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SEASON AND LACTATION NUMBER EFFECTS ON PRODUCTION AND REPRODUCTION OF DAIRY CATTLE IN ARIZONA

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SEASON AND LACTATION NUMBER EFFECTS ON PRODUCTION AND REPRODUCTION OF DAIRY CATTLE IN ARIZONA

by

Theodore John Halbach

A Thesis Submitted to the Faculty of the

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ABSTRACT

Records representing 19,266 Holstein cows from Arizona over a five-year period (1976-1981) were analyzed by least squares analysis of variance to determine effects of season and lactation number on production and reproduction.

All sources of variation were significant ($P<.05$) with the exception of the interaction between lactation number and season of calving for complete milk production (CMilk) ($P<.08$).

Milk production 305 days (M305) and CMilk were depressed for cows calving in summer and fall. First lactation cows were lowest in milk yield and maximum yield occurred in lactation four (CMilk) and five (M305).

Cows calving in spring and summer showed reduced reproductive performance as measured by calving interval (CFIN) and services per conception (SC). First lactation cows were poorest for both traits.

Previous days dry was negatively correlated to CMilk and M305 for spring calvings. Cows with higher M305 yield had reduced reproductive performance.

CHAPTER 1

INTRODUCTION

High ambient temperatures are known to adversely affect milk production and fertility in dairy cows. In Arizona, summers are characterized by intense heat and solar radiation extending from June through September. Economic loss associated with reduced fertility and milk production during the hot summer months was estimated at $13.5 million in 1984. Milk production is reduced and cows that do not become pregnant during the summer create a deficiency of early lactation cows in the herds during the following spring. To meet the consumers demand for a constant supply of fresh fluid milk, seasonal fluctuations of this nature pose a serious problem.

Reproductively, services per conception increases and the interval between calvings is lengthened, resulting in a number of cows maintained in the late-lactation stage of production longer than is economically desirable.

The objective of this investigation was to determine the effects of season and lactation number on production and reproduction of dairy cattle in Arizona, utilizing data from the Dairy Herd Improvement (DHI) program compiled over a five-year period (1976-1981).

CHAPTER 2

REVIEW OF LITERATURE

The Arizona Dairy Industry

Armstrong and Selley (1985) summarized some basic statistics for the Arizona dairy industry in 1984. Arizona had a total of 82,000 dairy cows in 155 dairy operations. These farms averaged over 500 cows per herd and grossed 175 million dollars. Eighty-five percent of the dairies are located within 50 miles of Phoenix in the Salt River Valley. Holsteins make up 90% of the state's dairy herd with 11% of that population being registered.

The most common facility arrangement is a herringbone parlor with a low-level milk line, bulk milk tank, jet cow washers in the holding pens, and milking machine detachers. Twenty-five percent of the cows are milked three times daily with the remaining milked twice daily. Corrals are constructed of steel cable and posts, with metal sun shades, perimeter feeding, and lock-in stanchions that hold groupings of 50 to 150 cows. Evaporatively-cooled shades and corral misters are used in about 20% of the operations. Approximately 59,000 cows were enrolled on official Dairy Herd Improvement Association

(DHIA) test. The twelve month rolling herd average of 7,331 kg of milk and 274 kg of fat ranks Arizona third nationally for production per cow.

General Parameters of Production and Reproduction for the Dairy Cow

Average milk production per cow in the United States has increased more over the past 30 years than in all previous years. McCullough (1984) reported production in 1952 for all cows was 2,087 kg of milk, and by 1982 that average was 4,627 kg. Wilcox et al. (1978) suggests that the increase in milk production was the result of combined genetic and management improvements.

Milk production is initiated by parturition and reaches a maximum in two to six weeks, after which it gradually declines (Bath et al., 1978). The normal lactation lasts 10 to 12 months, but lactation may continue much longer depending upon reproductive and environmental factors. During the early stages of lactation, the stimuli to secrete milk are able to overcome many environmental or management problems such as underfeeding or improper milking procedures. However, as lactation progresses, any adversity will reduce milk secretion to a greater extent than that observed in cows during early lactation. Lactation yields increase at a decreasing rate until about the 8th year of age, depending on the breed, then decrease at an increasing rate. The decrease after the 8th year is much less than the increase before this age. A mature cow (six plus years) will produce about 25% more milk than a first lactation heifer. Increased body weight accounts for about 5% of this increase, and the remaining 20% is credited to increased development of the udder during recurring pregnancies. Cows are usually milked two times daily but increasing milking frequency to three times daily has improved milk yield 3 to 39% (Waterman et al., 1983). Several factors other than environment and nutrition affect milk yield (Bath et al., 1978). Large cows tend to produce more milk than small cows. Cows with follicular cysts produce significantly more milk when adjusted for days not pregnant. Estrus has shown to temporarily depress milk yield. In addition, pregnancy decreases milk production especially during the later half of gestation (Smith and Legates, 1962).

Bath et al. (1978) reported that Holstein heifers are normally bred for the first time at a minimum of 750 pounds, or approximately fifteen months of age. In dairy heifers, average length of the estrous cycle is 20 $\pm$ 2 days, whereas in multiparous cows the cycle averages 21 $\pm$ 4 days. Gestation length varies by breed with Holsteins having a 279-day average gestation length. After calving, fertility is suboptimal until the uterus involutes. Uterine involution takes longer in multiparous cows and in cows that incurred complications during parturition. The length of time for the uterus to involute to its pre-breeding size can range from 12 to 56 days. Herds tend to have calving intervals that vary from 13 to 15 months, although 12 months is desirable. Conception must occur within 85 days postpartum in order to achieve a 12-month calving interval but the average cow does not have a breeding service before 90 days postpartum. Conception rates are lower for breedings before 60 days postpartum, with rates as low as 25% in cows bred 20 days postpartum, 50% between 40 and 60 days, and stabilizing at approximately 60% after 60 days. An average cow requires approximately two breedings or more per calf born. Kelly and Holman (1975) found that conception rates in South Carolina herds were less for artificial insemination services when compared to natural services (54.0 vs. 68.7% based upon 2,900 fertile service periods).

Olds et al. (1979) reported statistical trends in the relationship between milk yield and fertility indicating higher milk production was associated with lower conception rates. The partial regression coefficient for Holsteins was .014 and for Jerseys and Guernseys was .028 more services for each additional 100 kg of 120-day milk. Correlation coefficients between 305-day milk and calving interval were higher than those for 120-day milk. The researcher suggested that this should be expected since the effects of pregnancy on lactation generally would be well after 120-days of lactation. Fonseca et al. (1983) reported in a North Carolina study of 212 cows that a slight antagonism between milk yield and reproductive performance (days open) existed in Jerseys but not in Holsteins. Hillers et al. (1984) studied the effects of production, season, age of cow, days dry, and days in milk on conception to first service in large commercial dairy herds in Washington. Percentage conception to first service was not affected by milk production during current or previous lactations. However, cows with higher production during current or previous lactation had longer intervals to first service. Previous days dry did not significantly affect conception or interval to first service. Conception was lower for cows with less than 50 days to first service (32%) than for cows with over 50 days to first service (49 to 57%).

Days open had a significant effect on milk production from data obtained in Israeli-Friesian milk recorded herds (Bar-Anan and Soller, 1979). The researchers suggest that for maximum productivity first-lactation cows in high-yielding herds (7,159 kg average) should be mated not earlier than 70 days postpartum, while multiparous cows should be mated in the range 41 to 90 days postpartum. First lactation cows in moderately-yielding herds (5,883 kg average) could be mated at any reasonable interval postpartum in the range of the study (31 to 200 days) with little effect on productivity, while multiparous cows should be mated as early as possible.

Olds et al. (1979) observed that each day open between 40 and 140 days of lactation resulted in an average of 4.5 kg less annual milk during current lactations of first-lactation cows and 8.6 kg less for cows in later lactations.

Schaeffer and Henderson (1972), using New York dairy records, reported that within-herd heritability estimates of days open were essentially zero, and that as the open period increased, 305-day milk yields increased in a curvilinear fashion. For a 10 day increase in days open beyond 70 days, increases in production became smaller. Within herd heritability estimates of days dry were .15, .33, and .34 for second, third, and later lactations. Higher-producing cows were reported having shorter dry periods than low-producing cows. Dry periods of 50 to 59 days yielded the highest average production in the subsequent lactation. However, the averages for 40 to 49 and 60 to 69 days dry were not greatly different on a practical basis (supporting data not presented).

In researching herd size efficiency, Laben et al. (1982) studied records from 201 California dairy herds of sizes from under 100 to over 1000 cows that had herd average milk yields from under 5,000 to over 10,000 kg. Average days to first postpartum breeding tended to be less in herds of over 500 cows, and herds of 300 to 600 cows had the highest production per cow. Services per conception changed little as herd yield increased, but days open for highest-producing herds averaged one estrous period shorter than for low-producing herds, suggesting better detection of estrus.

In a study of 125 New York herds, herds of less than 50 cows were found to exceed herds of 90 cows or more by 4.7, 5.8, and 10.7 percentage units in conception rate for first, second, and third service, respectively (Spalding et al., 1975).

Age Effects

Milk and fat yields increase with age up to maturity, then decline (Wilcox et al., 1978). Peak production for milk occurs at a different age from the peak production for fat. The age of maturity or maximum performance for fat occurs from 1 to 17 months earlier than milk maturity, depending upon the breed. In Holsteins, for example, the two peak yields occur at about the same age, with the national averages for age of peak yield in Holsteins at 79 months for milk and 78 months for fat. Breed differences in rate of maturity appear to effect initiation of lactation as well. Breeds with peak production occurring at a young age also tend to be younger at first calving. The average age of Holsteins calving for the first lactation before 35 months is 27.5 months.

Bath et al. (1978) contend that fertility in dairy cows as measured by services per conception and calving interval increases up to four years of age, remains fairly constant to six years, then gradually decreases with age. Schaeffer and Henderson (1972) concluded that age influenced length of dry period but not days open.

In an intra-herd study of New Jersey Holsteins, Wilcox et al. (1958) estimated heritability of longevity at 37%. The Wilcox study concluded that selection for this characteristic is justified if these trends exist in the overall dairy cattle population.

Butcher and Freeman (1968), using data from California and Iowa (67,729 and 60,788 lactation records respectively), concluded that relationships between pairs of lactations were not constant from one lactation to the next. The relationship between consecutive lactations increased gradually as the animals aged, and the relationship between non-consecutive lactations decreased gradually as the lactations became more separated in time. This study also determined that estimates of heritability for milk and milk fat of first lactation were higher than estimates for second lactation, although this difference was not significant.

Iowa State researchers reviewed 252,470 lactation records and suggested that management appeared to be the greatest factor in regard to age distribution, life expectancy and culling practices (Andrus and Freeman, 1969). Cows kept for another lactation were superior to those culled, as compared to herdmates, for milk and milk fat production through the sixth lactation. The average useful herd life of all cows was 3.1 years.

In a study of Canadian dairy cow disposals, reproduction and low milk production were the major causes of voluntary herd removal (Burnside et al., 1971). Percentages culled annually for these problems ranged from 13.4 to 24.4% for reproductive factors and from 15.5 to 28.3% for milk yield.

Seasonal Effects

Seasonal depression in reproduction and productive performance is considered to be the most serious problem in the dairy industry in central Arizona (Stott et al., 1972).

In reviewing research conducted in the area of heat stress, Fuguay (1981) reported that controlled-environmental chambers have been used to establish upper-critical temperatures for a number of production traits. Temperatures range between 24 and 27C for most traits. Upper-critical temperatures will vary depending on several factors, including degree of acclimation, rate of production (growth or lactation), pregnancy status, air movement around the animals and relative humidity. In high-producing cows, feed intake and milk production are reduced to minimize body heat production when the upper-critical point is exceeded and the animal is in a stressed condition (Bath et al., 1978).

Curtis (1983) reported that animals lose heat to, and gain heat from, the environment via three modes of energy transfer--radiation, convection, and conduction. They lose heat by evaporation of water from respiratory-tract and skin surfaces. Some heat can be gained by the animal during condensation of water on hair.

Fuquay (1981) concluded that for high production, a high plane of nutrition is necessary. However, animals on a high plane of nutrition react more drastically to hot conditions than those on a low plane. His review of heat stress research confirms that declining feed intake has been identified as a major cause of reduced milk production in dairy cows. There is also a reduction in the efficiency of converting feed energy to production units during heat stress. He reported that milk energy decreased about twice as much as digestible energy intake.

Seasonal Effects on Production

The influence of zone-cooling (head and neck) during summer on milk yield, milk constituents, rectal temperature, and respiration rate was reported by Roussel and Beatty (1970) in a Louisiana study. Daily milk production of the zone-cooled cows averaged 19% above that of the control cows during the five week experimental period. Milk fat, total solids, solids-not-fat, and Wisconsin Mastitis Test were not altered by zone-cooling but the percentage of fat decreased. They suggested that zone-cooled cows were able to dissipate more body heat, since they had lower respiration rates and rectal temperatures.

Maust et al. (1972) in a Maryland study reported that during summer months for all stages of lactation, 9% of the variation in milk yield, 13% in milk fat, 5% in feed intake, and 65% in rectal temperature were attributable to weather conditions (temperature, humidity and wind velocity). Rectal temperature and energy intake had the highest correlations with weather on the same day, while conditions two to three days previous were most closely associated with milk yield and milk composition. The researchers concluded that changes in daily milk yield depended largely on the stage of lactation; mid-lactation cows (100 to 180 days) were most adversely affected; late (180 to 260 days) intermediate, and early (< than 100 days) least. A possible explanation for the reduced performance in mid and late lactation groups is that during thermal stress the later groups gave priority to increasing body tissue at the expense of milk production, which may occur regardless of thermal stress. Early stage cows consumed the least total feed energy, but were highest in daily milk production, indicating they utilized body reserves rapidly to offset the impact of summer heat stress. Subsequent total lactation yield of cows calving duirng the summer months were most severely affected.

Thatcher (1974) reported that environmental conditions associated with subtropical areas contribute to lower milk production. Air conditioning dairy cows between 15.4 and 21.0C for 24 hours per day resulted in 9.6% more of 4% fat-corrected milk compared to nonair-conditioned control cows. In another Florida study, Thatcher et al. (1974) concluded that full time air conditioning increased milk yield (7.5%), fat percentage (.065%), daily fat yield (.053 kg), and 4% fat-corrected milk (9.3%) when compared to cows subjected to the natural environment.

In reporting the effects of climate on performance of Holsteins in a Maryland herd during first lactation, McDowell et al. (1976) found the percentage of variation in milk yield accounted for by four climatic variables (temperature, dew point, temperature-humidity index, and wind velocity), plus feed and body weight ranged from 11 to 62%. The highest percent of variation was for cows calving in July and August and the least for those calving in spring and fall. Climatic conditions appeared to have the greatest influence in the first 60 days of lactation. During this period, temperatures above 27C restricted feed intake, causing a rapid utilization of body reserves and high losses in body weight. Conversely, this study showed cold temperatures stimulated feed intake, resulting in higher yields and gross efficiency. This did not hold true for temperatures above 27C. However, after the first 60 days of lactation, nutrition was the primary environmental variable limiting performance irrespective of climate. In a direct comparison, cows calving in January and February were higher in milk yield (17%), fat percent (7%), and gross efficiency (14%) than cows calving in July and August.

Ingraham et al. (1979) studied the seasonal effects of tropical climate on shaded and non-shaded cows. Milk production declined 0.32 kg per unit increase in temperature-humidity index (THI). Nonshaded cows had higher rectal temperatures, a trend for lower plasma corticoids, less milk and fat production, and higher California mastitis test scores. Shaded cows maintained a higher fat percentage at 74 THI or above. THI is a derived statistic computed from the formula, THI = db-[(.55-.55RH) (db-58)] where db is dry bulb temperature and RH is relative humidity.

Collier et al. (1982) in a Florida study evaluated the effects of heat stress during pregnancy on calf birth weight and postpartum maternal milk yield. Milk yield was correlated (.29) in a linear manner with calf birth weight, and nonshaded cows exhibited reduced lactation performance after calving. Heat stress altered plasma hormone concentrations (estrone-sulfate, total thyroxine, total triiodothyronine, and progestins) during pregnancy, reduced calf birth weight and may have indirectly altered subsequent milk yield.

Seasonal Effects on Reproduction

In a ten year study of seasonal fluctuations in reproductive efficiency of dairy cows for six North Carolina herds, Poston et al. (1960) reported that the percent of cows bred which returned for second service within 60-90 days gradually increased from a minimum of 38% in January to a maximum of 56% in August. In general, these cows were bred at first estrus subsequent to 70 days postpartum. The month of freshening had an effect on the ensuing calving interval. A maximum interval of 422 days was observed for cows freshening in May. Subsequently, there occurred a monthly decline to a minimum of 397 days for cows calving in October. They also reported that cows with longer intervals from calving to successful mating also tended to require more inseminations before being diagnosed pregnant. Number of services increased from a minimum of 1.7 for cows calving in December to 3.0 for cows calving in April.

Stott (1961) reported that fertility (percent of first-service nonreturns) in Holstein cows declined 12.4 percentage points from May (59.1%) to August (46.7%). Cows bred in Palo Alto, California and Columbus, Ohio during the same period with semen from the same bulls used in Arizona showed a high rate of fertility during the summer months compared to the lowered breeding efficiency within Arizona.

He also reported differences in seasonal fertility according to breed. Jerseys showed no depression during the summer months, whereas both Guernseys and Holsteins showed dramatic declines in fertility.

Gangwar et al. (1965) reported that under cool climatic conditions (16 to 18C), the average length of the estrous cycle was 20 to 21 days, as compared with 21 to 25 days under controlled, cycled hot, and natural summer climatic conditions (average maximum daily temperatures 24, 29, and 35C, respectively). Controlled and cycled climatic conditions simulated Louisiana summer climatic conditions. The differences in response under hot and cool climatic conditions was highly significant. When exposed to natural spring weather, cycled hot, air conditioning, and natural summer climatic conditions the average duration of estrus was 20, 11, 20, and 14 hours, respectively. Thus, hot climatic conditions significantly depressed the length of the estrous period. Anestrus was 33% among heifers during the cycled, hot period (in climatic chamber). The intensity of estrus and length of post-ovulation bleeding time were decreased under heat stress conditions.

Wiersma and Stott (1969) reported that thermal and other environmental stimuli referred to as stress are causes of increased adrenal secretion of steroid hormones. These hormones invoke leucocytosis in blood and in milk and also affect fertility. Services per conception for cooled cows (7) and control cows (20) during summer (June, July, and August) was 1.2 and 2.5 respectively. Whereas, in fall (September and October) the number of services per conception for cooled (N=11) and control cows (N=19) was 2.1 and 3.1 respectively. Higher services per conception for fall indicated high ambient temperatures for an extended time period had an adverse cumulative effect on reproductive performance.

Britt and Ulberg (1970) in a nine year study of seasonal changes for herds from North Carolina showed the average Herd Reproductive Status (HRS) was highest (77) in April and was lowest in August and September (65). Percent of the herd conceiving each month showed a similar seasonal fluctuation with a high of 11% in March and a low of 4% in August. HRS is a derived statistic computed from the formula, $HRS = 100 - [\frac{ADO \times PC}{TC} 1.75]$ where ADO is average days open for problem cows, PC is the number of problem cows, and TC is the number of total cows in the herd.

Schaeffer and Henderson (1972) reported that month of calving influenced days open and days dry. Open periods were longer by 10 days for cows that freshened during the summer months than those freshening in winter and spring.

Cows that freshened in the spring months of March, April, and May tended to have longer than average dry periods whereas summer fresheners had shorter than average dry periods. These data were in agreement with McDowell et al. (1976) that cows calving in January and February had a higher breeding efficiency (32 fewer days open) than cows calving in July and August. Vincent (1972) found that in warm, humid areas, cow fertility was lowest during late summer and fall. Heat stress resulted in delayed puberty, anestrus, depressed estrual activity, lower conception rates, abortions, and increased perinatal mortality. Cows were most susceptible to the depressing effects of heat stress on fertility near the time of breeding; a negative relationship existed between body temperature at breeding and subsequent conception rates. He also reported significant differences among breeds in their ability to adapt to heat stress and that the degree of acclimatization altered the length of estrus and blood progesterone content following heat stress.

Ingraham et al. (1974) evaluated conception rates of a Holstein dairy herd near Culiacan, Mexico. THI was used to measure the degree of stress two days prior to breeding, the day of breeding, and the day following breeding. The conception rate for 191 cows bred on days with THI<66 was

67% as compared to 21% for cows serviced at THI>76. Conception rates declined from 55 to 10% as the average index of the second day prior to breeding increased from 70 to 84. They also reported that between 68 and 82 THI the average conception was 42.3% if the average index of the two days prior to breeding was less than on the day of breeding. Conception rates averaged 10.4% lower (31.9%) if the index of the two days prior to breeding was higher than on the day of breeding, indicating that temperature-humidity of individual days prior to breeding influenced breeding efficiency.

A significant reduction in fertility occurred during the summer in heat-stressed Holstein-Friesian cows in Arizona (Monty and Wolff, 1974). The fertility rate decreased from a maximum in April and November of approximately 50% to less than 20% during the very hot summer months of July, August, and September, as determined by the number of live calves born per number of breedings per month. Average days open ranged from 63 to 140 days longer in cows exposed to hot weather. They also observed that estrus was significantly shortened.

Thatcher (1974) concluded that fertility in Florida dairy cows is inversely related to the maximum environmental temperature the day after insemination and to uterine temperature both at insemination (UT_0) and the day after insemination (UT_1). As maximum temperature increased from 21.1 to 35.0C, conception rates declined from 40 to 31%. Evaluation of the partial regression coefficients indicated that a deviation of .5C above the mean UT_0 and UT_1, resulted in decreased conception rates (12.8 and 6.9%, respectively).

Gwazdauskas et al. (1975) found conception rates in Florida were lower during hot months (June through October) than cool months (November through May) (33.7 vs. 40.1%). Conception rates declined with age: virgin heifers, 47.6%; cows in lactations one to four, 42.7%; cows in lactations five to nine, 31.9%.

Ingraham et al. (1976) studied the effect of climate on reproductive performance of Holstein cows in Hawaii. They concluded that conception rates were correlated negatively with the average THI of each day of the estrous cycle beginning 11 days prior to breeding. Slopes of regression lines differed, suggesting varying sensitivity of conception rate to heat stress on different days of the cycle. The THI of the second day prior to breeding was most closely correlated (-.978) with conception rate. Conception rates declined from 66 to 35% as the index increased from 68 to 78.

Ron et al. (1984) observed the largest differences in conception rate were between cows (40.4%) and virgin heifers (64.3%) and among insemination month for cows (23.5 to 51.5%) in Israeli dairy herds. They concluded the major increase of conception rate may be expected from reducing adverse effects of summer conditions on reproductive performance.

Badinga et al. (1985) found that conception rates of lactating cows decreased sharply when maximum air temperature on day after insemination exceeded 30C for a Florida herd. In contrast, conception rates for heifers did not decline until 35C. Virgin heifers had higher conception rates for all services (50%) than lactating cows (34%) and suffered only slight depression of fertility during summer months. The researchers reported heifers required 1.5 services per conception compared with 2.3 for lactating cows. Jerseys had higher conception rates (45%) than Holsteins (39%) and Brown Swiss (41%). Services per conception were 1.7, 2.0, and 1.9, respectively.

CHAPTER 3

MATERIALS AND METHODS

Source of Data

Magnetic tapes containing data for the state of Arizona were obtained from the Dairy Herd Improvement Program (DHI). This data contained information on 230,178 cows, collected between January 1976 and August 1981. Each record had the following information: state, county, herd, birthdate, registration or official ear tag number, cow identification, lactation number, calving date, previous days dry, lactation milk production for 305 days or less and complete lactation, lactation fat production for 305 days or less and complete lactation, breeding dates, services per conception, and the date the lactation was terminated. The records were in sequence according to date of lactation termination.

Raw Data Programming

The data file was reviewed using the SPSS Aggregate program (Nie et al., 1975). Herds outside Maricopa County (19,662 cows) were identified and eliminated to reduce the area effect in this study. Only Holstein cows were used in the study, so all other breeds of cattle were removed to onsure that breed effects were not a factor (Stott, 1961; Vincent, 1972; Badinga et al., 1985). This removed 38,643 cows from the data file. A program was then used that eliminated the duplicate records contained in the data. Using herd, cow identification, calving date, birth date, and year the record was terminated, these records were removed. A total of 1,099 records were found to be duplicates. Also, all lactation numbers identified by 0 were excluded, with 479 records deleted for that reason. A total of 170,295 records remained in the data file.

Calving interval and gestation length were then calculated. SPSS Aggregate (Nie et al., 1975) was utilized on a herd basis to determine herd size and to evaluate the breeding information. Herds with less than 100 records represented and those that had not turned in the optional breeding data information were removed from the analyses. For the breeding information, the mean for services per conception (SC) of each herd was evaluated along with percentages of each herd that had SC<2, >2, and 2. Using these results, it was determined that any herds with SC<1.75 had questionable data. Through a review of the data and correspondence with herd owners, reporting procedures for questionable herds were determined, and herds for which complete breeding information had not been recorded were removed from the study.

A new working file containing 69,437 records from 35 herds was created. Calving month was recoded calving season, and sixth or greater lactation numbers were consolidated into the sixth lactation group. The new file contained: cow identification, herd, lactation number, calving season, calving interval, gestation length, days open, services per conception, previous days dry, and lactation milk production for 305 days or less and complete lactation. Records for 46,160 cows were edited where calving interval and gestation length could not be calculated. This eliminated cows with only one record, and the last record for cows with more than one lactation. Also, only calving intervals between 300 and 600 days, and gestation lengths between 265 and 295 days were included in the final data set. Fifty-four records were removed because of calving interval values outside this range, and 3,957 records were edited out for gestation length. A total of 19,266 records remained in the data file for analysis.

Traits

The dependent variables studied are defined as follows:

Production Traits.

Milk Production 305 days: (M305)	measured in kg by the cumulative monthly DHI test milk weights for 305 days or less.
Complete Milk Production: (CMilk)	measured in kg by the cumulative monthly DHI test milk weights for all days of lactation.

Reproductive Traits.

Calving Interval: (CFIN)	the time period from one parturition to the next.
Services Per Conception: (SC)	the number of breeding services to achieve conception.

Models and Analyses

The independent variables used in the models included lactation number, calving season, herd, and the interaction between lactation number and calving season. For the production models, milk production traits (M305 and CMilk) were regressed on days dry. For the reproductive models CFIN and SC were regressed on M305. Partial regressions were calculated on data within each season.

Climatic data were obtained from reports prepared at Phoenix Sky Harbor International Airport (Maricopa County). Average maximum, minimum, and daily temperatures on a monthly basis and average relative humidity were calculated (Table 1). Four calving seasons were established based on this information.

Winter (1)	December, January, February
Spring (2)	March, April, May
Summer (3)	June, July, August
Fall (4)	September, October, November

Lactation number was listed numerically one through six, with the sixth lactation representing six or more lactations Lactation numbers was used as the standard measure of age in this study as the potential existed for the dairymen to assume a birthdate for grade cows enrolled for first lactation increasing the error for this factor.

The least-squares analysis of variance with unequal subclass numbers described by Harvey (1975) was used to analyze the data. The following models were used:

For M305 and CMilk:

$$Y_{ijkl} = \mu + H_i + L_j + C_k + (LC)_{jk} + b_1 Z_{ijkl} + b_2 S_{2k} Z_{ijkl} + b_3 S_{3k} Z_{ijkl} + b_4 S_{4k} Z_{ijkl} + e_{ijkl}$$

where

Y_{ijkl} = the dependent variable for the l^{th} cow in the k^{th} season of calving in the j^{th} lactation in i^{th} herd,

μ = the least-square mean,

H_i = the effect of i^{th} herd ($i = 1,2,3,\ldots, 35$),

L_j = the effect of j^{th} lactation number ($j = 1.2.3....6$),

C_k = the effect of k^{th} season of calving ($k = 1,2,3,4$),

$(LC)_{jk}$ = the effect of j^{th} lactation number by the k^{th} season ($j = 1,2,3,\ldots,6$) ($k = 1,2,3,4$),

b_m = regression coefficient ($m = 1,2,3,4$),

$Z_{ijkl} = (D_{ijkl} - \bar{D})$ where D_{ijkl} is the number of previous days dry and $\bar{D}$ is the overall arithmetic mean for the D_{ijkl}'.

S_{pk} = indicator variable (coded 1 if $p = k$ and 0 otherwise) for the season of calving ($p = 2,3,4$) ($k = 1,2,3,4$), and

e_{ijkl} = the error term.

For CFIN and NBRC:

The variables included in the reproduction model were the same as those used for production except for Z_{ijkl}.

$Z_{ijkl} = (M_{ijkl} - \overline{M})$ where M_{ijkl} is kg of M305 and $\overline{M}$ is the overall arithmetic mean of the M_{ijkl}.

Duncan's Multiple Range Test (DMRT) was used to test differences between means. In addition, T-tests for the homogeneity of the regression coefficients of spring vs summer and spring vs fall were performed (Steel and Torrie, 1980).

CHAPTER 4

RESULTS AND DISCUSSION

The meterological data in Table 1 showed summer and early fall (September) had the highest daily average maximum temperatures (>37.3C) and monthly averages (>30.5C) for the duration of this study (January 1976 through August 1981). In contrast, the lowest daily average maximum temperatures (<22.3C) and monthly averages (<.15.5C) were recorded during winter months. Relative humidity was lowest at 17.4% in June and increased to 33.4% in September. Winter months were highest in relative humidity (between 41.8 and 55.1%). During this study period, temperatures were slightly warmer than the long term averages. These data indicate that heat stress occurred during those months that upper-critical temperatures were exceeded (Fuquay, 1981).

Mean squares and degrees of freedom from the analyses of variance are presented in Table 2. All sources of variation were significant ($P<.01$) with the exception of the interaction between lactation number and season of calving for M305 ($P<.05$) and CMilk ($P<.08$). The residual correlation between CFIN and SC was 0.71 and between M305 and CMilk was 0.91.

Table 1. Meterological data for Phoenix, Arizona (Sky Harbor International Airport).

	Daily Average Temperature °C			
	Maximum	Minimum	Monthly	Daily Relative Humidity, Pct.
	Averages for January 1976 through August 1981			
January	18.9	7.0	13.0	55.1
February	22.3	8.6	15.5	46.2
March	23.5	10.0	16.7	41.0
April	29.7	13.9	21.8	28.2
May	33.2	18.2	25.7	24.9
June	40.5	24.3	32.4	17.4
July	41.3	28.0	34.6	30.3
August	40.1	26.9	33.5	32.1
September	37.3	23.7	30.5	33.4
October	32.1	17.7	24.9	34.2
November	24.4	9.8	17.1	38.7
December	20.9	6.8	13.8	41.8
	Long term averages (1941-1971) recording period			
January	18.2	3.1	10.7	50.5
February	20.7	4.9	12.8	43.3
March	23.6	7.1	15.4	40.0
April	28.7	11.0	19.8	28.0
May	33.9	15.3	24.6	22.5
June	38.6	19.8	29.2	20.8
July	40.5	25.3	32.9	31.5
August	39.0	24.5	31.7	35.8
September	36.9	20.6	28.8	35.8
October	30.9	13.8	22.4	36.3
November	23.7	7.1	15.5	42.8
December	19.1	3.6	11.4	50.3

Table 2. Mean squares for milk 305, complete milk, calving interval, and services per conception.

Independent Variable	Degrees of Freedom	Milk 305	Complete Milk	Calving Interval	Services Per Conception
Herd	34	7635771**	9798795**	67761**	60**
Lactation Number (L)	5	16673978**	15256681**	146132**	51**
Calving Season (C)	3	3469672**	3182328**	250437**	153**
L X C	15	133625*	184866†	9436**	5**
Regressions:					
Overall[a]	1	1281016**	1172625**	4275101**	1755**
Within Season[b]	3	543337**	1086829**	54415**	44**
Error	19204	72378	120541	2500	1

†(P<.08; *(P<.05); **(P<.01)

[a] overall regression with milk production regressed on days dry and reproductive traits regressed on Milk 305.

[b] partial regression with milk production for each season regressed on days dry and reproductive traits for each season regressed on Milk 305.

Milk Production

Milk 305--Main Effects

Cows in lactation one had the lowest average production (Table 3). Lactation two averages were also lower than the remaining lactation groups. The rate of production increase diminished with the onset of third lactation (Figure 1). Peak yield occurs at fifth and sixth lactation. These data are in agreement with Bath et al. (1978) and Wilcox et al. (1978), showing that milk production significantly increases at a decreasing rate with lactation number.

Cows calving in the summer months were lowest in M305, when maximum ambient temperatures above 40C are prevalent in Arizona (Table 1). These data are in agreement with McDowell et al. (1969) who reported environmental conditions the first 60 days of lactation had the greatest influence on lactation yield. Cows with spring and winter freshening dates were highest in M305 while cows calving in fall were intermediate. These data indicated a carry-over of heat stress effects into the fall months as suggested by Wiersma and Stott (1969).

Milk 305--Interaction Effect Between Lactation Number and Season

For lactation one cows, the highest production occurred in winter and fall (6,783 and 6,721

Table 3. Least squares means and standard errors for complete milk and milk 305 (kg)--main effects.

Lactation Number	Sample Size	Milk 305	Complete Milk
1	7,073	6,657 ± 193[e]	7,114 ± 219[d]
2	4,331	7,355 ± 193[d]	7,667 ± 218[c]
3	3,236	7,769 ± 193[c]	8,066 ± 219[b]
4	2,044	7,894 ± 194[b]	8,246 ± 220[a]
5	1,218	7,989 ± 196[a]	8,355 ± 223[a]
6	1,364	7,914 ± 195[a,b]	8,352 ± 222[a]
ALL	19,266	7,596 ± 192	7,967 ± 217

Calving Season	Sample Size	Milk 305	Complete Milk
Winter (1)	5,270	7,765 ± 193[a]	8,023 ± 219[b]
Spring (2)	3,713	7,690 ± 195[b]	8,215 ± 221[a]
Summer (3)	4,856	7,387 ± 193[d]	7,813 ± 219[c]
Fall (4)	5,427	7,543 ± 193[c]	7,815 ± 219[c]

a, b, c, d, e. Means with different superscripts for each main effect are significantly different ($P<.05$) by Duncan's Multiple Range Test.

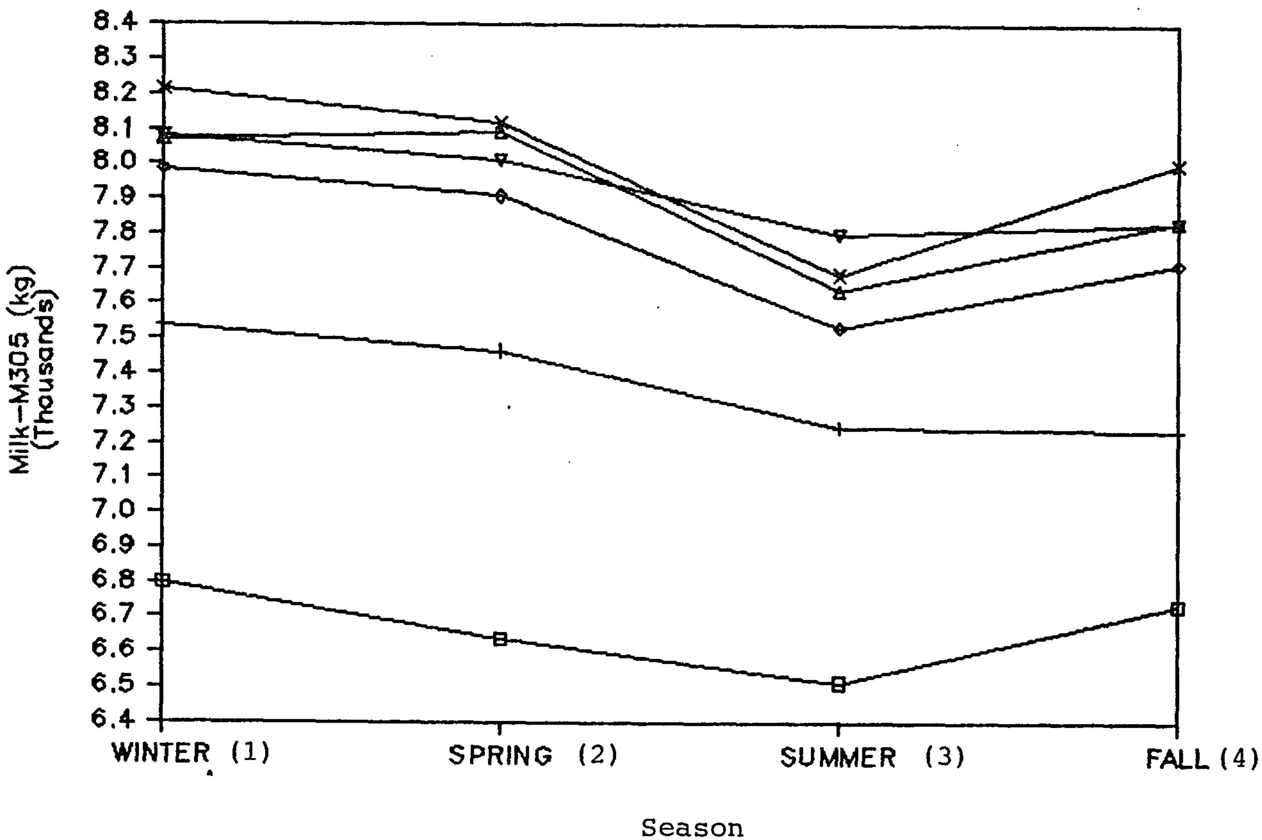

Figure 1. Milk 305 by calving season.

Lactation 1 □ Lactation 4 △
Lactation 2 + Lactation 5 ✕
Lactation 3 ◇ Lactation 6 ▽

respectively), and the lowest in summer (6,499) (Table 4). Lactation one cows calving in spring (6,625) were significantly lower yielding than winter freshenings (6,783). All other lactation groups showed a stable production level between winter and spring. It appears that during heat stress, lactation one cows gave priority to growth and body maintenance at the expense of milk yield. This group was apparently more sensitive to heat stress in the early stages of lactation (cows that calve in spring and summer) when production and energy requirements are highest.

For the second lactation, winter and spring freshenings (7,525 and 7,450 respectively) resulted in higher production than those in summer and fall (7,230 and 7,218 respectively). Cows calving during summer (7,230) had significantly less production than those freshening in the spring (7,450). However, a subsequent fall calving increase did not occur (7,218) (Table 4).

Lactations three through five showed stable production levels for winter and spring calvings. There was decreased production for summer freshenings followed by a fall calving increase.

For lactation six, summer freshenings (7,781) were not significantly different from those in spring (7,996) or fall (7,816) giving this group the least statistical

Table 4. Least squares means and standard errors for milk 305 (kg)--interaction effect.

Lactation Number	Calving Season	1 (Winter)	2 (Spring)	3 (Summer)	4 (Fall)
1		6,783 ± 197$^{a/D}$	6,625 ± 198$^{b/C}$	6,499 ± 196$^{c/D}$	6,721 ± 197$^{a/D}$
	n	1,760	1,915	1,636	1,762
2		7,525 ± 195$^{a/C}$	7,450 ± 197$^{a/B}$	7,230 ± 195$^{b/C}$	7,218 ± 195$^{b/C}$
	n	1,130	806	1,249	1,146
3		7,969 ± 197$^{a/B}$	7,893 ± 202$^{a/A}$	7,517 ± 197$^{c/B}$	7,698 ± 197$^{b/B}$
	n	922	462	861	991
4		8,054 ± 198$^{a/B}$	6,715 ± 209$^{a/A}$	7,624 ± 200$^{c/AB}$	7,821 ± 199$^{b/AB}$
	n	672	248	486	638
5		8,198 ± 203$^{a/A}$	8,103 ± 223$^{ab/A}$	7,668 ± 205$^{c/AB}$	7,985 ± 202$^{b/A}$
	n	373	127	301	417
6		8,064 ± 202$^{a/AB}$	7,996 ± 219$^{ab/A}$	7,781 ± 205$^{b/A}$	7,816 ± 200$^{b/AB}$
	n	413	155	323	473

a,b,c,d. Different superscripts indicate means within the rows that are significantly different ($P < .05$) according to Duncan's Multiple Range Test.

A,B,C,D. Different superscripts indicate means within the columns that are significantly different ($P < .05$) according to Duncan's Multiple Range Test. n=sample size.

variation (Table 4). Lactation six cows were highly selected, having endured intense production culling practices over five or more lactations. One possible reason for this longevity was that they were able to adapt to hot summer climatic conditions, allowing them to continue as viable production units. Though lactation four and five cows freshening in summer changed rank with lactation six, the results were not statistically significant (Table 4, Figure 1).

Complete Milk--Main Effects

CMilk production and M305 were similar (Table 3), having the lowest production levels for lactation one cows and reduced yields in the summer months. CMilk, however, had highest yields in lactations four through six while M305 had highest yields in lactation five and six only. CMilk was highest for cows freshening in spring and did not show the same fall calving production increase as M305, indicating that for fall freshenings, lactating past 305 days increased the effects of heat stress during later lactation. Maust et al. (1972) suggested body tissue is increased at the expense of milk production in late lactation, which may transpire regardless of thermal stress.

Reproduction

In discussing the reproductive data, the delay from a cow's freshening date to the first breeding date (approximately 40-60 days), must be considered in order to evaluate the results for seasonal groupings. With categories assigned by month of calving, it is not possible to precisely determine the occurrences of attempted rebreeding. For example, cows freshening early in a calving season may have a breeding service in that period, but parturitions later in a season would be bred in the following period.

Calving Interval--Main Effects

Lactations two through five had a shorter CFIN than lactations one and six. Lactation one cows had the longest CFIN (Table 5, Figure 2). These data agree with Bath et al. (1978) that fertility in dairy cows increases to four years of age, remains fairly constant to six years, then gradually decreases with age. Gwazdauskas et al. (1975) in a Florida study was in disagreement with these findings, reporting that fertility, as measured by conception rate, declined with age: virgin heifers, 47.6%; cows in lactations one to four, 42.7%; cows in lactations five to nine, 31.9%. However, it can be speculated that several factors unique to the Arizona dairy industry may have influenced the fertility results. According to D.

Table 5. Least squares means and standard errors for calving interval and services per conception--main effects.

Lactation Number	Sample Size	Calving Interval	Services Per Conception
1	7,073	388.9 ± 3.5^{a}	$2.28 \pm .11^{a}$
2	4,331	377.0 ± 3.6^{c}	$2.06 \pm .11^{c}$
3	3,236	371.4 ± 3.6^{d}	$1.97 \pm .11^{d}$
4	2,044	374.3 ± 3.7^{c}	$1.99 \pm .11^{cd}$
5	1,218	375.7 ± 3.8^{c}	$2.02 \pm .11^{cd}$
6	1,364	382.5 ± 3.8^{b}	$2.19 \pm .11^{b}$
ALL	19,266	378.3 ± 3.5	$2.08 \pm .10$

Calving Season	Sample Size	Calving Interval	Services Per Conception
Winter (1)	5,270	369.0 ± 3.6^{c}	$1.90 \pm .11^{c}$
Spring (2)	3,713	385.6 ± 3.7^{a}	$2.23 \pm .11^{b}$
Summer (3)	4,856	386.8 ± 3.6^{a}	$2.32 \pm .11^{a}$
Fall (4)	5,427	371.8 ± 3.6^{b}	$1.89 \pm .11^{c}$

[a,b,c,d]Means with different superscripts for each main effect are significantly different ($P<.05$) by Duncan's Multiple Range Test.

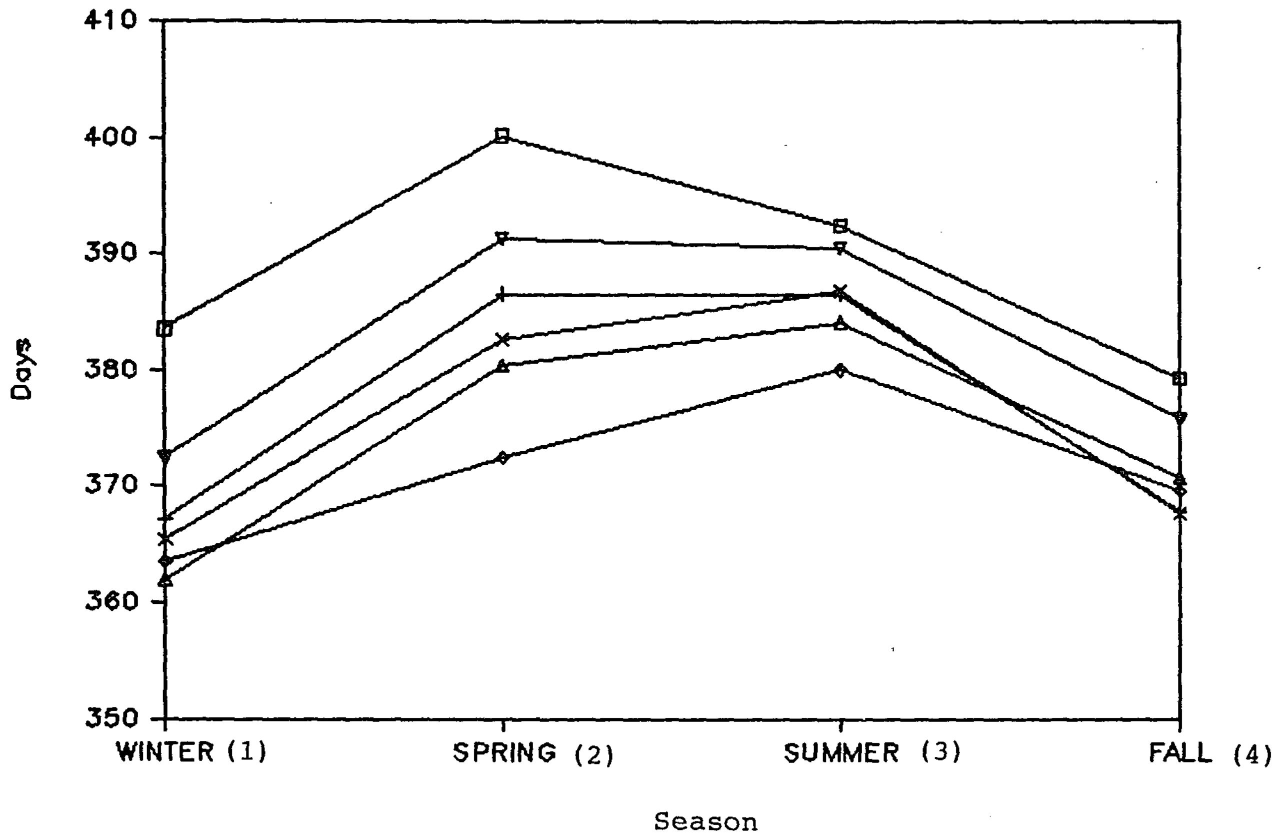

Figure 2. Calving interval days by calving season.

Lactation 1 □ Lactation 4 △
Lactation 2 + Lactation 5 ×
Lactation 3 ◇ Lactation 6 ▽

Armstrong (unpublished data), approximately 40% of the replacement heifers entering Arizona herds are raised out-of-state with a majority of those coming from locations with cooler climatic conditions (Idaho, New York, Pennsylvania, Utah, Wisconsin). Of those raised in-state, 30% are reared in close proximity to the herd of destination and 30% are raised and enter production at one location. A large proportion of the out-of-state replacements arrive in Arizona just prior to parturition suggesting relocation stress (acclimatization) may affect reproductive performance. Other factors that may influence first lactation fertility in dairy cows subjected to intensive herd management as practiced in Arizona are social hierarchy, body condition score, and herd size (J. L. Albright, personal communication).

Lactation six had the next longest CFIN. Fonseca et al. (1983) theorized that older cows may be more susceptible to possible effects of higher milk yield on involution of the cervix and uterus in addition to delaying first postpartum ovulation. Recovery from clinical abnormalities may require more time for older cows due to slower healing processes.

Generally, CFIN was highest for cows freshening in spring and summer with decreases for those in fall and winter, in agreement with Monty and Wolff (1974) and

Poston et al. (1960). Fall calvings were slightly higher than winter freshenings for CFIN showing a decrease in breeding efficiency caused by the thermal stress of early fall.

Calving Interval--Interaction Effect Between Lactation Number and Season

Lactation two, four, five, and six cows calving in spring and summer were not statistically different, whereas lactation one cows calving in spring had a significantly longer CFIN (400.2) than those calving in summer (392.5). Conversely, lactation three spring freshenings had a significantly shorter CFIN (372.5) than summer calvings (380.1) (Table 6). Cows calving in spring (range of 27.7 days) had the greatest seasonal variation among lactation groups. The differences were much less in summer and fall (12.4 and 11.7 respectively) with an intermediate value of 21.7 in winter (Figure 2). These data indicate that lactation one cows freshening in spring were more sensitive than other lactation groups to the thermal stress of early summer.

Rank changes occurred for CFIN that were not significant. Lactation two and five cows that freshened in summer (386.5 and 386.9 respectively) and fall (367.8 and 367.7 respectively) were not statistically different (Table 6). They decrease in fall, changing rank with

Table 6. Least squares means and standard errors for calving interval-interaction effect.

Lactation Number	Calving Season	1 (Winter)	2 (Spring)	3 (Summer)	4 (Fall)
1		$383.6 \pm 3.7^{c/A}$	$400.2 \pm 3.7^{a/A}$	$392.5 \pm 3.7^{b/A}$	$379.4 \pm 3.7^{d/A}$
n		1760	1915	1636	1763
2		$367.2 \pm 3.8^{b/BC}$	$386.6 + 3.9^{a/B}$	$386.5 \pm 3.8^{a/BC}$	$367.8 \pm 3.8^{b/C}$
n		1130	806	1249	1146
3		$363.6 \pm 3.9^{c/CD}$	$372.5 \pm 4.2^{b/C}$	$380.1 \pm 3.9^{a/C}$	$369.6 \pm 3.8^{b/C}$
n		922	462	861	991
4		$361.9 \pm 4.0^{c/D}$	$380.5 \pm 4.7^{a/BC}$	$384.2 \pm 4.2^{a/BC}$	$370.7 \pm 4.0^{b/BC}$
n		672	248	486	638
5		$365.4 \pm 4.4^{b/BCD}$	$382.7 \pm 5.7^{a/BC}$	$386.9 \pm 4.5^{a/ABC}$	$367.7 \pm 4.3^{b/C}$
n		373	127	301	417
6		$372.4 \pm 4.3^{c/B}$	$391.3 \pm 5.3^{a/B}$	$390.6 \pm 4.5^{a/AB}$	$375.8 \pm 4.2^{b/AB}$
n		413	155	323	473

a,b,c,d. Different superscripts indicate means within the rows that are significantly different ($P<.05$) according to Duncan's Multiple Range Test.

A,B,C,D. Different superscripts indicate means within the columns that are significantly different ($P<.05$) according to Duncan's Multiple Range Test.

n=sample size.

lactation three and four (Figure 2). However, lactations two through five form a group of means which are not significantly different.

Services Per Conception--Main Effects

Lactation one had the highest SC possibly explained by that group giving priority to growth and body maintenance needs in addition to the factors presented in the discussion of first lactation CFIN results (Table 5, Figure 3).

The fewest SC occurred for cows calving in fall and winter. SC for spring and summer freshenings were higher with the most in summer. These results agree with other reports that high ambient temperatures similar to those occurring in Arizona during summer reduce conception rates (Monty & Wolff, 1974; Poston et al., 1960; Stott, 1961; Vincent, 1972; Gwazdauskas et al., 1975). For example, Monty and Wolff (1974) in a comparative analysis between cows which calved and conceived during cool weather (N=14) and those which calved and were bred during hot weather (N=10) in Arizona found that the cool group averaged 1.1 SC, whereas the hot weather group averaged 3.3 SC.

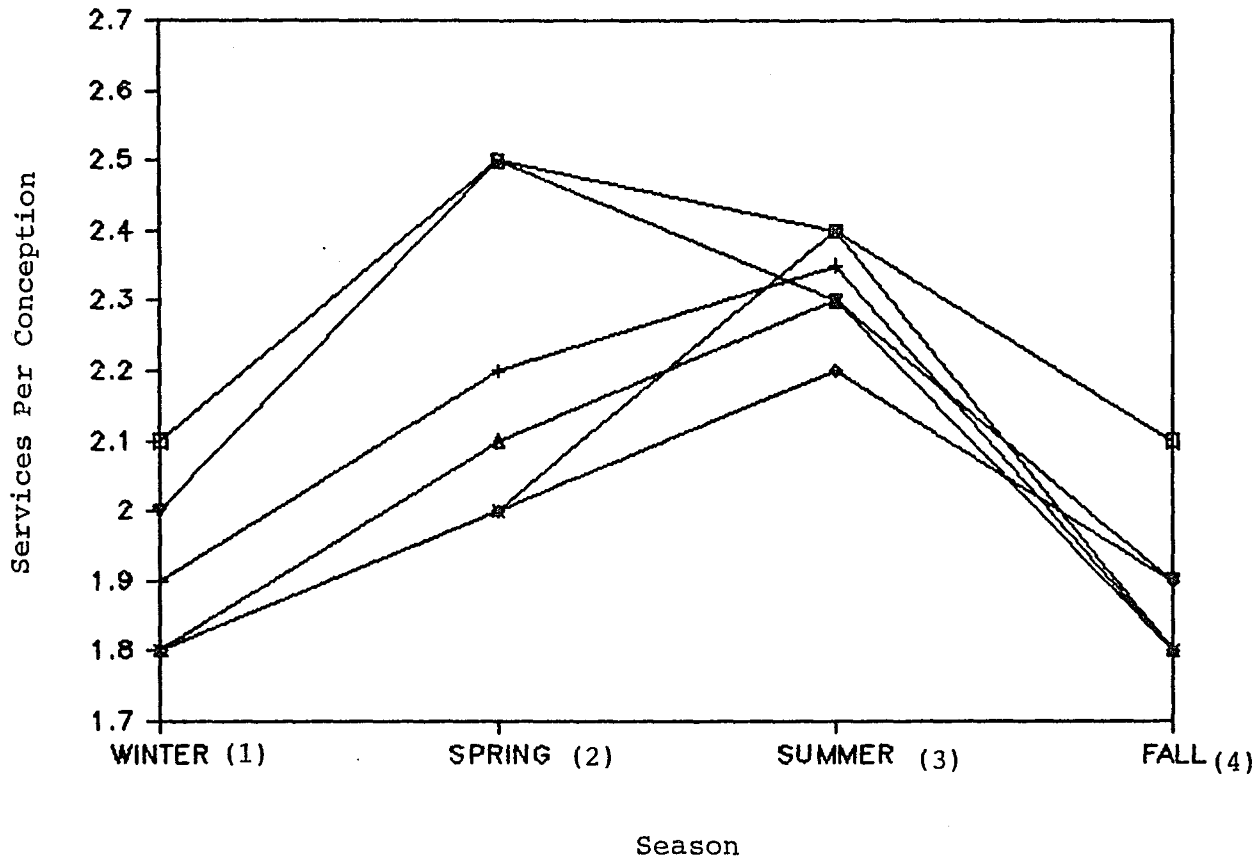

Figure 3. Services per conception by calving season.

Lactation 1 □ Lactation 4 △
Lactation 2 + Lactation 5 ×
Lactation 3 ◇ Lactation 6 ▽

Services Per Conception--Interaction Effect Between Lactation Number and Season

Lactations two through five cows calving in summer months had highest SC, whereas lactation one and six cows peaked in spring (2.53 and 2.52, respectively). Lactation one showed a significant drop for cows that freshen in summer (2.41) while lactation six cows calving in summer (2.31) were lower but not significantly different than spring. These results are consistent with those found for CFIN. Most groups recorded fewer SC for cows freshening in fall rather than spring. However, lactation three had SC for these months (1.90 and 1.99 respectively) that were not significantly different, implying lesser seasonal effect on this group. Also contrary to the norm, lactation five had SC for winter and spring freshenings (1.86 and 2.04 respectively) were not statistically different. This finding may result from the smaller sample size (Table 7).

For SC, the greatest seasonal variability among lactation groups was shown in spring (range of .54 breedings). SC for winter, summer and fall calvings were less variable (.36, .23, and .29 respectively). The large spring variability resulted from reduced performance by lactation one and six indicating they had a higher sensitivity to the heat stress of early summer.

Table 7. Least squares means and standard errors for services per conception--interaction effect.

Lactation Number	Calving Season	1 (Winter)	2 (Spring)	3 (Summer)	4 (Fall)
1		$2.13 \pm .11^{c/A}$	$2.53 \pm .11^{a/A}$	$2.41 \pm .11^{b/A}$	$2.06 \pm .11^{c/A}$
	n	1760	1915	1636	1763
2		$1.86 \pm .11^{c/BC}$	$2.20 \pm .11^{b/B}$	$2.35 \pm .11^{a/A}$	$1.83 \pm .11^{c/B}$
	n	1130	806	1249	1146
3		$1.80 \pm .11^{c/C}$	$1.99 \pm .12^{b/C}$	$2.18 \pm .11^{a/B}$	$1.90 \pm .11^{bc/B}$
	n	922	462	861	991
4		$1.77 \pm .12^{c/C}$	$2.07 \pm .13^{b/BC}$	$2.28 \pm .12^{a/AB}$	$1.84 \pm .12^{c/B}$
	n	672	248	486	638
5		$1.86 \pm .12^{bc/BC}$	$2.04 \pm .15^{b/BC}$	$2.39 \pm .13^{a/A}$	$1.77 \pm .12^{c/B}$
	n	373	127	301	417
6		$1.99 \pm .12^{b/B}$	$2.52 \pm .15^{a/A}$	$2.31 \pm .13^{a/AB}$	$1.94 \pm .12^{b/AB}$
	n	413	155	323	473

^{a,b,c,d}Different superscripts indicate means within the rows that are significantly different ($P<.05$) according to Duncan's Multiple Range Test.
^{A,B,C,D}Different superscripts indicate means within the columns that are significantly different ($P<.05$) according to Duncan's Multiple Range Test. n=sample size

Across seasons, SC for lactation five and six show the greatest range (.62 and .58 respectively). The changes in rank for these groups in summer and fall were not statistically significant.

Regressions

CMilk and M305 were regressed on days dry (DDry). The overall least squares mean for DDry was 42 with the fewest DDry reported in spring (39.5) and the most in fall (44.3) (Table 8). It should be noted that the potential existed for inaccurately reported dry up dates that could consequently shorten DDry averages. Some cows may be dry a greater part of the test period than the date submitted extending days in milk. Individual and herd production averages may be enhanced in this manner. The regression coefficients for CMilk and M305 showed a similar pattern of increases and decreases. Across seasons, coefficients were positive except for spring calving when values were negative (-0.64 and -2.18 respectively). Maximum production gain per DDry occurs in fall freshenings for both variables (4.0 and 5.53 respectively). Cows calving in fall would incur the least stress during lactation as their dry days correspond to late summer when ambient temperatures are highest. Production increases for summer and winter calvings also occur (Figure 4). For M305 and CMilk, the decreased production per additional DDry for

Table 8. Regression of productive and reproductive traits on independent variables.

Dependent Variable	Independent Variable	Least Square Mean	Regression Coefficient	Standard Error of the Regression Coefficient
Productive Change Per Day Dry				
Milk 305	Days Dry, Overall	42.0	1.81	.41
	Days Dry, Winter (1)	41.5	2.09	.86
	Days Dry, Spring (2)	39.5	-0.64	1.00
	Days Dry, Summer (3)	41.9	0.86	.73
	Days Dry, Fall (4)	44.3	4.90	.82
Complete Milk	Days Dry, Overall	42.0	1.72	.54
	Days Dry, Winter (1)	41.5	3.31	1.13
	Days Dry, Spring (2)	39.5	-2.18	1.32
	Days Dry, Summer (3)	41.9	0.03	.91
	Days Dry, Fall (4)	44.3	5.53	1.04

Table 8--Continued

Dependent Variable	Independent Variable	Least Square Mean	Regression Coefficient	Standard Error of the Regression Coefficient
Reproductive	Change Per 1,000 kg Milk 305			
Calving Interval	Milk 305, Overall	7,305	12	.3
	Milk 305, Winter (1)	7,348	12	.5
	Milk 305, Spring (2)	7,262	17	.7
	Milk 305, Summer (3)	7,252	12	.6
	Milk 305, Fall (4)	7,341	10	.5
Services Per Conception	Milk 305, Overall	7,305	.25	.01
	Milk 305, Winter (1)	7,348	.19	.01
	Milk 305, Spring (2)	7,262	.36	.02
	Milk 305, Summer (3)	7,252	.27	.01
	Milk 305, Fall (4)	7,341	.19	.01

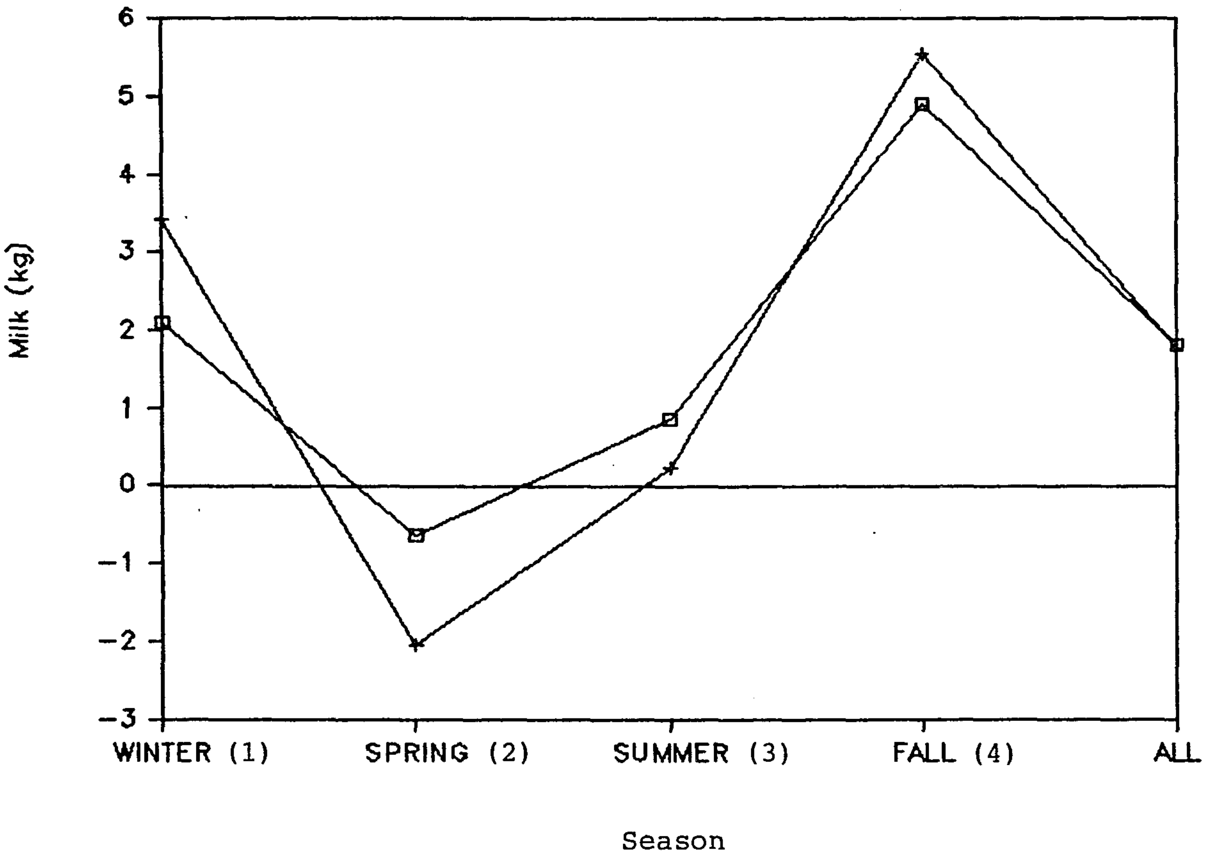

Figure 4. Regression coefficients of milk 305 and complete milk on days dry.

Milk 305 □

Complete Milk +

spring is statistically different ($P<.01$) from the increased milk production per DDry for summer and fall. However, these results do not appear significant on a practical basis. Arizona dairymen normally dry their cattle when production drops below approximately 9-11 kg of milk per day. A large percent of cows turned dry are producing above this level but are given a recommended (40-70 days) dry period prior to parturition. Based on these regression coefficients, production gains or losses per additional days dry are not great enough to justify a change in current dry cow management procedures. For example, the maximum CMilk yield for each additional day dry occurs in the fall (5.5 kg). Since this value is less than most dairymen's drying up level, the additional dry day is not justified by any subsequent increase in milk yield.

Reproductive parameters were regressed on M305 production. The highest values per 1000 kg change in M305 for CFIN and SC occurs for cows that freshen during spring (17 and .36 respectively) (Table 8). The lowest occurred in fall calving (10 and .19 respectively). Both CFIN and SC show similar patterns of seasonal increases and decreases (Figure 5). These data agree with Olds et al. (1979) that higher milk production is associated with lower reproductive performance. The Kentucky researcher

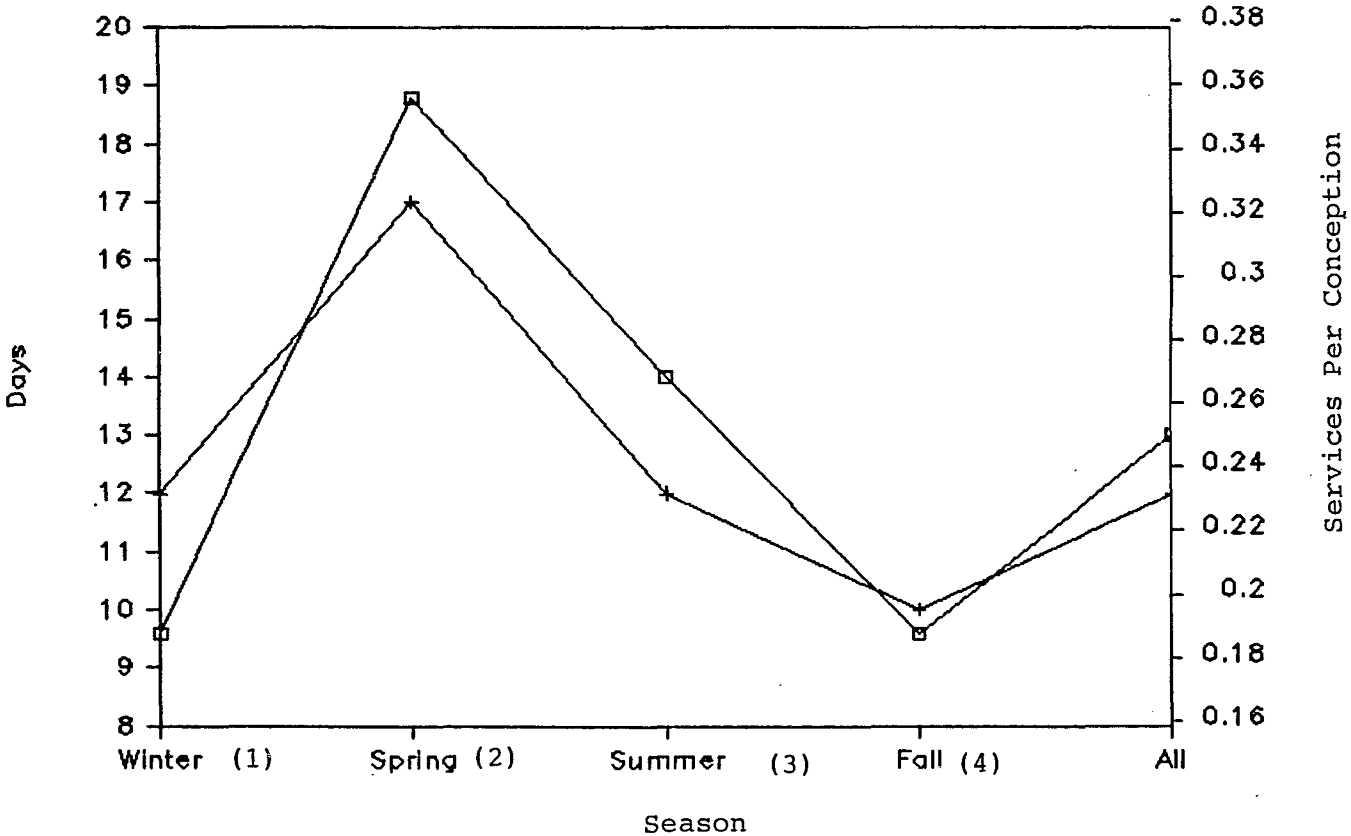

Figure 5. Regression coefficients of calving interval and services per conception on milk 305.

Services Per Conception □

Calving Interval +

found 7% of the variation in days open (DO) was determined by variation in 120-day milk yield, and 11% of the variation in M305 was determined by variation in DO. The regression coefficient indicated that each additional DO resulted in 4.5 kg more M305.

For CFIN and SC the spring increase per 1000 kg change in M305 was not significantly different from the fall or summer increase. These results imply a fairly stable increase in the reproductive variables per 1000 kg change in M305.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Records representing 19,266 Holstein cows from 35 Arizona herds over a five-year period (1976-1981) were analyzed by least squares analysis of variance to determine effects of season and lactation number on production and reproduction.

Production traits (M305 and CMilk) were depressed for cows calving in summer and fall. First lactation cows were lowest in milk yield while maximum yield occurred in lactation four (CMilk) and five (M305). Previous days dry was negatively correlated to production for cows calving in spring.

Reproductively, cows calving in spring and summer showed reduced performance for CFIN and SC. First lactation cows were poorest for both traits. Cows with higher M305 yield had reduced reproductive performance. Despite the negative effects of thermal stress, milk yield and fertility were not depressed as severely as reported in previous studies conducted in Arizona. This may be indicative of the high level of management practiced in the state.

The sample population was highly selected in an attempt to insure valid reproductive data. For example, natural services were omitted as editing procedures would have removed records lacking a date of service that coincided with an inappropriate gestation length. Also, problem breeders that were culled could not have been included in this study as a calving interval and gestation length could not be calculated. One could speculate that the results would have differed had the population been less selected. However, cows in the sample population were obviously the most adapted, both productively and reproductively.

Evidence from this study, the most comprehensive research of the factors affecting production and fertility in Arizona dairy cattle to date, indicates that calving season should be considered in evaluating dairy cow performance. Also, calving schedules should be adjusted to minimize the effect of heat stress. Research regarding the practical application of these findings is warranted. In addition, study of the long-term effects of dairy cow relocation are needed.

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