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EFFECTS OF SIRE, RATION, AND INTERACTION OF SIRE WITH RATION ON REPRODUCTIVE PERFORMANCE OF HOLSTEIN DAIRY COWS

by

Jen-hon Justin Chen

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Dairy Science

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1987

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Jen-hon Justin Chen

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ABSTRACT

Effects of Sire, Ration, and Interaction of Sire with Ration on Reproductive Performance of Holstein Dairy Cows

by

Jen-hon Justin Chen, Master of Science

Utah State University, 1987

Major Professor: Dr. Robert C. Lamb
Department: Animal, Dairy, and Veterinary Sciences

A study was conducted to analyze reproductive data gathered over a ten-year period at the Utah State University Dairy Farm. The study utilized 289 complete first lactations of Holstein cows, including 150 daughters of 10 sires in Trial I and 139 daughters of 8 sires in Trial II. One sire was used in both trials; this was sire 4 in Trial I and sire 18 in Trial II. The study measured ration, season, and sire effects and their interactions on the reproductive performances of dairy cows.

Reproductive traits analyzed were: days from calving to first estrus, days from calving to first breeding, days from first breeding to pregnancy, days open, number of services per pregnancy, pregnancy rate, calving interval, number of estrous cycles to first breeding, and number of estrous cycles to pregnancy.

Sire effect examined the effect of predicted difference for milk (PDM) of sires on reproductive performances of their daughters. There was 1352 kg PDM difference between lowest and highest sire. There was no sire effect among North American sires, but daughters of one sire from New Zealand had significantly lower reproductive performance. Reproductive performance of daughters was not related to PDM of sire.

Ration affected calving interval in the comparison of all four rations. But more data is needed to verify this because only one sire had daughters on all rations.

Effect of season of calving on days open and days from first breeding to pregnancy is also very questionable because of small numbers of daughters in some seasons. Ration by season interaction affected days open, services per pregnancy and pregnancy rate. The high energy ration enhanced reproduction in cold season and low energy was more beneficial in cows calving in hot season.

There was no sire by ration interaction effect.

(78 pages)

INTRODUCTION

About 25% of dairy cows are culled annually from dairy herds and one-fourth of these are culled for reproductive failure. Reproductive problems rank second to low production as a major cause of cows leaving the herd. Reproductive problems could have a genetic source, they could be caused by environmental factors, or they could be due to a genetic by environment interaction. Nutrition is one of the major non-genetic factors affecting reproduction. Another environmental (or non-genetic) factor is season of calving.

Artificial insemination is used heavily in dairy herds. Because the semen from a sire can be diluted and used to breed many dairy cows, the effects of a single sire in the genetic improvement of a dairy herd are more important than the effects of a single cow. The chances for a single sire to negatively affect a trait, such as reproduction, is equally possible. Therefore, it is important to determine the effect of sires on reproductive efficiency of their daughters.

Dairymen feed a wide range of forage:concentrate combinations. These create a wide range of nutritient levels, and nutrition is one of the major environmental variables which can affect reproduction. Thus, it is important to know whether different combinations of concentrates and forages have an influence on reproductive efficiency of Holstein cows.

Although there are many reports in the literature on the role of nutrition on reproduction, there are very few reports on the genetic influence or on the combined effects (or interaction) of ration and genetics on reproductive traits.

Another major environmental variable is season of calving. Season has been shown to have a definite detrimental effect on reproduction of dairy cows in hot climates. The effect of season of calving, if any, in the more moderate intermountain area needs to be evaluated.

In this study, reproductive performance will be analyzed through the following reproductive traits: 1) days from calving to first estrus; 2) days from calving to first breeding; 3) days from first breeding to pregnancy; 4) days open; 5) number of services/pregnancy; 6) pregnancy rate; 7) calving interval; 8) number of estrous cycles to first breeding; and 9) number of estrous cycles to pregnancy.

The first objective of this study is to estimate the effect of sires on reproductive performance of their daughters.

The second objective is to measure the reproductive performance of dairy cows fed four different combinations of forages and concentrates.

The third objective is to determine the effect of interaction of sire and ration on reproductive performance of dairy cows.

The fourth objective is to determine the effect of season of calving on reproductive performance of Holstein dairy cows.

REVIEW OF LITERATURE

The phenotypic expression of reproductive performance in dairy cattle can be caused by genetic or environmental factors or their interaction. Wilcox (96) indicated that evaluation of environmental effects is an important part of the study of dairy cattle genetics. Nutrition, season, and disease are three of the major non-genetic factors affecting reproduction.

Sires entering AI service in the United States have been selected principally on the basis of their daughters' milk yield (9). This has resulted in substantial progress in improving genetic merit for milk yield. Reproductive performance is lower in higher producing cows than in their lower producing herdmates (9). Because production has been improving but reproduction has not, reproductive problems are becoming more important than milk yield problems. To determine the effect of sire on reproductive performance of daughters is important in the dairy business.

Genetic Effects and Heritability

Heritability of overall reproductive efficiency was reported low, from 0 to .10 (26,30,37,45,61,77). Shanks et al. (86) reported that many reproductive traits had moderate repeatabilities around .20.

Heritabilities of specific reproductive traits have been more variable, but are still low. The heritability of length of period from calving to first estrus reported by Olds and Seath (71) was .27 for first single records and .32 for all records, but estimates by Rognoni and Betta (80) and Buch et al. (10) were only .06. Berger et al. (6) found the heritability of interval to first service in primiparous cows was .04. Pou et al. (77) reported the heritability of service period was .07.

The heritability of days open reported by Berger et al. (6) was .04 in days to last breeding of cows that conceived, but only .01 when modified to include all primiparous cows. Schaeffer and Henderson (83) reported heritabilities for days open in 1st, 2nd, and 3rd lactations of .02, .04, and .00 respectively. Heritability .06 for days open was reported by Kragelund et al. (50) in Israeli Friesians.

Murray et al. (70) reported that nonreturn rate accounts for only 8.7% of the total genetic variation. Dunbar and Henderson (18) estimated the heritability of nonreturn rate to first service was .004. Berger et al. (6) found heritability of .04 for days to first breeding. But Gaunt et al. (32) and Murray et al. (70) reported heritabilities of .25 and .21, respectively for the same trait.

Maijala (58) reviewed a large number of studies up to 1957, and reported an average of .03 for heritability of number of services per conception. Legates (56) also reported the heritability of services per pregnancy for primiparous cows to be .03, and Berger et al. (6) reported .01. Carman (12) also estimated this figure as close to 0. Metz and Politiek (65) reported .08, and Pou et al. (77) reported .07.

The heritability of pregnancy rate was estimated close to 0 by Dunbar and Henderson (18), considering nonreturn to first service by 180 days as indication of conception. Rottensten and Touchberry (82) and Collins et al. (15) analyzing conception rate at 1st and 2nd service, Maijala (58) who analyzed half a million 1st services, and Hahn (36) who analyzed 1000 herds all obtained similiar results. Bar-Anan et al. (4) estimated heritability of conception rate at .04. Ron et al. (81) reported heritabilities of sire effect on conception rate were .02 for cows and .01 for heifers. Inskeep et al. (45) found an additive genetic variance (heritability) of conception rate on the order of .08.

Wilcox and Pfau (97) reported the heritability of calving interval to be .32, but Dunbar and Henderson (18) and Legates (56) reported heritability of 0 when calving interval was used as the measure of fertility. Maijala (58) reported a heritability of calving interval of .03. Miller et al. (66) reported a heritability of calving interval of .04.

Nutritional Effects

Dunbar and Henderson (18) indicated that genetic improvement of fertility is not very effective and that any marked improvement obtained in reproductive efficiency of the dairy cattle population must be brought about by improvement of nutritional, pathological, and/or other environmental factors which exert on influence on the process of reproduction.

Laben et al. (53) indicated that high yield or associated factors have a small but real antagonistic association with reproductive efficiency. This antagonism can be effectively overcome by good management. Britt (9) indicated nutrition and herd health are two areas of management which can affect reproductive performance. Boyd (7) reported that inadequate energy and mineral imbalance are nutritional factors associated with reduced fertility. Hansen et al. (38) reported that when nutrients are limited, cows with genotypes for high milk production will have longer postpartum anestrous periods relative to cows with genotypes for low milk production. Ample nutrient availability will shorten the interval to first estrus for high milk producing cows. Ducker (17) reported that reproductive performance can be improved by a sound nutritional program.

Dairymen have greatly increased the level of concentrates in dairy rations in recent years (43,44). Future food shortages may decrease the use of potential human food as animal feed. Wiggans and Van Vleck (95) indicated that this might reduce the proportion of net energy (NE) in dairy cattle rations derived from concentrates. Conversely, overeating of concentrates and lack of fiber in the ration causes an increase in adipose tissue (22,63). The accumulation of adipose tissue can cause "fat-cow" syndrome (67) and associated health problems. Morrow (67) also reported fat cows were more susceplible to reproductive problems. Holter et al. (42) reported that when high quality high energy forages are fed free choice, only minimum increases in yield would be expected in response to increased concentrate feeding, particularly in early lactation and especially in first-calf cows.

Cows fed low energy diets had longer intervals to first estrus (19,99,100), longer gestation periods (51), and lower fertility (28,100) than cows fed diets higher in energy.

Whitmore et al. (94) reported that cows of high production potential on high nutrition showed a longer interval from calving to first estrus. Butler et al. (11) reported that energy balance during the first 20 days of lactation is important in determining the onset of ovarian activity. Everson et al. (27) reported that a group of cows fed a ration of varied ratio of forage to grain, in comparison to a group on a constant ratio, showed a more positive energy balance in early lactation, higher intake, less body weight loss, and earlier postcalving estrus.

Jordan and Swanson (47) found excess crude protein in the diet of high producing cows lowered reproductive efficiency and did not increase production. Higher levels of crude protein in the diet have been implicated in lowered reproductive performance, as measured by days open and services per conception (47,48). Morrow et al. (68) showed that when dairy cows were fed grain liberally there was no effect on the interval from parturition to first estrus and on the subsequent estrus intervals, but there were significant differences in calving intervals and services per conception. Morrow (67) suggested that the ration should have at least 40% roughage on a dry matter basis and a minimum of 15% crude fiber.

Carstairs et al. (13) reported that high energy rations may lower resistance to disease. Reproductive disorders caused more days open and longer calving intervals (23,74). Ishak et al. (46) reported there were fewer services per conception when grain was replaced with soyhulls in the ration. Ducker (17) reported nutrition can have a marked effect on reproductive performance, that precise control of feed inputs can increase fertility.

When nutrition of postpartum cows is limited by energy content of ration rather than amount of feed available, postpartum reproductive performance may not be affected in cows capable of consuming large amounts of feed. Hansen et al. (38) reported that nutritional regimen may then be a more important determinant of postpartum reproduction in primiparous females than multiparous females.

Seasonal Effects

The prepubertal and postpartum periods both require the transition from anestrus to estrus. The observation that season effects age at puberty in heifers (34,40), led to the question of whether postpartum reproduction may also be influenced by season. Stott and Williams (89) found that the breeding efficiency of the cow can be affected by the time of ovulation, failure to ovulate, failure to manifest estrual activity, viability of the gametes, embryo survival, and fetal development. Under stress of high ambient temperatures, one or a number of these conditions could be important. The influence of high environmental temperature on viability of sperm and ova, and on uterine environment, has been reviewed (20,92). High ambient temperatures were deterimental to reproduction in sheep (2) and cattle (14,84).

Seasonal influences are a source of considerable variation in breeding efficiency in dairy cattle, particularly as measured by services/conception (24,25,41,76). A large percent of the cows bred during the summer months did not return to estrus by 35 days, but were found without viable embryos at the 35-41 day pregnancy examinations (89). Coming into heat later, these animals manifested long estrual intervals which correspond with the months of low seasonal breeding efficiency. Days from calving to first insemination of Jerseys were affected by season of calving (29). High environmental temperature (90°F) had an adverse effect on the ova (3,21) and probably on the sperm when in the female reproductive tract (21), resulting in low fertility. The high temperature also affected the developing young embryos, resulting in a high rate of embryonic mortality.

Stott and Williams (89) reported that as the maximum daily temperatures increase by 15^{o}F from the first of June (92^{o}F) to the 15th of June (107^{o}F), the number of animals conceiving and maintaining the conceptus declined from 61.5 to 31.0%. Through September and October, with declining temperatures, there was a proportional increase in fertility and again the change occured corresponding to the time of insemination. Hansen and Hauser (39) indicated animals that calved in winter had longer intervals from parturition to first estrus then those that calved in summer.

Genetic X Nutrition Interaction

Deutcher and Whiteman (16) and McGinty and Frerichs (64) reported low reproduction performance of beef x dairy crossbreds when energy level was low. Kropp et al. (52) found the moderate level of supplement was adequate to support reproduction for crossbreds, but definitely inadequate for Holsteins. Dunn et al. (19) indicated the number of services per conception was greater for Hereford cows on the high precalving energy intake than those on the low energy intake (2.08 vs. 1.39), and the opposite situation was found for Angus cows(1.67 vs. 2.16). Whitemore et al. (94) indicated that the interaction of genetic level of milk production and nutrition was signicificant ($p < .05$) for number of days open in dairy cattle.

Wood and Frappell (101) found there was no interaction between sire and reproductive performance.

Reproductive Traits

High production and reproductive efficiency are two traits needed to make a profit in the dairy business. Reproductive performance has an important influence on milk production and also on how long a cow remains in a herd. Reproductive performance controls the number of replacements produced per cow, and influences culling practices (6,8,72,86). Pelissier (75) has estimated the cost of reproductive inefficiency, based upon 1981 economics, to be about $116 per cow annually. Gerrits et al. (33) estimate in 1979 placed the potential savings by improved reproductive performance near $300 million annually in the U.S. These included reducing: 1) calving interval by 15 d; 2) reproductive culling from 5 to 2 %; 3) calf losses from 10 to 4%; and 4) services per conception from 2.0 to 1.5.

In this study several traits are included in a cow's reproductive performance.

Days from calving to first estrus. Morrow et al. (69) reported averages of 15 days from parturition to first ovulation in normal parturition cows and 34 days in abnormal cows. Fonseca et al. (29) showed that first ovulation occurred about 3 wk postpartum, and interval to first ovulation was greater in cows that had clinical abnormalities postpartum than in normal cows. Marion and Gier (60) reported 13.1, 14.0, and 36.9 days between parturition and first ovulation and 28.4, 33.1, and 36.9 days between parturition and first standing estrus in low, medium, or high milk production cows. Olds and Seath (71) reported that interval from parturition to first observed estrus was 32 $\pm$ 18.6 days.

Days from calving to first breeding. Fonseca et al. (29) reported that days from calving to first insemination was reported to average 87.6 days in Holstein cows and 85.0 days in Jersey cows. Days from calving to first insemination and conception were greater in cows with postpartum clinical problems (29).

Days from first breeding to pregnancy. Days from calving to pregnancy (days open) was reported to average 109.2 days in Holstein cows and 94.8 days in Jersey cows (29). That means about 3 wks from first breeding to pregnancy.

Days open. Days open is a function of interval from parturition to first insemination, rates of conception at first and subsequent inseminations, and intervals between successive inseminations (29). Louca and Legates (57) reported an average decrease of 2.40 $\pm$ 1.09 Kg of milk for each additional day open for total accumulated lifetime production through the lactation termination nearest 48 mo after 1st calving. Gaines (31) reported an average of 174 days open in 1927. Kelly and Holman (49) reported at the 1974 ADSA symposium that days open ranged from 99 to 153. The range of 84 to 136 days open was reported by Barr (5), with the average days open being 126 in these Ohio DHI herds.

Number of services per pregnancy. In California dairy herds Pelissier (73) reported 2.55 services per pregnancy for all cows and 2.02 for fertile cows. Services per pregnancy was reported as 1.7 by Barr (5) in Ohio DHI herds. Holstein data ranged from 1.66 to 2.54 services per pregnancy (62). Olds et al. (72) reported that higher 120-day milk yields result in more services per pregnancy.

Pregnancy rate. Pregnancy rates have been sometimes wrongly decribed as "conception rate" when really measuring pregnancy rate. Conception rate includes all cows which conceive, whereas pregnancy rate does not include cows in which embryonic death occurs. Shanks et al. (86) reported that the average conception interval (days open) of all cows was 146 days, conception rate was 87%. Approximately 90% of the Holsteins and Jerseys had conceived by three services while only 80% of the Guernseys and Ayrshires had conceived by three services (88).

The pregnancy rate of heifers versus parous cows was investigated by Inskeep et al. (45), who found that fertility did not vary significantly, with averages of 67.3% and 68.3%, respectively. But Mares et al. (59) found 63.6% pregnancy rates in heifers and a much lower rate (55.3%) in parous cows, all from first inseminations.

The pregnancy rate to first service found by Touchberry et al. (91) approached 50% for heifers that became pregnant, but when all heifers were considered the rate dropped to 42.5%. Seath et al. (85) reported pregnancy rates ranged from 40 to 90 percent and Leaver (55) found the average pregnancy rate was 67% when determined 8 to 10 weeks after service .

Calving interval. The most frequently cited reproductive performance is calving interval. Intervals from calving to first service and from first service to conception and services per conception were major factors affecting calving intervals (88). Williams (98) recognized twelve months as an ideal calving interval. Louca and Legates (57) suggested optimum production would be obtained with a 13-mo calving interval for first lactation and a 12-mo interval for second and later lactations. Allalout (1) demonstrated that an average interval of 385 days was favorable. An average calving interval of 13.08 months was found by Dunbar and Henderson (18), while Legates (56) found a mean of 406 days (13.53 months). Riera (79) reported a calving interval of 420 $\pm$ 5.5 days in a tropical climate.

Number of estrous cycles to first breeding. Smith (87) reported that number of estrous cycles to first breeding is one of the measures of reproductive efficiency related to estrus detection. Gray and Varner (35) reported estrous detection failure is the most serious and widespread problem that affects breeding efficiency in cows. Because estrous detection is affected by a large number of factors, such as temperature will increase the difficulty in detecting estrus (93), few people have reported the number of estrous cycles to 1st breeding. Also, management may have a great influence on estrus detection.

Number of estrous cycles to pregnancy. Thatcher and Wilcox (90) reported that the number of services per pregnancy was related to the frequency of heats during 0 to 60 days postpartum. Cows exhibiting 0, 1, 2, 3, and 4 heats during the first 60 days postpartum required 2.60, 2.58, 2.32, 2.21, and 1.75 services per pregnancy, respectively. A significant decline in services required was associated with increased number of heats.

MATERIALS AND METHODS

Data on reproductive performance are available from a study on the influence of sire and ration on milk production (54). This study looks at the effect of sire, ration, season, and the interaction of sire and ration on reproductive performance. This study utilized 289 first lactation records from daughters of 17 Holstein sires.

Experimental Design

Genetic mating system. Two separate trials were run using the Utah Experiment Station Dairy Herd between June, 1961, and December, 1969. Reproduction data were from 289 complete first lactations of Holstein cows, including 150 daughters of 10 sires in Trial I and 139 daughters of 8 sires in Trial II. One sire was used in both trials; this was sire 4 in trial I and sire 18 in trial II. The Holstein sires were selected in pairs and used over 2 yr; two new sires started service each year. Sire 1 was a young bull from the USDA herd at Beltsville, MD. Sire 3 was from New Zealand and was selected for the superior performance of his daughters on all-forage rations. All other sires were selected to represent many bloodlines and various geographical areas of the U. S. and Canada, and all had plus daughter-dam comparisons at selection. However, later USDA daughter-herdmate comparisons on these bulls resulted in predicted differences for milk (PDM) ranging from -695 to + 657 kg (Table 1). Each sire was mated to sufficient females to expect 20 daughters to complete a first lactation. All sires were mated as equally as possible to cows of various levels of production and to daughters of previous sires. All females were raised similarly until freshening. As calves, they were fed on forage alone from 10 mo of age to calving. Initial breeding began with first observed estrus after 15 mo of age. Only heifers pregnant by 24 mo of age were used.

Rations. The experimental period began on the 4th day after first calving and continued through a 305-day lactation. Daughters of each sire were assigned alternately at calving to one of two rations which were fed for the entire first lactation. The two rations for Trial I were alfalfa hay ad libitum (ration 1) and alfalfa hay ad libitum plus 1 kg concentrate/3.5 kg of 4% fat-corrected-milk (FCM) produced (ration 2). In Trial II, the rations were alfalfa hay ad libitum plus 1.4 kg concentrate/day (ration 3) and alfalfa hay ad libitum plus .6 kg concentrate/kg of 4 % FCM produced above 4.5 kg/day with a minimum of 10.9 kg concentrate/day for the first 6 wk and 2.7 kg/day thereafter (ration 4). Realized mean ratios of forage : concentrate intake were 100:0, 73:27, 91:9, and 55:45 for rations 1 to

TABLE 1. USDA sire summaries of sires in this study[a].

Sire code	Reg. No.	Name	Predicted difference Milk(kg)	Predicted difference Fat(kg)	Repeat-ability (%)
Trial I					
01	1258450	BDI Sovempgov Apex	-63	-2	27
02	1117039	Pond Gate Mister	-695	-21	99
03[b]	-	Rauview Ideal	-	-	-
04[c]	1200082	Carnation Ensign Major Madcap	-93	-6	99
05	1195312	Naches Foreman	+502	+6	89
06	961535	Sutton Oaks Lockinvar Heilo Burke	+223	+6	84
07	1189870	Osborndale Ivanhoe	+286	+10	99
08	1169417	Carnation Profile	-323	-5	97
09	1244845	Grayview Skyliner	+355	+6	99
10	1230640	Polytechnic Imperial Montvic	+89	+1	97
Trial II					
11	1239242	Sevens Burke Skylark	+432	+15	96
12	1126307	Wis Magistrate Burke	+124	+7	87
13	1274923	Sequoia Jo Star	-290	-12	96
14	1223243	Wil-O-Whit Burkgov Fobes Dagan	+294	+10	97
15	1221226	Smoky Hill Whirlwind Mark	-48	-7	96
16	1242221	Polytechnic Imperial Knight	+657	+22	63
17	1106334	Elmoka Joe Homestead	+63	+11	96
18[c]	1200082	Carnation Ensign Major Madcap	-93	-6	99

a All proofs from April, 1967 DHIA sire summary list, except sire 16, which is from May, 1968 list.
b Bred in New Zealand; - = data not available.
c Sire 04 in Trial I & Sire 18 in Trial II are the same sire.

4, respectively.

Table 2. Mean digestible energy intake by rations.

Ration	DE (Mcal/kg)
1	2.53
2	2.90
3	2.69
4	3.14

Cows on both rations in each trial were fed from the same lots of high quality second-cutting alfalfa hay. The concentrate in all trials consisted of 79% steam rolled barley, 14% molasses dried beet pulp, 5% molasses, 1% trace mineral salt, and 1% dicalcium phosphate. Cows were fed individually but were allowed free access to trace mineral salt, dicalcium phosphate, and water.

Season of calving. The whole year is separated into 4 seasons of calving. The 1st season of calving is from June to August; the 2nd season of calving is from September to November; the 3rd season of calving is from December to February; and the 4th season of calving is from March to May.

Housing and management. Management was the same for all rations. Cows were housed together in loose housing and milked twice daily in a parlor. Milk production and feed intake were recorded daily. Heat detection was twice per day for at least 30 minutes each time. Dairy reproductive management was as follows: Rectal examinations 30 $\pm$ 7 days postpartum; artificial insemination at 1st heat after 60 days postpartum; rectal pregnancy examinations at 40 $\pm$ 7 days postbreeding; and additional rectal examinations if the cow displayed abnormal reproductive symptoms.

Data.

Data utilized in this research covered the period from parturition to pregnancy except for calculations of calving interval and pregnancy rates which used the date of second calving. Data used in this study included the following:

- -Cow.
- -Sire.
- -Ration.
- -Trial.
- -Season.
- -Days from calving to first estrus.
- -Days from calving to first breeding.
- -Days from first breeding to pregnancy.
- -Days open.
- -Number of services per pregnancy.
- -Pregnancy rate.
- -Calving interval.

-Number of estrous cycles to first breeding.

-Number of estrous cycles to pregnancy.

Reproductive Variables

Nine reproductive traits were analyzed to measure more precisely the reproductive performance of cows. The definition used for each trait is as follows:

1) Days from calving to first estrus. Number of days from parturition to first observed and reported estrus.

2) Days from calving to first breeding. Number of days from parturition to first Artificial Insemination. Cows were all bred artificially at first observed estrus after 60 days postpartum.

3) Days from first breeding to pregnancy. Number of days from the first breeding to the breeding which resulted in pregnancy. Other terms with the same meaning are interval of breeding or service period.

4) Days open. Number of days from parturition to pregnancy.

5) Number of services per pregnancy. Two methods were used to measure number of services per pregnancy. One was all services of all cows divided by number of pregnant cows. The other was all services of only pregnant cows divided by

number of pregnant cows. The former is larger than the later.

6) Pregnancy rate. Pregnancy was determined by birth of a calf or by rectal palpation for a few cows sold prior to second calving. Pregnancy rate was percent of cows which became pregnant for a second calf.

7) Calving interval. The number of days between parturition with the first and 2nd calf. It can also be expressed as the sum of the number of days open and length of gestation.

8) Number of estrous cycles to first breeding. The number of estrous cycles from parturition to first breeding.

9) Number of estrous cycles to pregnancy. The number of estrous cycles from parturition to pregnancy.

Statistical Analysis

Reproductive traits were studied with one analysis of variance model using the least squares method. The model used for each trial was:

$$Y_{ijk} = u + D_i + R_j + S_k + DR_{ij} + RS_{jk} + e_{ijk}$$

where:

Y_{ijk} = An observation of the i^{th} sire, j^{th} ration, k^{th} season of calving.

u = Population mean common to all observations.

D_i = The effect of the i^{th} sire, (i = 1...10 for trial I, 11...18 for trial II).

R_j = The effect of the j^{th} ration, (j = 1 and 2 for trial I, 3 and 4 for trial II).

S_k = The effect of the k^{th} season, (k = 1...4).

DR_{ij} = The contribution due to the interaction between the i^{th} sire and the j^{th} ration.

RS_{jk} = The contribution due to the interaction between the j^{th} ration and the k^{th} season.

e_{ijk} = Random error term unique to each observation.

Sire 4 and sire 18 are the same sire, the only sire used in both of the trials to compare reproductive performances under high forage (rations 1 and 3), standard feeding (ration 2), and high grain feeding (ration 4) systems. The model for this analysis of sire 4/18 data is:

$$Y_{ij} = u + R_i + S_j + RS_{ij} + e_{ij}$$

where:

Y_{ij} = An observation of the i^{th} ration, of the j^{th} season.

u = Population mean common to all observations.

R_i = The effect of the i^{th} ration, (i = 1...4).

S_j = The effect of the j^{th} season, (j =1...4).

RS_{ij} = The contribution due to the interaction between the i^{th} ration and the j^{th} season.

e_{ij} = Random error term unique to each observation.

RESULTS AND DISCUSSION

Variables

Five independent discrete variables (main effects) were studied: 1) the effect of sire, 2) the effect of ration, 3) the effect of season, 4) the interaction between sire and ration, and 5) the interaction between ration and season.

Nine reproductive performance variables (dependant) were measured and analyzed: 1) Days from calving to first estrus (C-E1), 2) Days from calving to first breeding (C-B1), 3) Days from first breeding to pregnancy (B1-P), 4) Days open (DO), 5) Services per pregnancy (S/P), 6) Pregnancy rate (PR), 7) Calving interval (CI), 8) Number of estrous cycles to first breeding (E-B1), and 9) Number of estrous cycles to pregnancy (E-P).

Analysis of Reproductive Traits

Since sire 4/18 was the only sire used in both trials,the analysis was done in three parts, Trial I, Trial II, and Sire 4/18. Except for sire 4/18, there is no way to test for differences between the two trials. For the other sires, the overall ration effect (rations 1 and 2 versus rations 3 and 4) is completely confounded with sire effect. As a consequence, except for sire 4/18 data, it is impossible to tell if differences between trial I and trial II are due to different rations or to the different sires.

Means and standard deviations for reproductive variables of Trial I, Trial II, and Sire 4/18 are in Table 3. Comparing the results of this study with previous studies it can be concluded: days from calving to first estrus, days from calving to first breeding, days from first breeding to pregnancy, and days open in this study are more than those reported in literature review. Olds and Seath (71) reported that days from calving to first estrus was 32 $\pm$ 18.6 days. Standard deviations of days from calving to first estrus in this study are greater than 18.6 days. Thus, in this study cows not only had a greater number of days from calving to first estrus than in the study by Olds and Seath (71), but they were also more variable.

Days from calving to first breeding in this study (104 - 112 days) are longer than the 87.6 days reported by Fonseca et al. (29).

Days from first breeding to pregnancy in this experiment (44 - 57 days) were about one estrous period longer than reported in the literature (29).

Days open in this experiment (154 - 162 days) were about

Table 3. Means and standard deviations for reproduction variables in Trial I, Trial II, and Sire 4/18.

	MEAN (STD DEV)		
	Trial I	Trial II	Sire 4/18
Days from calving to first estrus (C-E1)	56.54 (35.67)	59.32 (42.21)	47.24 (30.16)
Days from calving to first breeding (C-B1)	109.55 (29.03)	112.45 (35.37)	103.92 (19.98)
Days from first breeding to pregnancy (B1-P)	43.97 (71.58)	51.80 (93.02)	56.92 (74.72)
Days open (DO)	153.52 (79.39)	162.22 (90.38)	160.84 (75.96)
Services per pregnancy[a] (S/P)	1.73 (1.36)	1.80 (1.51)	1.78 (1.18)
Services per pregnancy[b] (S/P)	1.92 (1.49)	2.00 (1.68)	2.11 (1.29)
Pregnancy rate (PR)	.86 (.35)	.86 (.35)	.79 (.41)
Calving interval (CI)	415.65 (66.37)	425.27 (82.90)	407.00 (41.26)
Number of estrous cycles to first breeding (E-B1)	1.39 (1.13)	1.28 (.99)	1.60 (1.13)
Number of estrous cycles to pregnancy (E-P)	3.16 (1.80)	3.10 (1.64)	3.68 (1.65)

[a]The numbers of services included only pregnant cows.

[b]The numbers of services included all cows.

the same as that reported by Kelly and Holman (49), but longer than the 126 days reported by Barr (5).

Rakes (78) indicated that it is very difficult to meet the TDN or energy requirements of most heifers with roughage alone, especially for heifers less than one year of age. Heifers in this study were fed on forage alone from 10 mo of age to calving. This might have caused heifers to lack enough energy and have poor reproductive performance prior to first calving, but should not have carried over into this study. Low energy rations in this study might cause abnormal estrus and fewer numbers of estrus before 60 days postpartum, which could make estrus detection difficult. Different sires used in this study might be one of reasons for large differences in reproductive performances. Days from calving to first breeding plus days from first breeding to pregnancy are not equal to days open in trial II. Because of missing data in trial II there are different numbers of observations in each trait. Other reproductive traits in this study are close to those in earlier reports.

Reproductive performances in trial II generally were not as good as those in Trial I. This may be because the standard ration (ration 2) in Trial I was more conducive to better reproductive performance, although from Sire 4/18 analysis, effect of ration was significant only for calving interval. Another cause of differences between Trial I and Trial II may have been differences in farm personnel at the time the two trials were conducted, with some personnel not being as proficient in observing estrus or in the breeding program.

Results of the analysis of variance obtained by the linear model procedure begin in table 4. There are no statistically significant differences in days from calving to first breeding (table 4), number of services per pregnancy for all cows (table 5), and number of estrous cycles to pregnancy (table 6). Olds et al. (72) reported that higher 120-day milk yields result in more services per pregnancy, but this was not significant in this study. Thatcher and Wilcox (90) reported that a significant decline in services required was associated with increased number of heats prior to breeding, but this did not occur in this study.

Days from calving to first estrus (C-E1) is shown in table 7. Sires differences were significant ($p < .05$) in Trial I, but were not significant in Trial II. This suggests that within a given group of sires there may be a genetic cause of difference in number of days from calving to first estrus. But the results of Trial II indicate that this difference does not exist among all sires.

Table 4. Analysis of variance mean square error, F-ratios and their significance level for days from calving to first breeding (C-B1) in Trial I, Trial II, and Sire 4/18.

	Trial I		Trial II		Sire 4/18	
Source	df	F	df	F	df	F
Ration	1	1.06	1	.04	3	.98
Season	3	1.38	3	2.65	3	2.11
R x S	3	1.20	3	1.40	6	2.42
Sire (D)	9	1.86	7	1.57		
R x D	9	.37	7	.73		
Error[a]	124	808.51	114	1197.34	25	369.83

[a] Entries on the Error line are mean square error.

Table 5. Analysis of variance mean square error, F-ratios and their significance level for number of services per pregnancy (S/P)[a] in Trial I, Trial II, and Sire 4/18.

	Trial I		Trial II		Sire 4/18	
Source	df	F	df	F	df	F
Ration	1	.61	1	.30	3	.91
Season	3	.06	3	.39	3	1.24
R x S	3	1.96	3	.42	6	1.67
Sire (D)	9	1.23	6	.65		
R x D	9	.73	6	.75		
Error[b]	124	2.17	103	2.97	25	1.56

[a] Number of services per pregnancy for all cows.

[b] Entries on the Error line are mean square error.

Table 6. Analysis of variance mean square error, F-ratios and their significance level for number of estrous cycles to pregnancy (E-P) in Trial I, Trial II, and Sire 4/18.

	Trial I		Trial II		Sire 4/18	
Source	df	F	df	F	df	F
Ration	1	.62	1	1.36	3	.28
Season	3	.12	3	2.36	3	1.59
R x S	3	2.32	3	1.25	6	1.26
Sire (D)	9	.60	7	.73		
R x D	9	1.07	7	1.16		
Error[a]	124	3.32	116	2.56	25	2.72

[a] Entries on the Error line are mean square error.

Table 7. Analysis of variance mean square error, F-ratios and their significance level for days from calving to first estrus (C-E1) in Trial I, Trial II, and Sire 4/18.

	Trial I		Trial II		Sire 4/18	
Source	df	F	df	F	df	F
Ration	1	.40	1	.28	3	1.07
Season	3	.64	3	2.58@	3	2.11
R x S	3	.40	3	.81	6	2.42
Sire (D)	9	2.10*	7	1.36		
R x D	9	1.92	7	.41		
Error[a]	124	1137.00	116	1708.38	25	681.05

[a] Entries on the Error line are mean square error.

* Significant at $p < .05$.

@ Significant at $p < .10$.

Means and standard deviations of days from calving to first estrus by sire in Trial I are in table 8.

Season differences were significant ($p < .10$) in Trial II. There were more days from calving to first estrus for cows calving in spring and summer seasons. Means and standard deviations of days from calving to first estrus by season in Trial II are in table 9.

Analysis of variances for days from first breeding to pregnancy (B1-P) is in table 10. Days from first breeding to pregnancy are significant ($p < .05$) for sires in Trial I and for season in Sire 4/18 analysis. Estimated means and standard deviations of days from first breeding to pregnancy by sire in Trial I is in table 11. Sire 3 had an especially long number of days from first breeding to pregnancy. Semen from sire 3 was imported from New Zealand where he was selected for the superior performance of his daughters on all-forage rations. A possible reason for daughters of sire 3 being so different is that they were not suited to the different dairy management methods in the U.S. Also, sire 3 had fewer daughters than most other sires.

Estimated means and standard deviations of days from first breeding to pregnancy by season for sire 4/18 is in table 12. Number of cows in summer, fall, winter, and spring are 2, 3, 6, and 7, respectively. There were so few

Table 8. Estimated means and standard deviations of days from calving to first estrus by sire in Trial I.

	No. cows	Mean	Std dev
Sire 1	8	45.11	12.48
Sire 2	6	35.27	14.24
Sire 3	7	48.23	13.31
Sire 4	10	39.63	11.16
Sire 5	20	54.53	7.56
Sire 6	20	46.87	7.76
Sire 7	20	60.44	7.76
Sire 8	19	52.24	7.89
Sire 9	20	75.14	7.82
Sire 10	20	75.44	7.69

Table 9. Estimated means and standard deviations of days from calving to first estrus by season[a] in Trial II.

	No. cows	Mean (Std dev)
Summer	44	67.50 (6.46)
Fall	41	45.09 (7.24)
Winter	30	52.45 (7.95)
Spring	24	71.19 (9.15)

[a]Season was based on date of first calving, summer = June - August, fall = September - November, winter = December - February, and spring = March - May.

Table 10. Analysis of variance mean square error, F-ratios and their significance level for days from first breeding to pregnancy (B1-P) in Trial I, Trial II, and Sire 4/18.

	Trial I		Trial II		Sire 4/18	
Source	df	F	df	F	df	F
Ration	1	.27	1	.89	3	1.63
Season	3	.13	3	.18	3	3.95*
R x S	3	.74	3	2.15	6	1.46
Sire (D)	9	2.03*	7	1.59		
R x D	9	.70	7	1.56		
Error[a]	124	4932.24	116	8265.57	25	4718.66

[a] Entries on the Error line are mean square error.

* Significant at $p < .05$.

Table 11. Estimated means and standard deviations days from first breeding to pregnancy by sire in Trial I.

	No. cows	Mean	Std dev
Sire 1	8	13.98	25.98
Sire 2	6	45.81	29.65
Sire 3	7	139.32	27.73
Sire 4	10	41.93	23.26
Sire 5	20	20.69	15.75
Sire 6	20	20.92	16.16
Sire 7	20	45.50	16.16
Sire 8	19	39.24	16.43
Sire 9	20	54.88	16.30
Sire 10	20	57.76	16.02

Table 12. Estimated means and standard deviations of days from first breeding to pregnancy by season[a] for Sire 4/18.

	No. cows	Mean	Std dev
Summer	2	0.00	0.00
Fall	3	106.67	69.82
Winter	6	79.00	96.60
Spring	7	99.43	88.68

[a]Season was based on date of first calving, summer = June -August, fall = September - November, winter = December - February, and Spring = March - May.

cows in summer and fall season that the validity of this result is questionable. The mean of zero days for summer indicates that both cows settled on first service.

The effect of days open are in table 13. Sires in Trial I, the interaction of ration and season in Trial II, and season in Sire 4/18 analysis were significant ($p < .05$). Estimated means and standard deviations of days open for sires in Trial I are in table 14. Again sire 3 has by far the longest number of days open. This may be because the daughters were not suited to the dairy management, it may be a genetic trait of that sire, or both, but daughters of this New Zealand sire did have poor reproductive performance. It should also be noted that there were only 7 daughters of this sire.

Estimated means and standard deviations for days open by ration and season in Trial II are in Table 15. Figure 1 shows the interaction efffect of ration and season in Trial II. Ration 3 has the lowest number of days open in summer season, but the longest in the another three seasons. Ration 4 has longer days open in summer season, but drops in fall and winter season, and then gets longer in spring season. Table 16 shows means and standard deviations of temperature by seasons at Utah State University, Logan during the time of this study.

Table 13. Analysis of variance mean square error, F-ratios and their significance level for days open (DO) in Trial I, Trial II, and Sire 4/18.

	Trial I		Trial II		Sire 4/18	
Source	df	F	df	F	df	F
Ration	1	.76	1	.55	3	1.82
Season	3	.50	3	.96	3	4.50*
R x S	3	1.14	3	3.29*	6	1.57
Sire (D)	9	3.11*	7	1.21		
R x D	9	.40	7	2.07		
Error[a]	124	5695.29	117	7555.26	25	4556.26

[a] Entries on the Error line are mean square error.

* Significant at $p < .05$.

Table 14. Estimated means and standard deviations of days open for sires in Trial I.

	No. cows	Mean	Std dev
Sire 1	8	115.92	27.92
Sire 2	6	131.28	31.86
Sire 3	7	281.38	29.80
Sire 4	10	144.69	24.99
Sire 5	20	125.74	16.93
Sire 6	20	123.95	17.36
Sire 7	20	162.05	17.36
Sire 8	19	146.27	17.65
Sire 9	20	171.11	17.51
Sire 10	20	173.57	17.21

Table 15. Estimated means and standard deviations for days open by ration and season[a] in Trial II.

	No. cows	Ration 3 Mean (Std dev)	No. cows	Ration 4 Mean (Std dev)
Summer	21	129.67 (50.80)	23	178.26 (119.13)
Fall	27	164.11 (102.71)	14	136.50 (60.31)
Winter	14	184.00 (114.67)	16	147.25 (58.14)
Spring	9	209.56 (75.16)	15	171.00 (59.30)

[a]Season was based on date of first calving, summer=June- August, fall =September- November, winter = December - February, and spring = March - May.

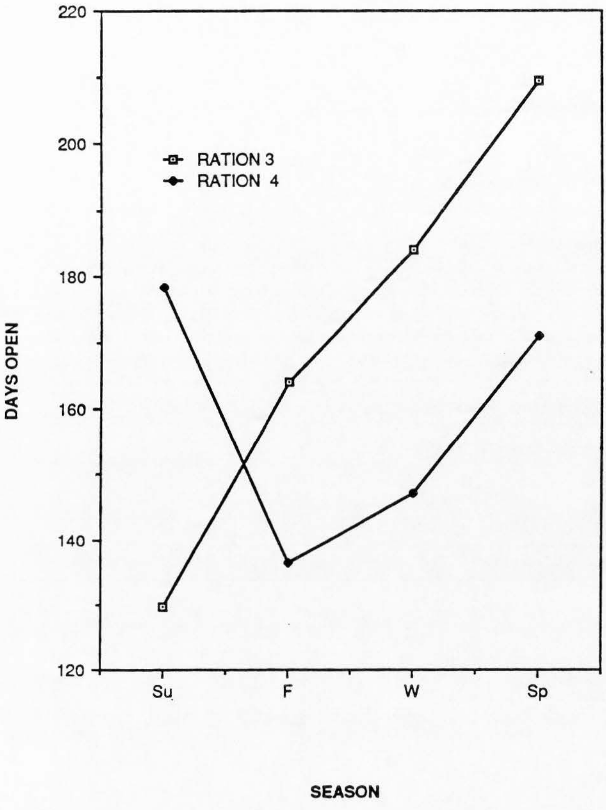

Figure 1. Days open by R x S for Trial II

Table 16. Means and standard deviations temperature (^{o}F) at USU, Logan (June, 1961 - December,1969).[a]

	MEAN	STD DEV
Summer	69.10	5.02
Fall	50.08	10.04
Winter	26.26	5.03
Spring	45.83	9.36

[a] Data are from Climatological Data. Utah. 1961 - 1969, Vol. 64 - 71.

The high energy ration (ration 4) was good for days open in cold seasons, but days open increase in warmer seasons. The low energy ration (ration 3) was helpful for shortening days open in hot season, but poor in other seasons.

Estimated means and standard deviations for days open by season for Sire 4/18 is in table 17.

Table 17. Estimated means and standard deviations for days open by season[a] for Sire 4/18.

	No. cows	Mean	Std dev
Summer	2	90.98	27.50
Fall	3	116.23	30.20
Winter	6	171.67	24.84
Spring	7	212.15	22.85

[a]Season was based on date of first calving, summer = June - August, fall = September - November, winter = December - February, and spring = March - May.

Number of cows in summer, fall, winter, and spring are 2, 3, 6, and 7, respectively. There were so few cows in summer and fall seasons that the results of analysis of days open by season for Sire 4/18 are questionable.

The analysis for number of services per pregnancy for cows which were pregnanct is in table 18. The services per pregnancy was significant ($p < .05$) for ration x season in Trial I. Estimated means and standard deviations for services per pregnancy by ration and season for Trial I are in table 19. Figure 2 shows number of services per pregnancy by ration and season for Trial I. Ration 1 has the highest services per pregnancy (2.2) in summer season, but drops to about 1.5 in the other three seasons. Ration 2 has

Table 18. Analysis of variance mean square error, F-ratios and their significance level for number of services per pregnancy (S/P)[a] in Trial I, Trial II, and Sire 4/18.

	Trial I		Trial II		Sire 4/18	
Source	df	F	df	F	df	F
Ration	1	.47	1	.30	3	1.49
Season	3	.13	3	.39	3	1.61
R x S	3	2.70*	3	.42	5	2.21
Sire (D)	9	.87	7	.65		
R x D	8	.51	7	.75		
Error[b]	110	1.87	103	2.40	20	1.24

[a] Number of services per pregnancy only for pregnant cows.

[b] Entries on the Error line are mean square error.

* Significant at $p < .05$.

Table 19. Estimated means and standard deviations for services per pregnancy[a] by rations and seasons[b] for Trial I.

	Mean (Std dev)			
	NO. cows	Ration 1	No. cows	Ration 2
Summer	15	2.20 (.41)	15	1.31 (.42)
Fall	21	1.52 (.36)	23	2.19 (.33)
Winter	13	1.59 (.43)	18	1.93 (.39)
Spring	25	1.51 (.33)	20	2.25 (.35)

[a]Number of services per pregnancy for pregnant cows only.

[b]Season was based on date of first calving, summer = June - August, fall = September - November, winter = December - February, and spring = March - May.

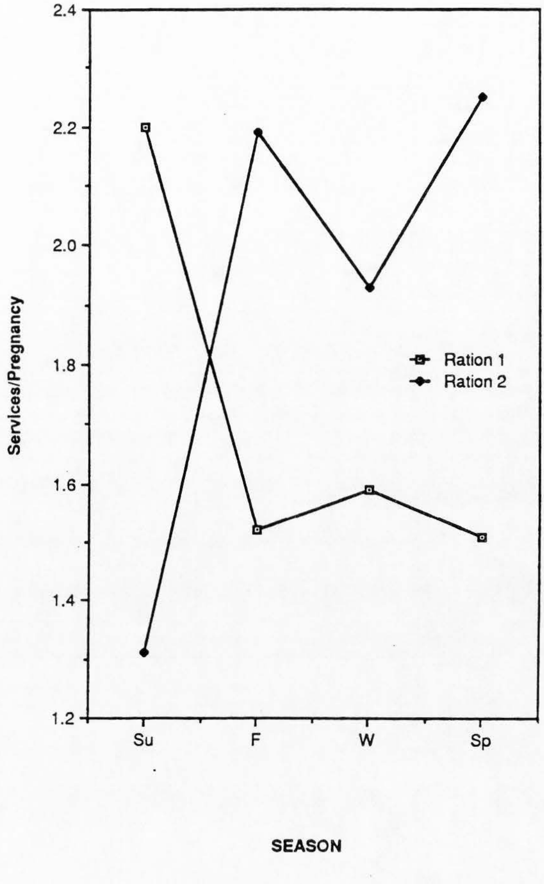

Figure 2. Services per pregnancy by R x S for Trial I

the lowest services per pregnancy (1.3) in summer season, but goes up to 1.9 in winter season, and 2.2 in fall and spring seasons. Thus, cows calving in summer did not follow the pattern of cows calving in other three seasons. Ration 1 was a low energy ration, and ration 2 was a standard ration. Ration 1 had a high number of services per pregnancy for cows calving in summer season, but was good in other seasons. Standard energy ration (ration 2) was good for services per pregnancy for cows calving in summer season, but harmful to those calving in fall and spring seasons. This is not the results one would expect and there does not appear to be a logical explanation for these results.

Analysis of pregnancy rate is in table 20. Pregnancy rate was significant ($p < .05$) for sire in Trial I and ration x season in Trial II. Estimated means and standard deviations of pregnancy rate by sire in Trial I is in table 21. Sire 3 has a pregnancy rate much lower than any other sire. Again this may be due to daughters not adapting to the environment, it may be a genetic trait, or it may be chance due to the small number of daughters of this particular sire.

Estimated means and standard deviations for pregnancy rate for rations and seasons for Trial II are in table 22. The interaction in pregnancy rate by ration and season for

Table 20. Analysis of variance mean square error, F-ratios and their significance level for pregnancy rate (PR) in Trial I, Trial II, and Sire 4/18.

	Trial I		Trial II		Sire 4/18	
Source	df	F	df	F	df	F
Ration	1	.25	1	1.38	3	1.79
Season	3	.35	3	.17	3	2.35
R x S	3	.62	3	3.27*	6	1.99
Sire (D)	9	4.29*	7	1.19		
R x D	9	1.11	7	1.03		
Error[a]	124	.10	117	.12	25	.14

[a] Entries on the Error line are mean square error.

* Significant at $p < .05$.

Table 21. Estimated means and standard deviations for pregnancy rate by sire for Trial I.

	No. cows	Means	Std dev
Sire 1	8	.99	.12
Sire 2	6	.83	.13
Sire 3	7	.18	.12
Sire 4	10	.87	.10
Sire 5	20	.95	.07
Sire [illegible]	20	.94	.07
Sire 7	20	.91	.07
Sire 8	19	.94	.07
Sire 9	20	.74	.07
Sire 10	20	.86	.07

Table 22. Estimated means and standard deviations for pregnancy rate by ration and season[a] for Trial II.

	Mean (Std dev)			
	No. cows	Ration 3	No. cows	Ration 4
Summer	21	.94 (.08)	23	.71 (.08)
Fall	27	.80 (.07)	14	.97 (.10)
Winter	14	.74 (.10)	16	.92 (.09)
Spring	9	.75 (.12)	15	.92 (.09)

[a]Season was based on date of first calving, summer = June - August, fall = September - November, winter = December - February, and spring = March - May.

Trial II is shown in figure 3. Ration 3 has highest pregnancy rate in summer season (.94), but drops to .7 - .8 in other seasons. Ration 4 has the lowest pregnancy rate in summer season (.71), but above .9 in another three seasons. Ration 3, which is a low energy ration is helpful for pregnancy rate in hot season, but lack of energy may be detrimental in cold season. Ration 4, which is a high energy ration helped keep a high pregnancy rate in cold seasons, but was harmful to pregnancy rate in the hot season.

Analysis of variance for calving interval is in table 23. Ration had a significant effect ($p < .05$) for Sire 4/18. Estimated means and standard deviations for calving interval for all four rations for Sire 4/18 is in table 24. Ration 2, which was a standard ration, had the shortest calving interval. Rations 1 and 3 are low energy rations. Ration 4, which was a high energy ration had the longest calving interval. This suggests that suitable energy in the ration can shorten calving interval.

Analysis of number of estrous cycles to first breeding is shown in table 25. The effect of ration was significant ($p < .05$) in Trial I. Estimated means and standard deviations of number of estrous cycles to first breeding by ration in Trial I is in table 26. The low energy ration,

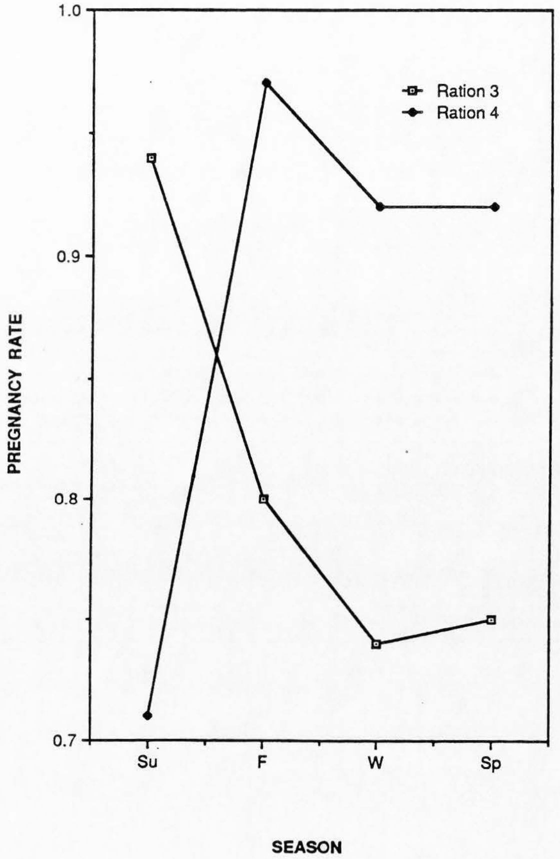

Figure 3. Pregnancy rate by R x S for Trial II

Table 23. Analysis of variance mean square error, F-ratios and their significance level for calving interval (CI) in Tial I, Trial II, and Sire 4/18.

	Trial I		Trial II		Sire 4/18	
Source	df	F	df	F	df	F
Ration	1	.20	1	.00	3	3.48*
Season	3	.66	3	.42	3	3.06
R x S	3	1.32	3	2.56	6	2.35
Sire (D)	8	1.43	7	.59		
R x D	8	.18	7	2.07		
Error[a]	90	4491.67	88	6580.85	25	1052.28

[a] Entries on the Error line are mean square error.

* Significant at $p < .05$.

Table 24. Estimated means and standard deviations for calving interval by rations for Sire 4/18.

	No. cows	Mean	Std dev
Ration 1	5	383.34	21.28
Ration 2	5	359.63	19.30
Ration 3	4	413.21	11.23
Ration 4	3	428.60	11.70

Table 25. Analysis of variance mean square error, F-ratios and their significance level for number of estrous cycles to first breeding (E-B1) in Trial I, Trial II, and Sire 4/18.

	Trial I		Trial II		Sire 4/18	
Source	df	F	df	F	df	F
Ration	1	5.77*	1	.45	3	.50
Season	3	.66	3	1.43	3	.64
R x S	3	1.22	3	.92	6	1.45
Sire (D)	9	1.46	7	.44		
R x D	9	1.81	7	.60		
Error[a]	124	1.17	116	1.01	25	1.15

[a] Entries on the Error line are mean square error.

* Significant at $p < .05$.

Table 26. Estimated means and standard deviations for number of estrous cycles to first breeding by ration for Trial I.

	No. cows	Mean	Std dev
Ration 1	73	1.76	.14
Ration 2	77	1.27	.14

ration 1, had a larger number of estrous cycles to first breeding than did the standard ration, ration 2.

SUMMARY AND CONCLUSIONS

Summary

Reproductive performance has a major influence on a dairy business. Nine reproductive traits were included in this study to investigate if there are any effects of ration, sire, season, interaction of ration and sire, and interaction of ration and season on reproduction in dairy cows. The nine reproductive traits were: days from calving to first estrus, days from calving to first breeding, days from first breeding to pregnancy, days open, services per pregnancy, pregnancy rate, calving interval, number of estrous cycles to first breeding, and number of estrous cycles to pregnancy.

Two hundred eighty nine first laction Holstein cows sired by 17 bulls were used in this study. One hundred fifty daughters of 10 sires were in Trial I, while 139 daughters of 8 sires were in Trial II. Sires 4 and 18 were the same sire used in both trials. Rations 1 and 2 were used in Trial I; rations 3 and 4 were used in Trial II. Rations 1 and 3 were low energy rations. Ration 2 was a standard ration. Ration 4 was a high energy ration. Four different seasons of first calving were included in this study. They were summer (June thru August), fall (September thru November), winter (December thru February), and spring (March thru May).

Table 27 shows reproductive traits which were significanlly affected by the different variables in Trial I, Trial II, and Sire 4/18. Days from calving to first estrus, days from first breeding to pregnancy, days open, and pregnancy rate were all influenced by sire in Trial I. Sire affect on days from calving to first estrus in Trial I appeared to increase over years, which may suggested that different personnel detecting estrus could have influenced this sire effect. Sire 3 was the main cause of differences in days from first breeding to pregnancy, days open, and pregnancy rate in Trial I. Sire 3 was from New Zealand and his daughters may have not adapted to the different dairy management in Utah. Disregarding the effect of sire 3 and the time trend in days from calving to first estrus, there is no effect of sire on reproductive performance of his daughters.

Ration affected calving interval in Sire 4/18 analysis and number of estrous cycles to first breeding in Trial I. Ration effect on calving interval in Sire 4/18 analysis was for ration 2 having the shortest calving interval. Ration 2 was the standard ration. Both the high energy and the two low energy rations were not as favorable for good calving

Table 27. Significant reproductive traits in Trial I, Trial II, and Sire 4/18.

	Trial I	Trial II	Sire 4/18
Days from calving to first estrus (C-E1)	Sire (D)[a]	Season[b]	-
Days from calving to first breeding (C-B1)	-	-	-
Days from first breeding to pregnancy (B1-P)	Sire (D)[a]	-	Season[a]
Days open (DO)	Sire (D)[a]	R x S[a]	Season[a]
Services per pregnancy[c] (S/P)	R x S[a]	-	-
Services per pregnancy[d] (S/P)	-	-	-
Pregnancy rate (PR)	Sire (D)[a]	R x S[a]	-
Calving interval (CI)	-	-	Ration[a]
Number of estrous cycles to first breeding (E-B1)	Ration[a]	-	-
Number of estrous cycles to pregnancy (H-P)	-	-	-

[a]Significant at $p < .05$.

[b]Significant at $p < .10$.

[c]The numbers of services included only pregnant cows.

[d]The numbers of services included all cows.

- No significant affects ($p \geq .10$).

intervals. The number of estrous cycles to first breeding in Trial I was lower for ration 2 than ration 1, but this affect did not carry on to later reproductive performance, which suggests a need for more investigations on effect of rations.

Season affected days from calving to first estrus in Trial II ($p < .10$). Higher temperature seems to increase days from calving to first estrus.

Season affected days from first breeding to pregnancy and days open ($p < .05$) for Sire 4/18. However, there were only 2 and 3 cows in summer and fall by sire 4/18, making it difficult to draw a conclusion.

Ration by season interaction affected days open in Trial II, services per pregnancy in pregnant cows in Trial I, and pregnancy rate in Trial II. High energy ration was good for reproductive performance in cold seasons, but was poor in hot seasons. Low energy rations were good for reproductive performances in hot season, but were poor in cold seasons. The standard ration was the best over all seasons.

Conclusions

Except for sire 3 from New Zealand, there was essentially no sire effect among North American sires. Reproductive performance of daughters was not related to PDM of sire.

Ration affected calving interval in the comparison of all four rations. This was with only five or fewer daughters of one sire per ration. Although this suggests a ration effect, more data is needed.

Season effect is also very questionable because of small numbers of daughters in some seasons.

There appears to be a ration by season interaction effect in days open, services per pregnancy and pregnancy rate. The high energy ration enhanced reproduction in cold season and low energy ration was more beneficial in cows calving in hot season.

There was no sire by ration interaction, indicating that among North American sires there is no detrimental effect of sire on reproductive performance of his daughters over the wide range of rations in this study.

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