer to select bulls that would sire progeny with superior growth potential as well as daughters which excel in reproductive performance. When selecting traits for use in sire evaluation programs, it is important to consider the ease in which this data may be collected, recorded and analyzed from field records.

Of the traits analyzed, first calving date exhibited the largest amount of genetic variation with a heritability estimate of $.17 \pm .04$. The lower heritability estimate of $.07 \pm .06$ for second calving date may be the result of the loss of records due to both voluntary and involuntary culling in these herds between first and second calvings.

Calving interval had a lower heritability ($.04 \pm .05$) than either first or second calving date. A short calving interval may be obtained by a cow that calves late in one year and early in the next making it a less satisfactory measure of reproductive performance. The heritability estimate of $.11 \pm .04$ for percent return suggests that differences existed among sires in the proportion of their daughters that returned to calve as 3-yr-olds. However, these differences may be influenced by voluntary culling decisions making interpretation on the genetic level difficult.

In conclusion, useful levels of genetic variation appear to exist for first calving date in the nine herds of Simmental cattle that were examined, suggesting that this measure of daughter's reproductive ability could be used in sire selection. Calving dates are generally available from existing field data and their use would require minimal modification of existing performance programs. More comprehensive evaluation of female reproductive performance is possible but would require more information about early reproductive performance. Traditionally, recording of data to be used in sire evaluation begins when a cow calves, or, in many cases, when she weans her first calf. This loss of information due to unrecorded cullings can limit the expression of sire differences in the reproductive ability of the

remaining females by removing the open daughters of each sire and may also result in underestimation of genetic parameters for other reproductive traits (Robertson, 1977; Fimland, 1979). However, capture of this early reproductive data would require some restructuring of existing performance programs.

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HERITABILITY ESTIMATES FOR CALVING DATE IN SIMMENTAL CATTLE

by

Nancy Meacham

(ABSTRACT)

Variation among sires in daughters' reproductive performance was analyzed using data on 4,300 cows from nine herds obtained from the American Simmental Association. Cows were required to have at least 50% Simmental breeding, to have calved first at 2 yr of age and to have been born and subsequently calved in the same herd and season. Traits analyzed included first and second calving dates, first calving interval and the percentage of cows that returned to calve in the same season as 3-yr-olds. Data were adjusted for effects of percentage Simmental and first-calf calving ease score. At second calving, purebred Simmentals calved 1.7 ± 1.2 d later than 75% Simmental cattle and 5.1 ± 1.4 d later than 50% Simmental cattle. When compared to cows that calved without assistance at first calving, cows experiencing easy pulls were $1.7 \pm 1.4\%$ less likely to calve as 3-yr-olds and had 4.9 ± 1.0 d longer calving intervals. Cows with hard pulls were $9.0 \pm 2.1\%$ less likely to return and had 6.5 ± 1.6 d longer calving intervals. Cows requiring Cesarean section were $23.1 \pm 2.5\%$ less likely to return and had 19.6 ± 2.4 d longer calving intervals. Heritability estimates were $.17 \pm .04$ for first

calving date, $.07 \pm .06$ for second calving date, $.04 \pm .05$ for calving interval and $.11 \pm .04$ for percent return. Calving interval does not appear to be a useful selection criterion to improve reproduction. Phenotypic and genetic correlations of first calving date with calving interval were $-.58$ and $-.83 \pm .37$, respectively. The genetic correlation between first and second calving dates was $.66 \pm .41$. Given current data recording procedures, calving date appears to be the most useful potential selection criterion to improve reproductive fitness.

(Key Words: Reproductive Traits, Cattle, Calving Date, Calving Interval, Heritability.)