

GENETIC AND PHENOTYPIC FACTORS
RELATED TO SOME REPRODUCTIVE
TRAITS IN A HERD OF DAIRY COWS

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
OF THE UNIVERSITY OF MANITOBA

BY
WESLEY CHRISTIE

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
OF THE DEGREE OF
MASTER OF SCIENCE

OCTOBER 1979

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A dissertation submitted to the Faculty of Graduate Studies of
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ABSTRACT

GENETIC AND PHENOTYPIC FACTORS RELATED TO SOME
REPRODUCTIVE TRAITS IN A HERD OF DAIRY COWS.

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The reproductive traits examined in this study were fertility, gestation length, and birth weight. The data were collected over a period of nine years from the University of Manitoba dairy herd.

Fertility was measured as the number of services per conception. The average number of services per conception between purebred (Holstein) and crossbreds (Holstein with Brown, Swiss and Ayrshire), and between cows of first parity and cows of second or subsequent parity were compared.

Birth weight and gestation length were analyzed for the effect of sire, breed of cow, sex of foetus, parity number, and year of birth. Least-squares means and standard errors for gestation length and birth weight were 280.88 ± 1.09 days and 41.08 ± 0.49 kg respectively. Year of birth had no significant effect on either birth weight or gestation length. Crossbred calves were 1.79 kg lighter than purebred calves although there was no significant difference in gestation length. Bull calves were 3.5 kg heavier than heifer calves and were carried 2.2 days longer.

Calves born from second or subsequent parity dams were 2.88 kg heavier at birth than calves from first parity dams, but there was no significant difference in gestation length. Sires significantly affected both birth weight and gestation length. The heritability of birth weight was 0.54 ± 0.57 and the heritability of gestation length was 0.19 ± 0.41 . The phenotypic correlation between birth weight and gestation length was 0.93 ± 0.17 .

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" ... to write something out of one's own mind
...is an arduous contrivance only to be achieved
in fortunate moments, few and far between."

Stephen Leacock

ACKNOWLEDGEMENTS

The author is indebted to Dr. M. E. Seale for placing the facilities of the Animal Science Department at his disposal, and for his help and advice throughout the preparation of this manuscript.

Sincere appreciation is extended to the author's adviser, Dr. R. J. Parker for his invaluable knowledge, guidance and inspiration throughout the course of study and preparation of this report.

Thanks is extended to both Mr. Cameron Patterson and Mrs. Karen Wittenburg for their excellent assistance with computer analysis.

The author is also obliged to his parents and Miss Tracy Stropole for their forbearance and support throughout the duration of this study.

Financial support from both the Faculty of Graduate Studies and the Department of Animal Science was sincerely appreciated.

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I. INTRODUCTION

Several studies have been carried out to determine the factors which influence reproductive traits in dairy cattle. Many of these studies have also produced estimates of the heritability of birth weight and/or gestation length. While experimental evidence from these studies has provided fairly uniform estimates as to which factors significantly influence the traits in question, estimates of heritability vary widely.

For several years data have been collected on services per conception, birth weight and gestation length in the University of Manitoba dairy herd. The present study is an investigation of the effects of certain factors on these reproductive traits to determine whether or not results obtained from the University herd are consistent with findings of similar research elsewhere. This study was also initiated to estimate the heritability of birth weight and gestation length in dairy cattle. The data for the study was collected during a nine year period from 1969 to 1977 inclusive.

II. REVIEW OF LITERATURE

FERTILITY:

Sterility and reduced fertility are in general significant reasons for the culling of dairy cows and bulls, even though there appears to be no causative infectious agents (Johansson, 1961; Spalding et al., 1975). It is probable that poor fertility may be associated with two alternative elements: (i) management practices such as herd size, housing systems, and feeding systems, (ii) genetic ability (Spalding et al., 1975). In keeping with the nature of this study the second component will be examined in relation to fertility.

Breeding efficiency or fertility has been estimated by several measures, some of these include days open, calving interval, days from parturition to first breeding, services per conception and nonreturn rates (Fig. 1) (Legates, 1954; Everett et al., 1966). A nonreturn system assumes that a cow serviced may be considered pregnant if a repeat service is not requested within a standard time span (ie: 60-90 day) after the initial service (Pelessier, 1972). Nonreturn to service rates are calculated by several methods the most popular being a 60-90 day basis described in many research studies and in reports of most artificial insemination (AI) organizations. Other reports use a 150-180 day range, and a few use standards falling within the scope of the two aforementioned.

Foote (1978) established that nonreturn rates calculated on a 150-180 day basis averaged 3.3 percent less than the 60-90

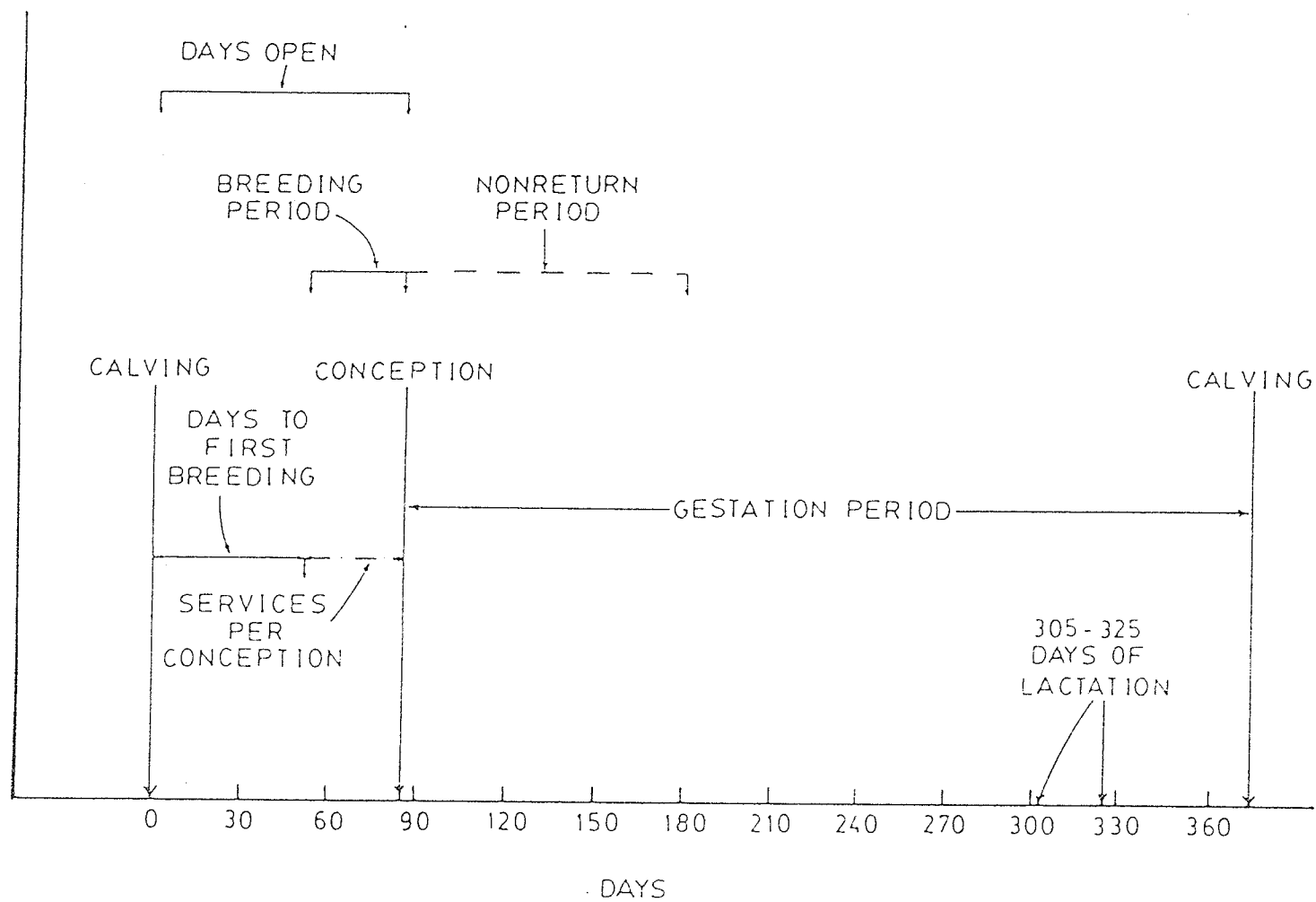


Fig. 1: Graphic representation of some measures of fertility.

day basis. Percentages of nonreturns to either 1, 2, 3, 4, 5, 6, or 7 to 13 inseminations were calculated on a 150-180 day basis to be 68.2, 64.6, 70.1, 66.3, 63.5, 63.4, and 54.4 percent respectively. Foote (1978) also determined that nonreturn rates were higher for grade cows than for registered (purebred) stock ($P < .01$). Studies carried out by Spalding et al. (1975) show a 69 percent nonreturn rate after 60-90 days, while Pelessier (1972) found a 60-90 day nonreturn rate of 58 percent. Shannon and Searle (1962) estimated 49 day nonreturn rates for particular bulls to range from 55 to 65 percent.

As a measure of fertility, services per conception provides data which differ from analogous data obtained from nonreturn rates. The percentage of cows which conceived to 1, 2, 3, 4, 5, 6, and 7 to 13 inseminations were 66, 59, 54, 47, 34, 33, and 21 percent respectively (Foote, 1978). Upon examination, these figures vary somewhat from those obtained on a nonreturn basis. Conception rate on first service, a sub-order of services per conception, have been evaluated in other studies and include values of 63.1% and 50% (Pelessier, 1972; Spalding et al. 1975). Spalding et al. (1975) also determined that 76% of cows conceived within their first two services, while 89% of cows were pregnant after 3 services. According to Foote (1978), the average number of services per conception for registered cows is 1.58, and 1.46 for grade cows. However, variation between registered cows and grade cows appeared to be due to management favouritism towards registered animals. In

agreement with the findings of Foote (1978), Legates et al. (1954) found average number of services per conception ranging from 1.58 to 2.02 depending on breed, with an overall mean of 1.80. These values are also substantiated by another study which quoted mean number of services per conception of 1.84 for Holsteins and 2.02 for Guernsey (Everett et al., 1966).

The difference between data obtained through nonreturn rates and data resulting from measures on conception rate or services per conception is primarily dependent on three factors: (i) cows which died or were disposed of after first service will not return for a second service, (ii) some cows may receive a second service outside the standard range of days, (iii) herds change AI organizations, or change bulls, between first service and second service.

Few studies use days open, calving interval, and days from parturition to first breeding as a gauge of fertility: the number of services per conception, and nonreturn rate to first service are superior measures of cow fertility because they are less influenced by the planned efforts of breeders (Johansson, 1961). Nonetheless, Everett et al. (1966) estimated that Holsteins had a mean calving interval of 387 days, a mean days open period of 107 days and a mean parturition to first breeding of 78 days. The authors did note, however, that days from parturition to first breeding was a poor measure of breeding efficiency due to the influence of herd management. Pelessier (1972) pointed out that calving interval and days open as indexes of fertility are limited in that they cannot be calculated

for cows which do not conceive. It also appears that service per conception are intrinsically involved in all the measures of breeding efficiency, except parturition to first breeding, which is almost a constant, and as previously stated, a poor measure of fertility (Everett et al., 1966).

Heritability (and repeatability of fertility are generally estimated from data generated from services per conception or nonreturn rate. Foote (1978) estimated the heritability of fertility for five dairy breeds from half-sib data on the number of services per conception. Values obtained for Holsteins, Guernseys, Jerseys, Ayrshires and Brown Swiss were 0.02, 0.02, 0.02, -0.02, and 0.06 respectively. None of these values were found to be significantly greater than zero.

Hahn (1969) studied two groups of herds: those with above average fertility and those with below average fertility. Heritability of fertility ranged from 0.05 to 0.15 in herds of low fertility, and from 0.0 to 0.01 in herds with above average fertility. Repeatability for 60-90 days nonreturn rate was estimated to be 0.23 in herds with low fertility.

Herds composed of Ayrshire, Guernsey, Holstein and Jersey cows were examined for the heritability of number of services per conception and calving interval (Legates 1954). The estimate for the former was 0.026 and 0.00 for the latter. Both values were calculated from within sire regression on the basis of average phenotypic values for the dams. Repeatability estimates for the two traits were estimated from an intra-class correlation, and were 0.0 and $0.133 \pm .026$ respectively.

Carman (1955) used the regression of daughter on dam to estimate the heritability of services per conception. Estimates from two herds were 0.08 ± 0.09 and -0.15 ± 0.19 . Repeatability of services per conception was calculated to be 0.06 for both herds. Carman (1955) also quoted heritability and repeatability estimates for 60 - 90 day nonreturn rate which were 0.004 and 0.027 respectively, as found by Dunbar and Henderson (1950).

Swarajasingam and Mukherjee (1975) estimated the heritability of both calving interval and conception rate for Red Sindhi (RS) and Local Indian Dairy (LID) cattle. Two separate methods were utilized to estimate the heritability of these traits: (i) variance component analysis (ii) intra-sire daughter-dam regression analysis. The heritabilities for calving interval as determined by variance component analysis were 0.54 ± 0.20 for LID and 0.91 ± 0.91 for RS. Estimates derived from the alternative method were 0.64 ± 0.54 and 0.00 ± 0.01 for LID and RS respectively. The heritability estimates for conception rate in 1/2 RS 1/2 LID animals were 0.29 ± 0.30 (variance component analysis) and 0.82 ± 0.79 (intra-sire daughter-dam regression). The authors felt that the differences in estimates obtained from the two methods may be due to a genotype environment interaction becoming confounded with the sire component of variance in method (i).

Tomar et al. (1976) estimated the heritability of services per conception on a herd of Haryana heifers. The heifers averaged 2.66 ± 0.16 services per conception with a heritability of 0.3774 ± 0.1766 (non significant $P > .05$), estimated from a paternal half-sib correlation.

Shannon and Searle (1962) studied the heritability and repeatability of conception rate for bulls, rather than cows, through a sire-son regression analysis. Percentage of non-return within 49 days was the criteria for conception. Over the course of five analysis heritability estimates for conception rate ranged from 0.34 ± 0.10 to 0.94 ± 0.08 , producing a pooled estimate of 0.55 ± 0.26 . The pooled estimate for heritability was significantly greater than zero ($P < .05$). The pooled repeatability estimate had a low standard error, and indicated that the repeatability of sire conception rate was high. Gaunt et al. (1977) also examined heritability of fertility of dairy sires because it was felt that "with the large number of services per sire through AI there was opportunity to minimize the effects of specific environmental factors and thereby maximize the genetic differences among sires". Both heritability and repeatability values were derived from 60 to 90 day non-return rate data on Holstein bulls. Heritabilities estimated with a half-sib correlation were 0.21 ± 0.18 for young sires and 0.35 ± 0.25 for mature sires.

The estimate from a sire-son regression was 0.24 ± 0.20 .
The repeatability of nonreturn rate was 0.12 ± 0.20 . None
of these estimates was found to be statistically significant.

Table 1: Summary of heritability and measures of fertility
in literature reviewed.

<u>AUTHOR</u>	<u>BREED</u>	<u>MEASURE OF FERTILITY</u>	<u>h^2 OF FERTILITY</u> **
Foote (1978)	Holstein		0.02
	Guernsey	Number Of	0.02
	Jersey	Services Per	0.02
	Ayrshire	Conception	-0.02
	Br. Swiss		0.06
Hahn (1969)	Holstein	60-90 Day	0.05, 0.15
		Non Return	0.0, 0.01
Legates (1954)	Ayrshire	(i) # Services	0.026
	Guernsey	Per Conception	
	Holstein	(ii) Calving	0.00
	Jersey	Interval	
Carman (1954)	Holstein	#Services/Conc.	0.08
			-0.15
Dunbar & Hend- erson (1950)	NA	60-90 Day N.R.	0.004
Sivarjasing & Mukharjee (1975)	RS *	Calving Int.,	0.91, 0.64
	LID *	Conc. Rate	0.54, 0.0
	$\frac{1}{2}$ RS $\frac{1}{2}$ LID		0.29, 0.82
Gaunt et al. (1977)	Holstein	60-90 Day N.R.	0.21, 0.35, 0.24

* Defined in text.

** More than one estimate indicates different methods of
estimation.

NA-Not available.

GESTATION LENGTH

The markedly lower conception rate of cows bred prior to
60 days postpartum is well documented (Schmidt and Van Vleck,
1974). It has already been pointed out that anywhere from thirty-
one to forty-two percent of cows will return for a second service

within 60 to 90 days. Gestation length is a fairly variable phenomenon, a fact which has been born out by Anderson and Plum (1965) in a review of literature containing some 68 studies on buffalo and cattle. Results of these studies showed a range of mean gestation lengths from 272.8 days to 291.5 days. If it is assumed that it is economically advantageous to decrease the calving interval, it follows that a decreasing gestation period via genetic manipulation may be one method of attaining this goal (Plum et al., 1965). Such action will also decrease the generation interval, resulting in more rapid improvement of cattle through selection (Defries et al., 1959).

The length of gestation in cattle is affected by several factors, some of which are age of dam, parity number, maternal effects, breed, direct genetic effects (sire effects and dam effects), and sex of calf (Giarola & Tyler, 1974). The latter three components are of particular interest in this text.

Defries et al. (1959) studied Ayrshire, Jersey, Holstein-Friesian, Guernsey and Brown Swiss cattle and estimated mean gestation lengths of 277.7, 279.5, 279.6, 284.7 and 291.5 days respectively. The gestation lengths were found to be significantly different ($P < .05$) among breeds with the exception of differences between Jersey and Holstein. Males were carried longer than females with the increased duration ranging from 1.00 days in Guernseys to 1.98 days in Ayrshire. The effect of sex of foetus on gestation length was significantly different for Ayrshires, Holstein-Friesians ($P < .01$) and Jerseys ($P < .05$).

There was no significant effect of foetus sex on gestation length for either Brown Swiss or Guernsey. Heritabilities for gestation period estimated with the regression of daughter on dam were 0.552, 0.264, 0.214, 0.644 and 0.188 for Ayrshire, Brown Swiss, Guernsey, Holstein and Jersey respectively. The pooled heritability found with the method was 0.474. Heritabilities estimated from a paternal half-sib correlation analysis were 0.708, 0.688, 0.492, 0.168, and 0.704 for the breeds as listed previously. The pooled estimate from this analysis was 0.420. Defries et al. (1959) calculated the repeatability of gestation period to be 0.189.

Foote et al. (1959) studied gestation period in Holstein cows for effect of sire line and calf sex. Gestation length ranged from 258 to 293 days (Mean 278.2 days). Male calves were carried an average 1.44 days longer than females ($P < .05$). Sires had a significant effect on gestation length ($P < .01$).

Plum et al. (1965) found a mean gestation length of 277.4 days and a heritability estimate for the trait in Holstein cattle of 0.60 ± 0.12 . Everett and Magee (1965) found a mean gestation length of $278.9 \pm .35$ days for Holsteins. Male calves were carried an average 0.9 ± 0.70 days longer. In contrast with estimates found by previous authors the heritability for gestation length was 0.10. Sires were found to affect the variance of gestation period more than dams.

Touchberry and Bereskin (1966) studied the effect of crossbreeding on gestation length. Holstein dams carried calves an average 2.6 days less than Guernsey dams, but crossing of the breeds had no significant effect on gestation

period. Batra & Touchberry (1974) also studied the effects of crossbreeding on gestation length and found that gestation period was 1.2 days shorter for crossbred dams. Male calves were carried an average of 1.34 days longer than female calves.

Gianola and Tyler (1974) studied the gestation length of Holstein cows. The mean gestation length was 276.7 ± 3.7 days, but contrary to other studies there was no significant difference between gestation period attributable to the sex of calf. However, sires were found to be a significant source of variation, such that they accounted for 13.6% of the phenotypic variance of gestation length, which agrees with estimates obtained by Foote et al. (1959). Paternal half sib heritability for gestation length was 0.54 ± 0.22 .

Fisher and Williams (1978) established that the mean gestation period of Holsteins was 282.3 days, while male calves were carried an average 1.7 days longer than female calves. Heritability of gestation length was 0.73 as a maternal trait, and 0.19 as an offspring trait, which appears to support the thought that the gestation period is controlled to a greater extent by the dam rather than the sire.

The gestation period of Simmental cattle has been studied by Burfening et al. (1978). Bull calves had average gestation lengths 1.1 days longer than heifer calves, such that the overall mean gestation period was 285.2 days. The heritability of gestation length was estimated to be 0.28 ± 0.04 . Sire, sex of calf, and crossbreeding significantly affected gestation period.

Foote (1978) studied gestation period and found the averages to be 278, 282, 278, 280 and 286 days for Holsteins, Guernsey, Jersey, Ayrshire and Brown Swiss respectively. The overall mean was 279.9 days. Female calves were carried an average 279.5 days, male calves 280.8 days. Sires accounted for 1.9, 1.8, 1.6, 1.3 percent of the variance of gestation period in Holstein, Guernsey, Jersey and Ayrshire breeds respectively. Brown Swiss sires made no contribution the gestation lengths of cows. These values are somewhat smaller than those reported by Gianola and Tyler (1974).

It is evident from Table 2 that there is considerable variance in mean gestation length among breeds but not within breeds. However, individual gestation lengths within a breed vary to a certain extent. There is no doubt that bull calves on average are in gestation longer than heifer calves. Heritability of gestation period ranges from 0.10 to 0.708 with most estimates falling in the range of 0.25 to 0.50. It is likely that gestation period may be manipulated by selection as a result of the heritability of the trait.

Investigators who have estimated sire effect on gestation length have gained differing results. Some have found sire effect to exist in a significant manner (Foote et al., 1959; Everett and Magee, 1965; Burfening et al., 1978; Foote, 1978) while others have not (Batra and Touchberry, 1974; Fisher and Williams, 1978).

Table 2: Summary of gestation length, heritability of gestation length and factors affecting gestation length in literature reviewed.

<u>AUTHOR</u>	<u>BREED</u>	MEAN GESTATION LENGTH (DAYS)	$\sigma > \phi$ IN UTERO (DAYS)	h^2 OF * GESTATION LENGTH	SIRE EFFECT ON VAR. OF GESTATION LENGTH
DeFries Et Al (1959)	Ayrshire	277.7	1.98	0.552, 0.708	NA
	Jersey	279.5	NA	0.188, 0.704	NA
	Holstein	279.6		0.644, 0.168	NA
	Guernsey	284.7	1.00	0.214, 0.492	NA
	B. Swiss	291.5	NA	0.264, 0.688	NA
	Pooled Estimate	NA	NA	0.474, 0.420	NA
Foote Et Al (1959)	Holstein	278.2	1.44	NA	Significant
Plum Et Al (1965)	Holstein	277.4	NA	0.60	NA
Everett & Magee (1965)	Holstein	278.9	0.9 ± 0.7	0.10	Sire Effect Dam Effect
Touchberry & Bereskin (1966)	Holstein	279.9	NA	NA	NA
	Guernsey	285.1	NA	NA	NA
Batra & Touchberry (1974)	Holstein	278.4	1.34	NA	Not Significant
	Guernsey	284.5		NA	
Gianola & Tyler (1974)	Holstein	276.7	Not Significant	0.54	13.6%
Burfening Et Al. (1978)	Simmental	285.2	Significant	0.28	Significant

<u>AUTHOR</u>	<u>BREED</u>	<u>MEAN GESTATION LENGTH (DAYS)</u>	<u>♂ > ♀ IN UTERO (DAYS)</u>	<u>H² OF * GEST. LENGTH</u>	<u>SIRE EFFECT ON VAR. OF GEST. LENGTH</u>
Foote, R.H. (1978)	Holstein	278	NA	NA	1.9%
	Guernsey	282	NA	NA	1.8%
	Jersey	278	NA	NA	1.6%
	Ayrshire	280	NA	NA	1.3%
	B. Swiss	286	NA	NA	Ø
	Pooled Est.	279.9	1.3	NA	NA
Fisher & Williams (1978)	Holstein	282.3	1.7	.73, .19	Dam Effect Sire Effect

NA - Not Available

* More than one value indicates different methods of estimation.

All studies are based on more than 300 gestation length.

BIRTH WEIGHT:

In past years birth weight of calves was only important insofar as it was fairly highly correlated with calving difficulty. However, according to Legault and Touchberry (1962) investigators have shown the importance of birth weight for predicting weaning weight, weight at one year, rate of gain to weaning, rate of gain from birth to slaughter, weight at six months, and final weight. Since dairy beef has become more important in recent years, and birth weight is attached to beef characters it is desirable to study the genetic factors of birth weight.

According to an extensive review of literature carried out by Lamb and Barker (1975) the birth weight of calves may be partially affected by breed, sex of calf, and sire and dam, as well as herd, month, and year. The latter three are primarily environmental in character.

Foote et al. (1959) examined the birth weights of calves from Holstein cows which represented six different sire lines. There was a significant difference in birth weight between sire lines. Inbreeding of the calf caused a significant decrease in birth weight, but inbreeding of the dam had no real effect on the trait. It is interesting to note that birth weight increased significantly with parity number of the dam. Male calves were significantly heavier at birth than female calves ($P < .05$) averaging 5.92 (2.7 kg) extra pounds. Males averaged 83.4 lbs. (37.9 kg), females 77.5 lbs. (35.2) with an overall average birth weight of 80.2 lbs. (36.4 kg).

Legault and Touchberry (1962) investigated birth weight data from the five major breeds of dairy cattle in an effort to determine a heritability value for the trait. The birth weight of Ayrshire, Brown Swiss, Guernsey, Holstein and Jersey calves were 84.3 (38.3 kg), 106.9 (48.6 kg), 76.2 (34.6 kg), 98.1 (44.5 kg), and 56.9 (25.9 kg) lbs. respectively for males and 76.5 (34.8 kg), 97.6 (44.4 kg), 67.5 (30.7 kg), 91.1 (41.4 kg) and 51.6 (23.5 kg) lbs. for females. The average birth weights differed significantly among breeds and between sexes. Parity number did not affect birth weight except in Holsteins and Brown Swiss, where the first calf was significantly lighter than the following offspring. Pooled within breed heritability estimates of birth weight determined by paternal half-sib correlation, intrasire regression of offspring on dam, and full-sib correction were 0.38, 0.48, and 0.51 respectively.

Plum et al. (1965) studied birth weight data from Holstein cattle in order to estimate the heritability of the trait. The overall mean birth weight for both sexes was 93.5 lbs. (42.5). The heritability of birth weight was 0.34 ± 0.09 . The genotypic correlation between birth weight and gestation length was 0.37.

The heritability of birth weight for Holsteins was calculated using an intrasire regression by Everett and Magee (1965), who obtained a value of 0.22. Sires influenced birth weight to a significantly greater extent than the dam. The overall average birth weight was 97.4 lbs. (44.3 kg) with males 1.6 lbs. (0.72 kg) heavier at birth.

Anderson and Plum (1965) carried out an extensive literature review pertaining to birth weight in cattle and buffaloes. In general there was a positive correlation between birthweight and gestation length, ranging from 0.15 to 0.52. Estimates of the heritability of birth weight ranged from 0.22 to 0.56. The evidence indicated that birth weight was affected more by the sex of calf, and sire of the calf than by the dam.

Touchberry and Bereskin (1966) looked at the effects of crossbreeding Guernsey and Holsteins on birth weight. Purebred male and female Holstein calves averaged 43.0 kg and 40.3 kg at birth respectively, while the same figures for purebred Guernsey calves were 41.4 kg and 38.6 kg., so that overall male calves were 2.48 kg. heavier than female calves. Calves by Holstein sires averaged 2.54 kg. heavier than those by Guernsey sires. Crossbreeding affected birth weight to the extent that each increase of one-eighth Holstein in the genotype of the dam resulted in an average 0.78 kg. increase in the birth weight of the calf. Since calves from Holstein dams weighed 6.22 kg. more than calves from Guernsey dams, and there was only a 2.54 kg. difference between breeds of sires, it was concluded that there may be a breed, maternal effect on birth weight.

In a report by Batra and Touchberry (1974) crossbred Guernsey-Holstein cattle averaged 35.9 kg. at birth, whilst purebreds averaged 34.6 kg. Therefore, crossbreds were 3.8% heavier than purebreds, which is underscored by a 4.3% difference found by Touchberry and Bereskin (1966).

Gianola and Tyler (1974) found the average birth weight of Holsteins to be 44.9 kg. Male calves averaged a 3.6 kg. heavier birth weight than females. It is notable that sires had an effect on the birth weight of calves from dams which had low milk production records, but had no effect on the birth weight of calves from dams who were high milk producers. Sire groups accounted for 7.6% of the phenotypic variance of birth weight, while the paternal half-sib heritability for birth weight was 0.30 ± 0.16 .

Lamb and Barker (1975) estimated the mean birth weight of Holstein calves to be 41.6 ± 4.9 kg. They found that birth weight differed significantly ($P .01$) between sires within herds, which supports the results of Gianola and Tyler (1974), Everett and Magee (1965) and Foote et al. (1959). The heritability of birth weight over six calvings in two herds ranged from 0.35 ± 0.75 to 0.82 ± 0.39 .

Swarajisingam and Mukherjee (1975) estimated the heritability for birth weight for RS*, $\frac{1}{2}$ LID $\frac{1}{2}$ RS,** and $\frac{1}{4}$ LID $\frac{3}{4}$ RS to be 0.84 ± 0.60 , 0.28 ± 0.10 and 0.25 ± 0.18 respectively.

Rajagopalan and Francis (1976) calculated the heritability of birth weight to be 0.527 ± 0.059 using a paternal half-sib correlation. The sire was also determined to affect birth weight significantly.

* Red Sindhi

** Local Indian Dairy

Burfening et al. (1978) analyzed factors affecting the birth weight of Simmental and crossbred Simmental cattle. Sire, sex of calf and percent Simmental were all significant sources of the variation of birth weight. Bull calves were on average 3.0 kg. heavier at birth, and 3/4 Simmental calves sired by Simmental bulls were 1.4 kg. heavier at birth than 1/2 Simmental calves. As gestation length increased, birth weight increased at a decreasing rate, and the residual correlation between the two traits was 0.20 ($P < .01$). The intraherd and interherd heritabilities for birth weight were 0.40 ± 0.04 and 0.32 ± 0.04 respectively.

Fisher and Williams (1978) established the overall mean birth weight for Holstein calves to be 42.9 kg. Male calves had an average birth weight 2.9 kg. heavier than females. Both sire ($P < .05$) and dam ($P < .01$) were significant sources of variation for birth weight. The heritability of birth weight as a progeny trait was 0.51, and 0.26 as a maternal trait. The genetic correlation between gestation length and birth weight as a progeny trait and a maternal trait were 0.46 and 0.35 respectively.

It is evident from Table 3 that mean birth weight varies considerably between breeds, but varies to a lesser degree within breeds. There is no doubt that bull calves on average are heavier at birth than heifer calves. Birth weight appears to be significantly affected by both the sire and dam. The heritability of birth weight ranges from 0.22 to 0.84.

Table 3: Summary of birth weights, heritability of birth weight, and factors affecting birth weight in literature reviewed.

<u>AUTHOR</u>	<u>BREED</u>	<u>MEAN BIRTH WT.</u>	<u>♂ WT. > ♀ WT.</u>	<u>SIRE EFFECT</u>	<u>DAM EFFECT</u>	<u>BREED EFFECT</u>	<u>h² * OF BIRTH WT.</u>
Foote <u>Et Al</u> (1959)	Holstein	83.4 lbs, 77.5 lbs. 80.2 lbs.	5.92 lbs.	Sign.	NA	NA	NA
Legault & Touch- berry (1962)	Ayrshire Br. Swiss Guernsey Holstein Jersey	84.3 lbs, 76.5 lbs. 106.9 lbs, 97.6 lbs. 76.2 lbs, 67.5 lbs. 98.1 lbs, 91.1 lbs. 56.9 lbs, 56.9 lbs.	Sign.	NA	NA	Sign.	0.38, 0.48 & 0.51
Plum <u>Et Al</u> (1965)	Holstein	93.5 lbs.	NA	NA	NA	NA	0.34
Everett & Magee (1965)	Holstein	97.4 lbs.	1.6 lbs.	Sign.	Sign.	NA	0.22
Anderson & Plum (1965)	Many Breeds		Sign.	Sign.	Sign.	NA	0.22--0.56
Touchberry & Bereskin (1966)	Holstein Guernsey	43.0 kg, 40.3 kg. 41.4 kg, 38.6 kg.	2.48 kg.	Sign.	Sign.	Sign.	NA
Batra & Touchberry (1974)	Guerx Holst. Purebred Average.	35.9 kg. 34.6 kg.		NA	NA	Sign.	NA
Gianola & Tyler (1974)	Holstein	44.9 kg.	3.6 kg.	Sign.	NA	NA	0.30
Lamb & Barker (1975)	Holstein	41.6 kg.	NA	Sign.	NA	NA	0.35--0.75

<u>AUTHOR</u>	<u>BREED</u>	<u>MEAN BIRTH WT.</u>	<u>♂ WT.> ♀ WT.</u>	<u>SIRE EFFECT</u>	<u>DAM EFFECT</u>	<u>BREED EFFECT</u>	<u>h² * OF BIRTH WT.</u>
Sivaratism & Mukherjee (1975)	RS ½LID½RS ¼LID¼RS	NA	NA	NA	NA	NA	0.84 0.28 0.25
** Rajagopalan & Francis (1976)	Crossbreeds	NA	NA	Sign.	NA	NA	0.527
Burfening <u>Et Al</u> (1978)	Simmental & (X)	NA	30 kg.	Sign.	NA	Sign.	0.40, 0.32
Fisher & Williams (1978)	Holstein	42.9	2.9 kg.	Sign.	Sign.	NA	0.51, 0.26

* more than one value indicates more than one method of estimation

NA - NOT AVAILABLE

** 123 birth weight records. All other studies used more than 300 records.

III. MATERIALS AND METHODS

The data for this study were collected from the University of Manitoba dairy herd during 1969 to 1977 inclusive. The herd was routinely pastured for four months in the summer, and housed in a stanchion barn in the winter. Calving was distributed uniformly throughout the year. Data recorded included birth weight, gestation length, services per conception, breed of sire, breed of dam, breed of calf, and parity number of dam.

Birth weights were recorded to the nearest kilogram within twenty-four hours of parturition. Gestation length was calculated as the number of days between the last service and the date of calving. The number of birth weights, gestations, parity groups, purebreds, crossbreds, and sires used in this study are recorded in Table 4.

The sixty-one sires used were purebred Holsteins from AI units. A number of dams were crossbreds from a previous crossbreeding experiment where Holstein dams were mated to Brown Swiss sires, and the BS x H female progeny were bred to Ayrshire bulls, after which Holstein bulls were used exclusively. Dams were classified as being either crossbred or purebred, the criteria for a purebred being defined as any animal with more than 5/8 Holstein background. The parity number of the dam was broken into two categories; the first for heifer dams and second for dams in their second

Table 4: Number of single records of birth weight, gestation length, parity group, breed, and sires used per year.

YEAR	(N) GESTATION LENGTH & BIRTH WEIGHT	(N) PARITY		(N) BREED OF DAM		(N) SIREs
		1	2+	PURE	CROSS	
1969	54	17	37	24	30	6
1970	58	20	38	24	34	9
1971	53	21	32	33	20	16
1972	55	19	36	39	16	13
1973	55	26	29	42	13	15
1974	42	15	27	38	4	11
1975	53	23	30	48	5	10
1976	51	15	36	46	5	12
1977	51	13	38	48	3	16
1969-1977	472	169	303	342	130	61

or subsequent parity. All dams with the exception of five, were produced in the University of Manitoba dairy herd.

Only birth weights and gestation lengths from live single birth calves were included; ie. twin or dead births were excluded in order to decrease unwanted sources of variation. However, data on services per conception included all cows which were determined pregnant regardless of twin births and full sib data, on the assumption that twin births and full sibs were independent of the number of services required for conception. A total of 512 animals were used in the fertility phase of this report.

The data for birth weight and gestation length were analyzed for the effect of sire, breed of cow, sex of foetus, parity number and year of birth using the least square method, described by Harvey (1960), for multiple classifications with unequal subclass numbers.

The model for the analysis of birth weight and gestation length is as follows:

$$Y_{ijklmn} = u + a_i + b_j + c_k + d_l + g_m + e_{ijklmn}$$

where: all variables are random.

Y_{ijklmn} = gestation length (or birth weight depending on data set) of the n^{th} calf of the k^{th} sex, born in the m^{th} year, from a dam of l^{th} parity, of j^{th} breed, by i^{th} sire.

u = overall population mean gestation length (or birth weight)

a_i = effect of i^{th} sire, $i = 1, 2, \dots, 61$.

b_j = effect of j^{th} breed of foetus, $j = 1, 2$. (purebred, cross-bred)

c_k = effect of k^{th} sex of foetus, $k = 1, 2$. (male, female)

d_l = effect of l^{th} parity, $l = 1, 2$ (first, subsequent)

g_m = effect of m^{th} year of birth, $m = 1, 2, \dots, 9$ (1969, 1970, \dots, 1977)

e_{ijklmn} = residual effect on gestation length (birth weight) of the n^{th} calf, born in the m^{th} year, from a dam of l^{th} parity, of k^{th} sex, of j^{th} breed, by the i^{th} sire

Heritabilities of birth weight and gestation length were determined from a half-sib correlation using the sire component of variance as outlined by Falconer (1960). The standard error of the estimate of heritability was determined in the manner described by Becker (1969). Heritability is then estimated as:

$$h_s^2 = \frac{4 \sigma_s^2}{\sigma_s^2 + \sigma_w^2}$$

where h_s^2 is the estimate of heritability, σ_s^2 the sire component of variance estimates 1/4 of the additive genetic variance and σ_w^2 estimates the remainder of genetic variance plus all environmental variance (Becker, 1967).

And the method for standard error (h_s^2) (Becker, 1967):

$$S.E. (h_s^2) = 4 \sqrt{\frac{2(N-1)(1-t)^2 [1+(k-1)t]^2}{k^2 (N-S)(S-1)}}$$

where:

N = total number of observations

$$t = \text{intra-class correlation} = \frac{\sigma_s^2}{\sigma_s^2 + \sigma_w^2}$$

k = mean number of observations per sire

S = number of sires

Genetic correlation, r_A , was estimated from the formula:

$$r_A = \frac{COV_{s_{BG}}}{\sqrt{(\sigma_{s_B}^2)(\sigma_{s_G}^2)}}$$

where $COV_{s_{BG}}$ is the sire component of covariance between birth weight and gestation length, $\sigma_{s_B}^2$ is the sire component of variance for birth weight and $\sigma_{s_G}^2$ is the sire component of variance for gestation length.

Phenotypic correlation, r_p , was estimated from the formula:

$$r_p = \frac{COV_{BG}}{\sqrt{(\sigma_B^2)(\sigma_G^2)}}$$

where COV_{BG} is the phenotypic covariance between birth weight and gestation length, σ_B^2 is the phenotypic variance of birth weight and σ_G^2 is the phenotypic variance of gestation length.

IV. RESULTS AND DISCUSSION

FERTILITY:

Fertility was measured as the number of services per conception because it provided accurate and easily obtainable data. The data were not adjusted for any sources of bias.

The data for all cows both crossbred and purebred, are shown in Table 5, and the distribution of these data is displayed in Fig. 2. The mean number of services per conception was 1.91. From Table 5 it can be calculated that 78.14% of cows conceived after two services while 89.07% had conceived after three services. The findings are in agreement with the results of Spalding et al. (1975) who quoted similar values of 76% and 89% respectively.

The data were divided into sub-groups for the examination of fertility in crossbred cattle compared to purebred cattle and heifers compared to cows of a second or subsequent parity. The number of services per conception for crossbred cattle and the distribution of these data are indicated in table 6 and in Fig. 3 respectively. The mean number of services per conception for crossbred cows was 1.96. The mean number of services per conception for purebred cows was 1.89; the data and distribution appearing in Table 7 and Fig. 4 respectively. These mean values differ somewhat from analogous means for registered cows (1.58) and grade cows (1.46) generated by Foote (1978), although Everett et al. (1966)

Table 5: Number of services per conception for purebred and crossbred cows.

SERVICES/CONCEPTION	(N) COWS	PERCENT OF ALL COWS
1	273	53.32
2	127	24.82
3	56	10.93
4	27	5.27
5	17	3.32
6-9	12	2.34
$\mu = 1.91$	$\Sigma N = 512$	100

Fig. 2 Distribution of number of services/conception for purebred and crossbred cows.

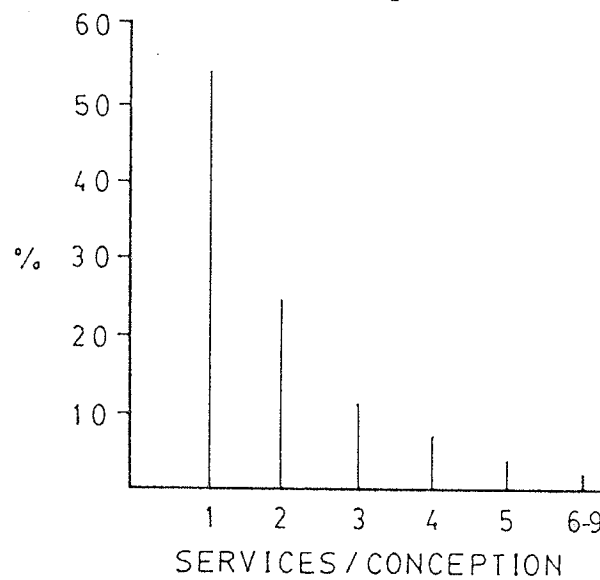


Table 6: Number of services per conception for crossbred cows.

SERVICES/CONCEPTION	(N) COWS	%
1	77	52.0
2	36	24.3
3	17	11.5
4	10	6.8
5	4	2.7
6-9	4	2.7
$\mu = 1.96$	$\Sigma N = 148$	100

Figure 3 Distribution of crossbred cows requiring varying services/conception.

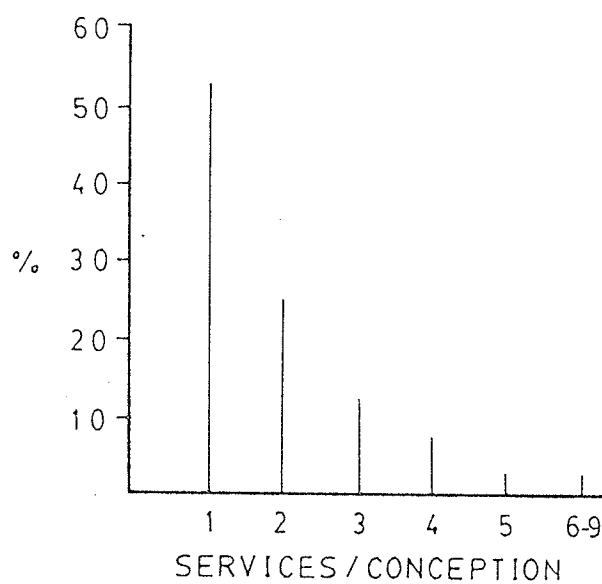
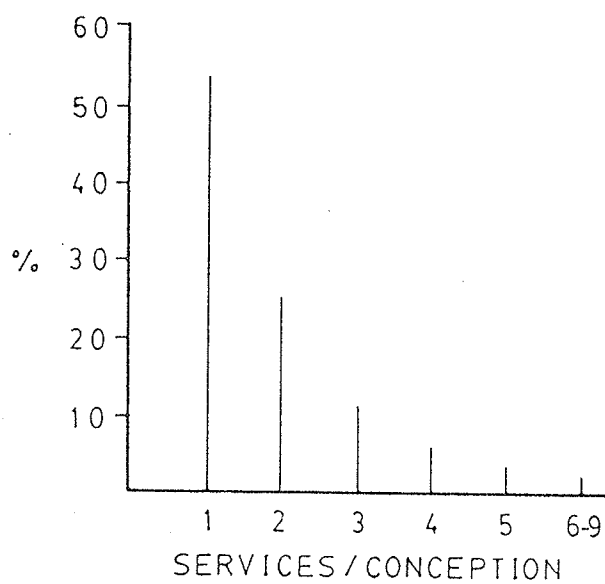


Table 7: Number of services per conception for purebred cows.

SERVICES/CONCEPTION	(N) COWS	%
1	196	53.8
2	91	25.0
3	39	10.7
4	17	4.7
5	13	3.6
6-9	8	2.2
$\mu = 1.89$	$\Sigma N = 364$	100

Fig. 4 Distribution of purebred cows requiring varying services/conception.



found a mean number of services per conception of 1.84 for Holsteins.

Table 8 and Fig. 5 show services per conception for heifers and its distribution, while Table 9 and Fig. 6 present the same data for cows in second or advance parity. The mean number of services per conception for heifers was 1.84 and 1.95 for cows. It is speculated that the relatively large difference in these means may be explained by a greater proportion of heifers not returning for a third service (and therefore not conceiving) as compared to cows, lowering the services per conception average for heifers.

It is difficult to state conclusively if any of the means quoted differ significantly. The discrete nature of the data and their non-normal distribution prevent the use of parametric methods. Transformation of the data to a normal distribution in order to allow statistical tests was not considered to be useful because of the lack of independence of services: ie. it is not possible to say that the reason a cow did not conceive on first service was independent of the reason a cow did not conceive on the second service.

However, examination of the means and the distribution of the data as presented would seem to support the conclusion that none of the stated means differ significantly. There is no firm evidence to conclude that purebred and crossbred cows have different mean services per conception, nor do heifers differ from cows of second or advanced parity.

Table 8: Number of services per conception for heifers.

SERVICES/CONCEPTION	(N) HEIFERS	%
1	95	53.98
2	49	27.84
3	12	6.81
4	11	6.25
5	7	4.00
6-9	2	1.14
$\mu = 1.84$	$\Sigma N=176$	100

Fig. 5 Distribution of heifer cows requiring varying services/conception.

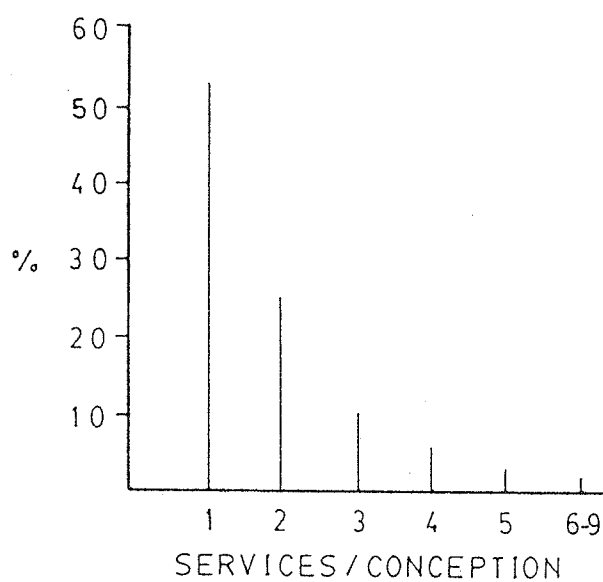
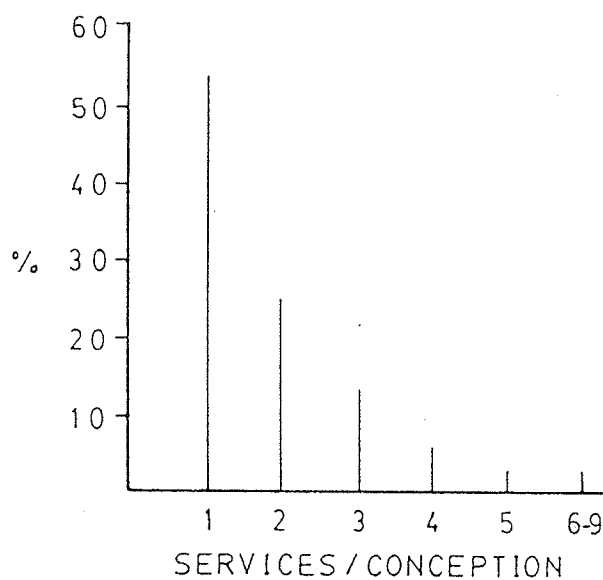


Table 9: Number of services/conception for cows of second or subsequent parity.

SERVICES/CONCEPTION	(N) COWS	%
1	178	52.97
2	78	23.21
3	44	13.1
4	16	4.76
5	10	2.98
6-9	10	2.98
$\mu = 1.95$	$\Sigma N = 336$	100

Fig. 6. Distribution of cows of second or advanced parity requiring varying services/conception.



Similarly, the nature of the data prevented any comparisons among sires or among cows in a one way analysis of variance to estimate heritability of fertility based on services per conception.

GESTATION LENGTH

The overall mean gestation length was 281.47 ± 0.51 days. Records of gestation length were adjusted for sire, breed of cow, sex of foetus, parity and year of birth in order to determine whether any of these variables affected the duration of gestation and to facilitate the computation of the heritability of gestation length from the sire component of variance. The overall adjusted mean gestation length obtained from least squares analysis was 280.88 ± 1.09 days. The analysis of variance is shown in Table 10.

Table 10: Least squares analysis of variance for gestation length.

	D.F.	M.S.	F.
BREED	1	36.67	0.321
SEX	1	474.30	4.151*
PARITY	1	57.50	0.503
YEAR	8	123.14	1.078
SIRE	60	157.73	1.38*
ERROR	400	114.26	

* = $P < .05$

There was no significant difference between the gestation lengths of crossbreds and purebreds as shown in Table 11 although the longer gestation length for crossbreds may be due to the Brown Swiss background. The adjusted mean gestation length of purebred Holsteins compares closely with estimates for the

gestation length of Holsteins calculated by other authors. These estimates ranged from 276.7 days to 282.3 days.

Table 11: Gestation lengths of purebred and crossbred cows.

BREED	(N) OBSERVATIONS	ADJUSTED MEAN GESTATION LENGTH	S.E.
Crossbreds	130	281.25	±1.42
Purebreds	342	280.50	±1.10

Sex of calf (See Appendix II) had a significant effect ($P < .05$) on the duration of gestation, as was expected. The adjusted mean gestation lengths for bull and heifer calves are summarized in Table 12. It was found that bull calves were carried an average 2.2 days longer than heifer calves. This value is slightly higher than those estimated by most authors reviewed in the literature, who found values ranging from 0.9 to 1.98 extra days of gestation for bull calves. The findings of this study, however, do not agree with the results of Gianola and Tyler (1974) who were not able to show that the sex of calf had any significant effect on gestation length.

Table 12: Gestation lengths of bull and heifer calves.

SEX OF CALF	(N) OBSERVATIONS	ADJUSTED MEAN GESTATION LENGTHS	S.E.	$\bar{d}$
Bull	238	281.98	±1.22	2.2
Heifer	234	279.78	±1.22	

Parity number of the dam had no significant effect on the length of gestation, which is again not in agreement with the results of Gianola and Tyler (1974) who found that calves from second and third calvings were carried for a significantly longer time (1.8 days) than those from first parity dams. Ajakie (1971) also found that calves from second and advanced parity dams were carried for an average period of 0.88 days longer than those from first parity dams. Conversely, the results of this study, though not significant ($P > .05$), show that there was a trend for first parity dams to have gestation lengths 0.88 days longer than dams of second or advanced parity.

Table 13. Gestation lengths of first and advanced parity dams.

PARITY	(N) OBSERVATIONS	ADJUSTED MEAN GESTATION LENGTH	S.E.	$\bar{d}$
First	169	281.32	± 1.34	0.88
Second+	303	280.44	± 1.16	

The year of birth was also found not to have a significant effect on the length of gestation (Table 14). This is in agreement with the findings of both Everett and Magee (1965) and Gianola and Tyler (1974). There would appear to be no reason to expect any differences in gestation length from one year to the next in this herd as a result of uniform management of cows throughout the study period.

Table 14. Mean gestation length of cows calving in each year of the study.

YEAR	(N) OBSERVATIONS	ADJUSTED MEAN GESTATION LENGTH	S.E.
1969	54	280.61	±3.76
1970	58	279.39	±2.96
1971	53	278.69	±2.75
1972	55	276.27	±2.98
1973	55	283.14	±2.92
1974	42	281.92	±2.63
1975	53	285.04	±3.18
1976	51	279.29	±2.99
1977	51	283.58	±4.43

Sires were found to have a significant effect ($P > .05$) on the duration of gestation. Similar results were found by Foote et al. (1959), Everett and Magee (1965), and Burfening et al. (1978). Conversely, Batra and Touchberry (1974) found no significant difference in gestation lengths due to differences among sires. Of the sires in the study which produced more than ten offspring a certain number were associated with longer than average gestation periods ranging from 286.9 ± 3.10 days to 289.32 ± 3.27 days (Table 15). At the other end of the distribution some sires with more than ten offspring serviced cows which subsequently had gestation periods of significantly short duration (Table 16) (see also Appendix I).

Table 15. Some sires of calves with longer than average gestation lengths.

Sire	(N) OBSERVATIONS	ADJUSTED MEAN GESTATION LENGTH	S.E.
Tayside Pabst			
Rockman	19	286.87	±3.10
Glenvue Bonanza	13	287.10	±4.29
Maycrest Alert	55 15	289.32	±3.27

Table 16. Some sires of calves with shorter than average gestation period.

SIRE	(N)	ADJUSTED MEAN	
	OBSERVATIONS	GESTATION LENGTH	S.E.
Forest Green Sears			
Mary	10	275.77	±4.29
Glenafton Bonaventure	20	272.87	±3.23

Assuming a normal distribution and random assignment of cows to each sire, the significant differences among sires for gestation length indicates the presence of gene action; ie. gestation length is affected in part by the sire's genotype. Therefore, in order to determine to what degree gestation length may be manipulated from a genetic standpoint, the heritability of gestation length was calculated with a paternal half-sib correlation estimated from the sire component of variance (Table 17).

Table 17. Heritability of gestation length and its components of variance.

(N) SIREs	σ_s^2	σ_w^2	h^2	S.E. (h^2)
61	5.69	114.26	0.19	±0.41

The estimated heritability of gestation length is very close to estimates by Defries et al. (1959) and Fisher and Williams (1978). Most estimates of heritability for this trait tend to be larger than the estimate obtained in this study. However, estimates of the heritability of gestation length calculated by authors reviewed in the literature

range from 0.10 to 0.73. This great range of values may be explained by the use of different methods of estimation, as in the case of Defries et al. (1959) who estimated the heritability of gestation length for Holsteins, obtaining values of 0.168 using a paternal half-sib correlation and 0.644 using the regression of offspring on dam. It is also important to realize that heritability is a property not only of a trait, but of the population, since gene frequencies and therefore components of variance differ between populations (Falconer, 1960), resulting in varying heritability estimates for the same trait in different herds.

BIRTH WEIGHT:

The overall mean birth weight of calves in this study was 41.89 ± 0.27 kg. Records of birth weight were adjusted for sire, breed of cow, sex of foetus, parity number and year of birth in the same manner as the records of gestation length (Table 18). After adjustment the overall mean birth weight was 41.08 ± 0.49 kg.

Table 18. Least-squares analysis of variance for birth weight.

	D.F.	M.S.	F
BREED	1	212.65	9.25 *
SEX	1	1196.70	52.03 *
PARITY	1	623.77	27.12 *
YEAR	8	14.61	0.635
SIRE	60	50.21	2.183 *
ERROR	400	22.99	

* = $P < .01$

Crossbred calves were born significantly ($P < .01$) lighter than purebred calves (Table 19). The adjusted mean birth weight of purebred Holsteins is in the range of birth weights for Holsteins estimated by authors in the literature review, although it is closer to the lightest estimates. This may be due to the fact that some 'purebred' calves included in the estimate were only 13/16 Holstein by virtue of the definition of purebred given in the materials and methods section. The fact that crossbred calves were born lighter than purebred calves is consistent with the results of Legault and Touchberry (1962), Touchberry and Bereskin (1966), Batra and Touchberry (1974), and Burfening et al. (1978).



Table 19. Birth weights of crossbred and purebred calves.

BREED	(N) OBSERVATIONS	ADJUSTED MEAN BIRTH WEIGHT (kg)	S.E.	$\bar{d}$
Crossbreeds	130	40.19	± 0.63	1.79
Purebreeds	342	41.98	± 0.50	

As expected, sex of calf (see appendix II) had a significant ($P < .01$) effect on birth weight. The adjusted mean birth weights for bull and heifer calves are summarized in table 20. Bull calves were on average 3.5 kg (7.70 lbs.) heavier than heifer calves, which is in agreement with results obtained by Foote et al. (1959), Legault and Touchberry (1962), Touchberry and Bereskin (1966), Gianola and Tyler (1974), Burfening et al. (1978), and Fisher and Williams (1978). However, Everett and Magee (1965) had a substantially lower estimate of 0.72 kg (2.2 lbs.).

Table 20. Birth weights of male and female calves.

SEX	(N) OBSERVATIONS	ADJUSTED MEAN BIRTH WEIGHT (kg)	S.E.	$\bar{d}$
Male	238	42.83	± 0.55	3.5
Female	234	39.33	± 0.55	

Parity number of the dam significantly affected ($P < .01$) the birth weight of the calf. The same result was found by Foote et al. (1959), Legault and Touchberry (1962), Plum et al. (1965), Everett and Magee (1965), and Gianola and Tyler (1974). Everett and Magee also stated that mature

cows had calves which average 4.7 lbs (2.14 kg) heavier than calves of two year old cows, which is close to the 2.88 kg (6.3 lb) difference found in this study (table 21). However, Batra and Touchberry (1974) found parity to have no significant effect on the birth weight of calf.

Table 21. Birth weights of calves from first and advanced parity dams.

PARITY	(N) OBSERVATIONS	ADJUSTED MEAN BIRTH WEIGHTS (kg)	S.E.	$\bar{d}$
First	169	39.64	±.60	2.88
Second +	303	42.52	±.53	

As with gestation length the year of birth was found to have no significant effect on the birth weight of calf. (Table 22).

Table 22. Mean birth weight of calves in each year of the study.

YEAR	(N) OBSERVATIONS	ADJUSTED MEAN BIRTH WEIGHT	S.E.
1969	54	42.07	±1.69
1970	58	42.00	±1.33
1971	53	41.26	±1.23
1972	55	39.72	±1.33
1973	55	41.77	±1.31
1974	42	42.2	±1.18
1975	53	41.43	±1.43
1976	51	40.46	±1.34
1977	51	38.83	±1.98

Sires were found to have a significant effect ($P < .01$) on birth weight of the calf. Similar results were found by Foote et al. (1959), Everett and Magee (1965), Anderson and Plum (1965), Touchberry and Bereskin (1966), Gianola and

Tyler (1974), Lamb and Barker (1975), Rajagopalan and Francis (1976), Burfening et al. (1978), and Fisher and Williams (1978). Of the sires which produced ten or more calves some threw calves which averaged 35.87 kg to 38.8 kg (Table 23); while others produced calves averaging 45.4 kg at birth (table 24) (See also appendix I). One bull had six offspring which averaged 48.5 kg at birth.

Table 23. Some sires of calves with lower than average birth weights.

Sire	(N) OBSERVATIONS	ADJUSTED MEAN BIRTH WEIGHTS (kg)	S.E.
Tayside Pabst			
Rockman	19	35.87	±1.39
Edgeware Pietje			
Boy	18	38.84	±1.34
Cornerset Centurion			
Medalist	30	38.98	±1.88

Table 24. Some sires of calves with greater than average birth weights.

SIRE	(N) OBSERVATIONS	ADJUSTED MEAN BIRTH WEIGHT	S.E.
Shorelea Pers	11	45.40	±1.86
Narfa Norseman	6	48.52	±2.94

Heritability of birth weight was estimated from the sire component of variance in the same manner as it was for gestation length (Table 25).

Table 25. Heritability of birth weight and its components.

(N) SIREs	σ^2_s	σ^2_w	h^2	S.E.
61	22.9	3.56	0.54	± 0.57

The estimated heritability of birth weight (.54 + .57) is similar to estimates calculated by Legault and Touchberry (1962), Anderson and Plum (1965), Lamb and Barker (1975), Rajagopalan and Francis (1976), and Fisher and Williams (1978). However, estimates for the heritability of birth weight have ranged from 0.22 to 0.84. This range of values may be explained, as it was for gestation length, by differences in methods of estimation and herd differences.

GENETIC AND PHENOTYPIC CORRELATION

An attempt was made to determine the genetic correlation between birth weight and gestation length using the sire component of covariance and the sire components of variance for each trait. Calculations yielded a genetic correlation of -5.7 ± 10.05 which is outside the -1 to +1 limits of a correlation estimated. Genetic correlation estimates are usually subject to large sampling errors (Falconer, 1960) and this would appear to account for the completely unreliable estimate obtained here.

The phenotypic correlation between birth weight and gestation length was 0.93 ± 0.17 . Such a value was expected because of the physical relationship between the traits,

ie., as a calf gestates its weight increases and therefore the longer the gestation period the greater the birth weight.

V. SUMMARY AND CONCLUSIONS

The study was conducted on data which included 472 birth weights, 472 gestation periods and 512 records of services per conception of purebred and crossbred dairy cattle in the University of Manitoba herd. The objective of this study was to determine which factors significantly affected services per conception (used as a measure of fertility), birth weight and gestation length, and to estimate the heritability of birth weight and gestation length.

Services per conception were analyzed to determine whether or not they were affected by breed (purebred vs. crossbred) or parity (first vs. subsequent). Although statistically comparison was not possible, it was concluded that there was no real difference among the breed or parity means. The mean services per conception were:

COMPARISON	GROUP	MEAN	$\bar{d}$
Breed	All cows	1.91	-
	Crossbreds	1.96	.07
	Purebreds	1.89	
Parity	Heifers	1.84	.11
	Second +	1.95	

Birth weight and gestation length records were analyzed for the effect of breed of dam, sex of calf, parity of dam, year of birth and sire of calf using Harvey's least-square method. Gestation length was significantly ($P < .05$) affected

by sex of calf and sire of calf, while birth weight was significantly affected ($P < .01$) by breed of dam, sex of calf, parity of dam, and sire of calf.

The overall adjusted mean gestation length was 280.88 ± 1.09 days and the overall adjusted mean birth weight was 41.08 ± 0.49 kg. Both values are in agreement with the findings of other researchers.

The heritability of gestation length and birth weight was estimated with a half-sib analysis using the sire component of variance. The estimates were 0.19 ± 0.41 and 0.54 ± 0.57 respectively. While these estimates had large standard errors, they are within the range of previously published heritabilities for these traits.

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APPENDIX I

Number of progeny, mean birth weight and mean gestation length of offspring for each sire in the study.

SIRE	PROGENY	MEAN BIRTH WT AND S.E.= (kg)	MEAN GEST. LENGTH AND S.E. (kg)
Edgware Rag Apple Dan	10	41.4±2.1	284.4±4.7
Bondhaven Maple Joe	28	39.8±1.4	284.5±3.1
Shorelea Pers	11	45.4±1.9	286.6±4.1
Lassie Leader	12	37.2±2.0	277.8±4.4
Zeldenrust Pontiac	6	44.7±2.2	284.4±5.0
Delight			
Duncheesin Wis Texal	17	42.1±1.7	280.1±3.7
Glenafton Herdmaster	12	39.4±1.7	282.6±3.8
Corneret Centurion	30	39.0±1.9	280.2±2.4
Medalist			
Don Augur Royal Allen	9	38.9±1.9	281.3±4.2
Kungla Kalev	8	41.9±1.9	287.3±4.3
Bondhaven Maple	4	43.0±2.5	282.1±5.6
Diplomat			
Glenvue Bonanza	8	41.6±1.9	287.1±4.3
Tayside Pabst Rock-	19	35.9±1.4	286.9±3.1
man			
Seiling Rockman	4	37.3±2.6	285.1±5.8
Edgware Pietje Boy	18	38.8±1.3	278.8±3.0
Flemingdale Perseus	7	41.0±2.0	283.2±4.4
Mark			
Seiling Triune	1	33.0±4.9	290.3±10.9
Achilles			
Almerson Rockman	11	40.4±1.8	279.4±4.1
Edwin			
Lanningdale Regent	19	39.4±1.5	289.0±3.3
Reflector			
Glenafton Man-O-War	3	39.9±3.0	277.8±6.8
Madawaska Centennial	3	42.9±3.0	278.3±6.7
Romandale Re Echo	1	35.6±4.9	252.7±11.0
Rocket			
Agro Acres Marquis Ned	7	42.3±2.0	285.9±4.5
Glenafton Bonaventure	20	43.4±1.4	272.9±3.2
Forest Green Sears	10	39.7±1.9	275.8±4.3
Mary			
Fleetridge Monitor	6	42.8±2.3	283.3±5.0
Heffering Stellar	2	43.7±3.6	279.9±8.0
Attraction			

SIRE	PROGENY	MEAN BIRTH WT AND S.E.= (kg)	MEAN GEST. LENGTH AND S.E. (kg)
Elmcraft Pontiac	1	28.0±5.0	280.7±11.1
Chiefton			
Waybrook Sir Winston	1	40.6±5.0	281.8±11.1
Enghill Perseus	11	40.2±1.7	280.6±3.7
Admiral			
Cloverbar Laddie	1	27.6±5.0	259.8±11.0
Dairylane Starfire	1	41.2±5.0	275.4±11.0
Hilltopper Reflection	2	42.1±3.6	280.1±8.1
Charles			
Bondhaven Royalstar	5	41.7±2.3	284.0±5.1
Moersch Dale Allstar	13	41.0±1.7	278.5±3.7
Maycrest Alert 55	15	45.3±1.5	289.3±3.3
Wenron Baronet	12	41.8±1.6	283.5±3.7
Corneret Medalist	1	40.3±5.0	272.8±10.9
Alpha			
Craiglan Sevens Senator	11	41.8±2.0	278.8±4.4
Ingholm Yukon	4	38.9±2.7	271.0±6.1
A Northcroft Admiral	10	41.4±2.0	277.3±4.5
Citation			
A Dutchcroft Fury lad	8	42.2±2.0	283.5±4.4
A Stardell Longlasting	7	42.3±2.3	275.7±5.1
Downalane Century Ensign	4	43.5±2.8	279.1±6.2
Glen Drummond Dimitri	5	38.5±2.7	282.2±6.0
Vigh Keyes Rocky A	9	41.6±2.2	284.6±4.9
Egremont Rockman Jason	12	39.8±2.2	281.7±4.9
Moersch Dale Dairy King	13	42.7±1.9	286.8±4.2
Sunnyville Citation	4	48.5±2.8	285.9±6.2
Master			
A Fairbreeze Elevation	1	43.7±5.3	290.2±11.7
Romandale Rockman	1	33.2±5.3	269.0±11.7
Inspiration			
Keendale Lodge Starchief	9	44.9±2.7	279.7±6.0
Allangrove Ovation	1	55.7±5.3	289.2±11.7
Fleetridge grand March	1	38.7±5.3	277.2±11.7
Keendale Lodge Starchief	1	42.5±5.3	279.3±11.8
Wholesome Perseus Leader	4	42.6±3.3	278.8±7.3
Toppenhuster Jopi Roy	2	47.9±4.0	279.6±9.0
Narfa Royal Viking	4	45.4±3.3	274.9±7.2
Woodrock Liberte	3	41.0±3.5	277.4±7.9
Narfa Noreseman	6	48.5±2.9	280.4±6.6
Ronbeth Lucky Seven	3	40.5±3.5	283.5±7.9

APPENDIX II

Number of male and female calves born in each year of the study.

YEAR	MALES	FEMALES	TOTAL
1969	28	26	54
1970	26	32	58
1971	23	30	53
1972	23	32	55
1973	28	27	55
1974	22	20	42
1975	35	18	53
1976	30	21	51
1977	23	28	51