FACTORS AFFECTING CONCEPTION RATE AND GESTATION LENGTH IN BEEF CATTLE

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By

RICHARD BRUCE WARREN

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APPROVED BY:

J. A. Whatley
Chairman, Thesis Committee

A. E. Darlow
Head of the Department
JAW

D. C. McIntosh
Dean of Graduate School

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INTRODUCTION

The animal breeder may improve his particular class of livestock by practicing better feeding and management methods and selecting genetically superior breeding stock. One of the important factors to consider in breeding genetically superior livestock is the number of offspring produced per female during a specified length of time. Especially is fertility a problem in breeding beef cattle, as nothing is saleable except the offspring produced. Thus, in beef cattle, the fertility of both the male and female is of great value in determining the breeding worth of the individual. Furthermore, fertility has a direct bearing on the selection intensity that can be practiced for breeding efficiency as well as for other economically important traits. Among the larger number of progeny from the more fertile animals there is more opportunity for selection than among the smaller number of progeny from the less fertile animals.

Knowledge of the length of gestation is helpful in knowing when to prepare for new-born. Also it aids in detection of diseased conditions when abnormal gestations occur.

With these problems in mind various factors affecting the conception rate and length of gestation within and between the Angus, Hereford, and Shorthorn breeds of beef cattle at Oklahoma Agricultural and Mechanical College have been analyzed and presented in this study.

REVIEW OF PREVIOUS INVESTIGATIONS

INHERITANCE OF INFERTILITY

Most of the investigations concerning the inheritance of infertility in cattle have been made with the dairy breeds.

The variation in breeding efficiency due to genetic causes is generally small when compared to the influence of nutrition, health, or other environmental factors. Yet the inheritance of fertility may play a large part in differences in breeding efficiency between herds or breeds of cattle.

Early work by Fincher and Williams (1926) revealed that one form of sterility in dairy cattle is inherited as a sex-limited trait. They bred a bull to unrelated females and found all of the F_1 males and females to be fertile. Many of the females resulting from mating the bull with his F_1 daughters proved to be sterile even though their reproductive tracts appeared to be normal.

Gregory, et al. (1945) in a 25 year study of Jerseys and Holsteins found sterility in cattle over three percent inbred to be twice that of the outbreds. They explained the Fincher and Williams work by assuming that the sire was homozygous for the gene for female sterility and the maternal grandams of the 23 inbred daughters were homozygous normals. With this assumption half of the inbred daughters should have been sterile. This theory was born out as 10 of the 23 females from the sire-daughter matings were sterile. From their work they concluded that a single recessive autosomal gene was responsible for conditioning female sterility, and all the observed sterile females could be accounted for by a specific gene for sterility. Judging from the number of sterile females in non-inbred populations they estimated the female sterile gene at a gene frequency of .1 or less. The authors stated, however, that sterile conditions may be affected by many different genes. They also mentioned that the Bates Dutchess Shorthorn family probably developed sterility at an increasing rate due to the increased gene frequency in the highly inbred Bates herd.

Gilmore (1949) and Tanabe and Casida (1949) have reviewed several anatomical abnormalities of the reproductive organs in dairy cattle and their effect on fertility. Many authors have found that genital abnormalities are responsible for much of the infertility in large animals.

According to Gregory, et al. (1945), a type of sterility in cattle that affected both the male and female was reported by Eriksson. The condition was a hypoplasia of the genital tract conditioned by one autosomal recessive gene with incomplete penetrance.

Tyler and Chapman (1948) were able to change the prolificacy in albino rats by selecting for high and low prolificacy. In the partial sterile (low producing) line, fertility was reduced 47% as compared to the outbred controls. The partial sterile rats produced fewer young at birth and a smaller number reached weaning weight. They concluded that the partial sterile rats were heterozygous for a translocation. No similar work with large animals has been reported.

That there are differences in families and breeds of cattle as to their breeding efficiency was reported by Kaab (1937), Jones (1946), and Bartlett (1948).

A study of dairy cattle records by Jones, Dougherty, and Haag (1941) showed that cows with the greatest number of descendants bred more regularly, usually dropped vigorous calves, and bred to an older age. They concluded that much of the poor fertility found in certain breeds and families was due to the close breeding of cattle for some character of economical importance other than fertility. It was also noted that families of cattle within breeds and even whole breeds have passed out of existence because of poor reproductive performance.

Speilman and Jones (1939) found a correlation coefficient in dairy cattle of $.56 \pm .118$ for the reproductive efficiency between the foundation cows and the mean of their female decendants. Trimberger and Davis (1945), however, reported that the female's breeding record gives little indication of the offspring's breeding performance.

In beef cattle Lashley and Bogart (1943) observed that cows with poor breeding records tended to repeat their performance. They concluded that cows could be culled for low reproductive performance at their second or third gestation period.

Jones, et al. (1941), as did other workers, found no correlation between the level of production of dairy cows and the amount of breeding troubles observed.

CONCEPTION RATES

Effect of Age

One of the most important factors in successful livestock production is the number of young produced per female in a specified length of time. The length of each service period (the period from the last parturition to the next conception) has a direct bearing on the number of offspring born in a female's lifetime. Thus, the number of services per conception is very important.

Baker and Quesenberry (1944) pointed out that age was an important factor in the breeding efficiency of Hereford cattle under range conditions. An analysis of 412 cows over a six year period showed that the highest calf crop was obtained from the nine-year-old group and the lowest calf crop from the four-year-old group. This difference, however, was not significant. Most of the shy breeders were disposed of before they were six years old and over half of them were culled before four years of age.

The fertility of range cows was shown by Lashley and Bogart (1943) to be lowest in the two to three-year-old group and highest in the five to six-year-old group. There was a gradual increase in services per conception after cows were six years old and a definite increase at 10 years of age.

Snapp (1946) states that beef cows reach their maximum production of weanling calves at six years of age.

Withycombe, Potter and Edwards (1930) compared the calving performance of Hereford heifers bred initially as yearlings to produce their first calf at the age of two years and heifers bred at two years of age to produce their first calf at three years. The heifers that calved at two years of age produced fewer calves at three and four years of age as compared to the later bred heifers, but had produced .7 more calves per cow by the time both groups reached six and one half years of age.

Range bulls, in the study by Lashley and Bogart (1943), withstood heavier service than dairy bulls. Older range bulls were shown by Baker and Quesenberry (1944) to have lost more weight during the breeding season than younger bulls. They also observed a significant variation between bulls in calf crop percentages. This might have been affected by the type of matings used, since there was a highly significant difference in calf crops between multiple and single bull cow herds. In the single bull herds 5.7 percent more calves were born than in the multiple bull herds.

White, et al. (1925) found that dairy heifers under 15 months of age required 2.4 services per conception while those from 15 to 21 months old only required 1.75 services. Heifers over 21 months old required over 2.50 services per conception. Jones, et al. (1941) reported that dairy heifers under 18 months, on the average, required more services per conception than older heifers. However, Hayden (1947) found that the services required for dairy cattle during the first conception gave no indication of the breeding efficiency during subsequent conceptions.

Another early study by Eckles (1932) revealed that of 311 heifers studied, 23 proved to be non-breeders. The other 288 heifers averaged 2.4 services per conception while the herd average was 2.5 services per conception. This led him to believe that the larger number of services required to settle virgin heifers was due to the undiscovered non-breeders within that group. Hilder, Fohrman and Graves (1944), however, as have other workers, reported that after the first gestation period, the age of the cow had little effect on her breeding efficiency. Still further work by Seath, Staples, and Neasham (1943) revealed that in Jerseys and Holsteins much of the reproductive trouble was traceable to about one half of each of the first three gestation groups. They found that the Louisiana heifers on an average differed about three services per conception between the low half and the more efficient half in the three gestation groups. All heifers were found healthy and normal as far as the veterinarians could determine.

Tanabe and Salisbury (1946) made a study of 12,621 services in New York Artificial Insemination Associations. They concluded that the highest reproductive efficiency in Holsteins occurred after the second or third gestation, remained at this high level for one or two gestations, then dropped as the cows increased in age. They also found that cows up to five years of age had the highest conception rate from the first service and cows over five years of age conceived more often from the second service.

Jones, et al. (1941) found the largest number of non-breeding dairy cows under two years and over 10 years of age, while Morgan and Davis (1938) found little variation in services per conception up to 13 years. Morgan and Davis did find, however, an unexplainable drop in fertility in the 10-year-old group, as did Tanabe and Salisbury (1946).

Jordao and Assis (1943) found that as Brazilian cows grew older the service period became shorter. The average interval between parturition and fertile service was 175 ± 5.11 days with the first service period being the longest.

Two-year-old heifers bred to two-year-old bulls were found by Morgan and Davis (1938) to be very similar in breeding efficiency to three to eight-year-old cows mated to similar aged bulls. Bulls over three years of age, however, were not efficient breeders of virgin heifers.

Tanabe and Salisbury (1946), in a study of artificial inseminations, found that regardless of the amount of selection for fertility in older proven sires, one to three-year-old bulls still have the highest fertility levels. This study also showed that bulls one to three years old when mated to cows four to six years of age resulted in the highest breeding efficiency of any age combination. Highly significant differences were found between bulls and cows mated at different ages in this study. The authors felt that the variations noted were very similar to those found under natural breeding conditions.

In a study of 725 females at the Beltsville Station, Hilder, et al. (1944) found that young bulls were considerably more efficient when bred to virgin heifers than bulls five years old and older.

Miller and Graves (1932) found that young bulls averaged 3.06 services per conception while mature bulls averaged 3.38 services per conception. Tanabe and Salisbury (1946) reported an average of 2.07 services per conception for the 41 bulls in their artificial insemination study. The two-year-old bulls were shown to be the most efficient breeders. Morgan and Davis (1938) also reported the highest efficiency for one to two-year-old sires but the breeding efficiency changed very little from two to eight years of age. Hilder, et al. (1944) observed a gradual decrease in breeding efficiency of the dairy bull with advancing age. There was a marked drop in fertility in the seven-year-old group.

The age of mare, breed, year bred, and the stallion all affected the reproductive efficiency of the western mare as reported by Speelman and Dawson (1943). The very young and the very old mares were low in fertility as were the old stallions. Lambert et al. (1939) after analyzing 10 years of Morgan horse breeding records reported that the highest fertility was found in mares between the ages of seven and 14 years with a definite lowering of fertility from 15 years on.

Effect of Season

The season of breeding the female has been shown in dairy cattle to have some effect on the conception rate. Specific studies in beef cattle pertaining to this factor in reproductive efficiency have not been reported.

Eckles (1932) in a 29 year study of dairy herds at Missouri University concluded that the season of year had little if any effect on fertility. Miller and Graves (1932), however, noted the lowest conception rate during July to September and the highest conception rate in December and May.

That the season has an effect upon conception rate was also shown by White, et al. (1925) in early work at Connecticut. They found an average service per conception of 2.02 from November to April while only 1.89 services per conception were required to settle cows from May to October. However, from a study of five dairy breeds in Nebraska, Morgan and Davis (1938) reported that 2.28 services per conception were needed to settle all the cows from May to October while 2.14 services per conception were needed from November to April. Most workers agree with the later findings.

Rhoad (1944) in analyzing records of pasture-bred cows at the Jeanerette station found that 52 percent of the cows became pregnant during the first 20 days of the spring breeding season, 80 percent the first 40 days, and 90 percent before the end of 60 days. On the average 1.83 heat periods had elapsed per conception for heifers and 1.80 for older cows. The gestation periods of the pasture bred cows were estimated at 282 days from the birth date of the calf until parturition. Twenty days was used as the estrus cycle period.

Erb, et al. (1942) concluded that the quality of dairy bull semen was best during the spring and poorest during the summer. Semen produced in the fall and winter was about average in quality. Several other studies agree with these findings.

After checking 125,000 artificial inseminations in New York, Mercier and Salisbury (1947) concluded that the male and female reproductive response to seasonal variations was dependent upon the age of the individual. Young dairy bulls were highest in fertility in the winter and lowest in summer. As the bulls aged the low point in reproductive efficiency came in the winter and reach a maximum in the early summer. These responses in older cattle were highly correlated with the length of day with a lag of one to two months.

In checking records of two breeds of dairy cattle and two breeds of beef cattle at three institutions situated at 45, 47, and 49 degrees latitude, Mercier and Salisbury (1947) found a significant difference at the five percent level between fertility at different seasons. Sunshine and temperature had no apparent affect upon reproductive efficiency, but longer days were correlated with higher conception rates with a lag of two months.

Anderson (1945) in Kenya, Africa showed a definite seasonal fluctuation in fertility and found that there seemed to be a seasonal rhythm in male reproductive performance associated with different climates. Thus, warm seasons produced an increase in mating desire and higher fertility and cooler seasons less desire and lower fertility.

Conceptions of 1472 grade Rambouilett range ewes were reported by Chittenden and Walker (1936). Thirty-four percent of the ewes conceived in the first week of the breeding season and 82 percent conceived before the first half of the breeding season was over. They also reported that 90 percent of the lambs were born the first three weeks of the lambing season.

Sykes and Cole (1944) increased the light three hours a day when breeding ewes during March, then decreased it in April and May until the light was six hours deficient each day. As a result five normal lambs out of eight ewes were dropped in November, which indicated that the artificially developed season had affected the estrus cycle and fertility of the tested ewes.

GESTATION STUDIES

Effect of Birth Weight

It has been found that certain lengths of gestation may be characteristic of a particular species, but individuals within these species will vary. Bryant (1943) states that it has generally been assumed that the length of gestation depends upon the constitution of the animal carrying the fetus. Rife et al. (1943), however, obtained data which indicated that the genotype of the fetus is the deciding factor in gestation length rather than the genotype of the mother. Angus cows bred to Angus bulls averaged 272.8 days gestation, while Hereford cows bred to Hereford bulls averaged 289 days gestation. The average gestation lengths on both Angus and Hereford cows carrying Hereford x Angus crossbred calves was 281.4 days with no difference between the reciprocal crosses. Differences in the gestation lengths of the above three groups were significant. Long, Gerlaugh, and Rife (1948) reported on more extensive data from the same crossbreeding experiment. There was a highly significant difference between the average gestation of 276.4 days for the purebred Angus and 286.3 days for the purebred Herefords. The crossbred calves were carried in utero 282.5 days and there was no significant difference between reciprocal crosses. Some of the difference between breeds in gestation length may have been due to breed differences in birth weight of the calf, since there was a high correlation between birth weight of the calf and length of gestation.

Knapp et al. (1940) also observed that cows tend to carry heavier calves longer, and found a correlation of about .50 between the birth weight and length of gestation in Shorthorns. The length of gestation, calving sequence, and weight of the dam was estimated to cause .38 of the total variance in birth weights of cattle. The length of gestation produced the greatest effect of the total variation. Piam (1944) did not find a significant correlation between the birth weight and length of gestation period.

Livesay and Bee (1945) studied two breeds of beef cattle and three breeds of dairy cattle to see if the early maturity of breeds is responsible for the variation in length of gestation. They analyzed 15 years of breeding records at the West Virginia station from the Angus, Hereford, Jersey, Ayrshire, and Holstein breeds. Highly significant differences were noted between the average 282.5 day gestation of the Angus and the average 285.2 day gestation of the Hereford. Significant variation in gestation was not found between the dairy breeds as they all averaged close to 278 days.

Early work in the four major breeds of dairy cattle by Fitch, McGilliard, and Drumm (1924) revealed that larger calves are carried longer than smaller calves within each breed, and that there was a slight tendency for smaller breeds to carry their calves longer.

Lambert et al. (1939) found a non-significant correlation between birth weight and the length of gestation for colt foals, but the birth weight of filly foals was significantly correlated with the length of gestation.

In swine, Lush et al. (1934) observed a tendency for large litters to be born sooner than smaller litters, but found that the litter weights did not affect the gestation period. The larger litters may have been born sooner because of the lack of nutrients for the developing fetuses. Thus, larger litters might be born at an earlier stage of development than smaller litters.

In guinea pig work, Wright (1921) showed that the rate of growth of the fetuses determined the birth weight of the pigs rather than the variation in gestation length.

Effect of Sex of Calf

Long et al. (1948) found that bull calves averaged 1.3 days longer in utero than heifers. Several other workers agree that the gestation period for bull calves is about one day longer than for heifer calves.

Spencer (1840) in some very early work found that bull calves averaged one day longer in gestation than heifers and reported an average gestation for Durham and Shorthorns of 283 days. Wing (1899) and McCandlish (1922) in working with Jerseys and Holsteins found no difference in gestation due to the sex of the calf. Fitch et al. (1924) reported a difference of 1.3 days due to sex of the calf in the four major dairy breeds studied. Later workers have generally agreed with the latter figures.

Lambert et al. (1939) reported a difference of one day on the length of gestation due to the sex of foal, while earlier workers reported 1.5 days difference.

No difference in gestation due to sex of the lamb was reported by Terrill (1944).

Effect of Age

Beef heifers generally carry calves shorter periods than older cows, according to Snapp, (1946). McCandlish (1922) and Jordao and Assis (1943) found no difference in gestation length of dairy cattle when heifers and older cows were compared.

Lambert et al. (1939) found a non significant difference between the age of the mare and the length of gestation.

A slight increase in length of gestation with advancing age of the ewe, especially in the fine wooled breeds was noted by Kammlade (1947). From a study by Terrill (1944) eight to nine-year-old range ewes were found to average nearly two days longer in gestation than two to three-year-olds. The earlier bred ewes also tended to have longer gestations.

Effect of Season

The season of the year in which the pregnancy begins has a slight effect on the length of gestation in some cases according to Lush (1945). McCandlish (1922) and Gowen and Dove (1931) found in dairy cattle, however, that the length of gestation was not influenced by the season of breeding or freshening.

Berliner (1942) in Mississippi found that mares and Jennetts that were bred in early spring had longer gestation periods than those bred after May. The March and April bred mares had gestation periods from 350 to 365 days, May bred mares from 340 to 360, while June and July bred mares ranged from 320 to 350 days.

The normal sheep breeding season in the United States, according to Kammlade (1947), extends from July until January. Therefore ewes are seasonally polyestrous. Rams, on the other hand, will mate all seasons of the year, but many are infertile during the hotter summer months.

Effect of Multiple Births

It has been noted by Kaab (1937) that twinning in the Franconian breed of cattle appeared to be inherited as a simple recessive. The few authors that have reported twinning in their studies noted that twins are generally born after shorter gestations than single offspring.

For convenience, the length of gestations of the various types and breeds of livestock are listed in the following tables.

TABLE I

Gestation Periods of Beef Cattle

Type or Breed of Animal	Average Gestation Length (days)	Difference in Gestation Due to Sex (days)	Length of Twin Gestation (days)	Source and Date
Cattle	282.1			Lush, 1945.
Beef	283			Snapp, 1946.
Angus	272.8			Rife et al. 1943.
	282.5			Livesay & Bee, 1945.
	276.4			Long, et al. 1948.
Hereford	289.0			Rife, et al. 1943.
	279.2	.77		Pism, 1944.
	285.2			Livesay & Bee, 1945.
	286.3			Long, et al. 1948.
Shorthorn	283.0	1.00	277	Spencer, 1840.
	280.8	2.00		Knopp, et al. 1940.
	281.1	.90		Dawson, et al. 1947.
Brahman	284 to 290			Littlewood, 1937.
Crossbreds				
Angus females x Hereford males	281.4			Rife et al. 1943.
	282.0			Long, et al. 1948.
Hereford females x Angus males	281.4			Rife, et al. 1943.
	283.2			Long, et al. 1948.

TABLE II

Gestation Periods of Dairy Cattle

Type or Breed of Animal	Average Gestation Length (days)	Difference in Gestation Due to Sex (days)	Length of Twin Gestation (days)	Source and Date
Cattle	282.1			Lush, 1945.
Dairy	280.0		shorter	Wing, 1899 & McCandlish, 1922.
	282.4	1.3	273	Fitch, et al. 1924.
Jersey	284.3 277.9	Bulls carried longer		Fitch, et al. 1924. Livesay and Bee, 1945.
Guernsey	283.0			Fitch, et al. 1924.
Ayrshire	284.6 278.3	"		Fitch, et al. 1924. Livesay and Bee, 1945.
Holstein	281.0 278.3	"		Fitch, et al., 1924. Livesay and Bee, 1945.
Milking Shorthorn	281.7			Knapp, et al. 1940.
Brazilian Black Pied Dutch Cattle	276.2	1.6		Jordao and Assis, 1943.

TABLE III

Gestation Periods of Other Farm Animals

Type or Breed of Animal	Average Gestation Length (days)	Difference in Gestation Due to Sex (days)	Length of Twin Gestation (days)	Source and Date
Horses	335.9	1.6 ± .2 and 1.7 ± .5		Lush, 1945.
Morgan	343.7	1.0		Lambert et al. 1939.
Work	348.0			Berliner, 1942.
Ass	366.9			Lush, 1945.
	355.0			Berliner, 1942.
Sheep	149.0			Chittenden & Walker, 1936.
	149.1			Lush, 1945.
	141 to 159	None	.6 day less	Terrill, 1944.
	149.0			Kammlade, 1947.
Range Sheep				
Rambouilett	151.0			Chittenden & Walker, 1936.
	151.0			Terrill, 1944.
Columbia	148			Terrill, 1944.
Corriedale	149.5			Terrill, 1944.
Mutton Sheep				
Hampshire	148			Chittenden & Walker, 1936.
Swine	114			Shelton, 1944.

SEX RATIOS

It seems unlikely at present that the breeder will ever be able to control the sex of the young produced. Many theories of sex determination, however, may be right in some cases, since the laws of chance permit the experimental samples to deviate widely from the expected values.

Pearl (1917) found that the sex of the offspring would not be influenced by the time or stage of estrus in which the dams were bred, and Johansson (1932) concluded that the age of the dam had no effect on the resulting sex of the offspring.

Also the phenotype of cattle, in a study by Gowden (1942) was no indication that a breeder could successfully select for one sex or another. He stated, however, that sires may produce offspring predominately of one sex for a period, but that the average did not deviate greatly from the one to one ratio.

No large animal experimentation to date has duplicated or been as successful as King (1918) in altering the sex ratio in albino rats by selection. King selected for high preponderance of males in one line and a corresponding high frequency of females in another line. After two generations of selection in a 79 percent inbred population 55.1 percent males were produced in line A and only 44.9 percent males in line B, the female line. King concluded that the X and Y mode of sex inheritance was not changed due to her selection and that there was not a definite sex determining factor in her rat line. She believed, however, that the metabolism of the ova may be such that it could be fertilized more easily by one sperm than another.

King's findings were paralleled in earlier drosophila work but later studies revealed that the deviation from the normal sex ratio might have been due to chance segregation or to a sex-linked lethal factor. Gershenson (1928) and Sturtevant and Dobzhansky (1936), however, found in Drosophila obscura that the sex gene may be localized in the X chromosome and be transmitted like an ordinary sex-linked gene, or the sex ratio may be controlled through the maturation behavior of the X and Y chromosome. Both cases would allow a large proportion of females to be formed in the population.

Several authors have found various sex ratios which are listed in the following table.

TABLE IV

Sex Ratios of Farm Animals

Type or Breed of Animal	Percentage Males of all Births	Source and Date
Cattle	50.5	Gowden, 1942.
	50.7	Lush, 1945.
	55.2 (intra-uterine)	Jewell, (date?)
Dairy Cattle	51.5	Johansson, 1932.
	53.75	Morgan and Davis, 1938.
	49.5	Seath, et al. 1943.
	49.4	Lush, 1945.
Horse	48.3	Crew, 1927.
	49.4	Lush, 1945.
Morgan	57.6	Speelman and Dawson, 1943.
Mule	44.3	Craft, 1932.
Sheep	49.5	Chapman and Lush, 1932.
Swine	51.1	Lush, et al. 1934.
	51.0	Lush, 1945.

OBJECTIVES OF THE STUDY

The objectives of this study were to determine the effect of certain factors on the conception rate and gestation length in beef cattle. An analysis was made of the effect of breed, bull, age of bull or cow, matings of different and similar age groups of cows and bulls, and season of breeding on services per conception. The breed, age of cow, season of breeding and sex of calf were studied to determine their effect on length of gestation.

SOURCE OF DATA

The data used in this study were obtained from the breeding and calving records of the Angus, Hereford, and Shorthorn herds at Oklahoma A. and M. College. Only the records giving specific breeding and calving dates were used in a period from 1941 through 1947. There were a few pasture matings in the herd but because of the absence of specific breeding dates these were excluded from the study.

During the 1941 and 1942 calving seasons there was some Brucellosis infection in the herd. In this study, the effect of the disease on conception rate was not great since only the breeding records that resulted in conceptions and normal calvings were included. After the 1942 calving season all cows were free from Brucellosis.

All calves born were the result of natural services except one Angus and seven Herefords. On the average, 1.37 services were required per conception for these calves conceived artificially. The limited use of artificial insemination was under the supervision of a veterinarian and the herdsman.

The 402 conceptions during the seven years included 137 Angus, 160 Hereford, and 105 Shorthorn calves (Table V).

The range in age of cows at breeding was from 2 to 14 years. However, 90 percent of the cows were between 2 and 10 years of age. The distribution of cows over nine years of age was so unequal within the breeds and season of breeding that cows beyond this age were not included in the analysis. The distribution of cows at different ages is shown in Table VI. The range in age of bulls was from two to eight years.

Calves were dropped rather uniformly throughout the four seasons of the year as shown by the conceptions in Table VII. The heaviest breeding season was in the spring and the lightest in the summer. The months included in each season were as follows: Winter - December to March; Spring - March to June; Summer - June to September; Fall - September to December.

Most of the cows were kept at the barn until they were rebred and their calves were weaned. They were then taken to the range until after the next parturition. Because of a limited pasture area at the beef cattle barn all the cows were supplemented with grain, hay, silage and protein supplement while nursing their calves and being bred. The cows at the range were grazed in summer on Bluestem and other native grasses, and were wintered on grass plus prairie and alfalfa hay and a protein supplement.

The bulls were generally kept at the barn and fed enough hay and grain to keep them in vigorous breeding condition. Exercise was provided for the bulls by allowing them to graze a few hours each day in small paddocks.

TABLE V

Number of Conceptions of the Three Breeds During the Seven Year Period

Breed	Years							
	1941	1942	1943	1944	1945	1946	1947	Total
Angus	13	18	23	15	14	25	29	137
Hereford	20	30	29	26	16	19	20	160
Shorthorn	15	14	16	19	12	16	13	105
Total	48	62	68	60	42	60	62	402

TABLE VI

Number of Conceptions by Years and Seasons

Year	Season				
	Winter	Spring	Summer	Fall	Total
1941	13	18	14	3	48
1942	11	22	14	15	62
1943	25	19	2	22	68
1944	11	21	12	16	60
1945	11	14	7	10	42
1946	18	17	17	8	60
1947	15	16	18	13	62
Total	104	127	84	87	402

TABLE VII

Number of Cows Bred at Different Ages

	Age in Years								
	2	3	4	5	6	7	8	9	Total
Number of Females	90	88	60	43	47	34	19	21	402

RESULTS

Services per Conception

The average services required per conception in each of the three breeds are shown in Table VIII. Although the services per conception were lowest in the Hereford and highest in the Shorthorn breed, the differences among breeds were not significant. All the factors affecting conception rate were tested for significance by using the Chi-square test (Snedecor, 1945). Expected values for the test were computed from the border totals.

TABLE VIII

Services Per Conception in the Three Breeds

Breed	Services	Conceptions	Services per Conception
Angus	266	155	1.71
Hereford	280	173	1.62
Shorthorn	206	115	1.79
Sum	752	443	1.69

The age of cow at breeding had a marked effect on the conception rate as shown in Table IX. Two-year-old heifers required more services per conception (2.04) than did any other age group of cows. The highest conception rate occurred in the eight and nine year age groups. An unexplainable increase in services per conception was found in Shorthorn cows at three and five years. This is probably a chance occurrence. Differences in conception rate among the different ages were highly significant.

TABLE IX

Services per Conception as Affected by Age of Cow

Breed	Age at Breeding							
	2	3	4	5	6	7	8	9
Angus	2.50	1.37	1.52	1.38	1.84	1.00	1.42	1.10
Hereford	1.75	1.72	1.40	1.50	1.50	1.68	1.50	1.00
Shorthorn	1.84	2.08	1.38	2.12	1.90	1.33	1.00	1.12
Average	2.04	1.71	1.43	1.58	1.72	1.36	1.31	1.09

Services per conception due to mating different and similar aged cows and bulls is shown in Table X. A significant difference in conception rate was noted when seven and eight-year-old bulls were mated to the different aged cows. The most inefficient performance of 3.00 services per conception occurred when seven and eight-year-old bulls were mated to two and three-year-old heifers. The highest breeding efficiency of 1.14 services per conception was found when four to seven-year-old bulls were bred to seven to ten-year-old cows. Another efficient breeding group was the two and three-year-old bulls mated to four to seven-year-old cows.

TABLE X

Services per Conception as Affected by Mating
Different and Similar Age Groups of Cows and Bulls

Age of Bull (years)	Age of Cow (years)		
	2 to 4	4 to 7	7 to 10
2 to 4	1.61	1.37	1.42
4 to 7	1.55	1.45	1.14
7 to 9	3.00	1.86	1.44

Differences in conception rate due to the season of breeding were significant at the five percent level. In Table XI it can be seen that the highest rate of conception was in the fall, while the lowest rate was in the summer. In all breeds except the Shorthorns summer was the least efficient breeding season. There appears to be no logical explanation for the lower breeding efficiency of the Shorthorns during the winter and spring.

TABLE XI

Effect of Season of Year on Services per Conception

Breed	Season of Breeding			
	Winter	Spring	Summer	Fall
Angus	1.41	1.62	2.68	1.57
Hereford	1.40	1.73	1.81	1.34
Shorthorn	2.05	1.81	1.57	1.52
Averages	1.51	1.72	1.87	1.48

Different years of breeding were also responsible for significant amounts of variation in services per conception, but no table was set up to show these differences as all the factors affecting conception rates were tested from the total conceptions of all seven years.

Comparisons of services per conception were made between bulls of the same breed that had sired ten or more calves. Though the conception rates of the different bulls as shown in Table XII appear to be quite varied, the differences between bulls within the same breed were not significant.

TABLE XII

Effect of Bull on Services per Conception in Angus Breed

	Quality Prince of Sunbeam	Quality Prince 12th	Prince Blackcap 12th
Number of Conceptions	103	18	11
Services per Conception	1.78	1.77	1.27

Effect of Bull on Services per Conception in Hereford Breed

	T. Royal Rupert 23rd	Tone T. 44th	Hazford Tone 158th	Tone T. 75th	Dandy Domino 19th
Number of Conceptions	96	21	18	12	11
Services per Conception	1.48	1.38	1.88	1.75	2.00

Effect of Bull on Services per Conception in Shorthorn Breed

	Glenburn Defiance	Edellyn Royal Leader 3rd	Divide Jupiter
Number of Conceptions	30	37	21
Services per Conception	1.88	1.75	1.84

Highly significant differences at the one percent level were found between the services per conception of bulls of different ages. The general trend of more services per conception with an increase in the bull's age is shown in Table XIII. The Shorthorn bulls, however, were least efficient breeders when four and five years old. They showed greater fertility at six, seven, and eight years of age, but these averages were from only 12 conceptions.

TABLE XIII

Effect of Age of Bull on Services per Conception

Breed	Age of Bull						
	2	3	4	5	6	7	8
Angus	1.55	1.83	1.21	1.52	2.18	2.40	1.86
Hereford	1.81	1.24	1.26	1.79	1.29	2.17	2.70
Shorthorn	1.44	1.58	2.03	2.00	1.33	1.25	1.00
Averages	1.57	1.57	1.54	1.77	1.56	2.16	2.11

Length of Gestation

The average length of gestation for each breed was determined by averaging the number of days from fertile service to the calving date. All the gestation estimates were tested for significance by the analysis of variance method described by Snedecor (1945). Standard deviations on the gestations in Table XIV were calculated from the formula $s = \sqrt{Sx^2/n-1}$. Standard errors of the means were computed by the formula $s/\sqrt{n}$. The gestation lengths of the three breeds shown in Table XIV were significantly different at the one percent level.

Shorthorn gestations were the most uniform as shown by a standard deviation of 8.05 days. The most variable gestation periods were in the Angus cows with a standard deviation of 10.11 days. The average gestations of the Hereford, Angus, and Shorthorn herds were 286.1, 284.4, and 282 days respectively.

TABLE XIV

Average Lengths of Gestation and Standard Deviations in the Three Breeds (days)

Breed	Average	Standard Deviation
Angus	284.4 $\pm$ 1.60	10.11
Hereford	286.1 $\pm$ 1.44	9.62
Shorthorn	282.0 $\pm$ 1.49	8.05
Average	284.1 $\pm$ .88	9.53

The age of the cow at breeding had no significant effect on the length of gestation. Table XV shows the varied lengths of gestation at the different ages of breeding, but these estimates show no general trend with respect to age.

TABLE XV

Length of Gestation as Affected by Age of Cow (days)

Breed	Age of Cow at Breeding							
	2	3	4	5	6	7	8	9
Angus	285.0	281.7	282.7	283.1	288.4	287.5	280.7	285.0
Hereford	282.7	287.7	287.4	287.7	286.2	284.2	284.5	283.6
Shorthorn	283.4	280.6	280.3	283.1	281.2	282.3	286.2	284.0
Average	283.7	283.8	283.8	285.6	285.8	285.1	283.5	284.4

Significant differences in gestation lengths at the one percent level were noted when cows were bred in different seasons of the year. Table XVI shows that cows bred in the summer averaged 286.1 days in gestation and those bred in the spring averaged only 282.3 days.

On the average the summer and fall bred cows had two to three days longer gestation than those bred in the other seasons.

TABLE XVI

Length of Gestation as Affected by Seasons

Breed	Season of Breeding			
	Winter	Spring	Summer	Fall
Angus	284.9	282.0	285.4	285.5
Hereford	286.6	285.5	288.6	283.7
Shorthorn	279.0	279.6	284.3	285.3
Average	283.5	282.3	286.1	284.8

In all breeds the bull calves averaged two days longer in utero than heifers as is shown in Table XVII. Although this difference was rather consistent in all breeds, it was not statistically significant.

TABLE XVII

Length of Gestation as Affected by Sex of Calf

Breed	Sex	
	Male	Female
Angus	285.5	282.0
Hereford	287.0	285.3
Shorthorn	283.0	281.2
Average	285.4	283.3

Other Factors

Some beef cattle breeders have stated that the longevity of breeds is different. Table XVIII gives the average age of all the cows studied and the percentage of cows under five years old. Angus cows averaged 5.37 years in age while the Herefords were youngest at 4.57 years. Forty-three percent of the Angus cows were over five years of age as compared to 35 percent of the Hereford cows. These figures may not indicate real differences between the breeds in longevity. In those herds the Angus cows were generally better producers of good cattle than the Hereford cows and for that reason there would be a tendency to retain the Angus cows in the breeding herd to more advanced ages than would be true for the Hereford cows. Differences in average ages are more indicative of differences in culling the cow herd than differences in longevity.

TABLE XVIII

Average Age and the Distribution of Ages of Cows Used in This Study

Breed	Average Age	Percent Cows Under 5 Years
Angus	5.37	.57
Hereford	4.57	.70
Shorthorn	4.88	.65
Total	4.92	.64

The ratio of bull calves to heifers in the three breeds is shown in Table XIX. An unusually high percentage of Angus bulls were born during the seven year period, but the Herefords and Shorthorns did not vary widely from the one to one ratio. The ratio estimates were based on the normal calves born.

TABLE XIX

Sex Ratios of the Different Breeds Based on Normal Calves Born

Breed	Sex	
	Percent Males	Percent Females
Angus	61.9	38.1
Hereford	47.3	52.7
Shorthorn	53.9	46.1
Average	54.1	45.9

Twin calvings were found only in the Hereford breed. Two sets of twins were recorded, one with a gestation of 284 days and the other 288 days. In both cases bulls were born.

DISCUSSION

It must be realized that the data in this study were taken from the performance of around 400 animals and included only seven years records. The results, however, coincide with much of the earlier work in beef and dairy cattle.

Although it was felt that there might be a difference in breeding efficiency between different families in each of the three beef breeds studied, no estimates of this kind were made. Some of the objections to such a study with these records was the short period which the data covered and the lack of adequate family comparisons because of small numbers.

The fact that no difference in conception rate was found between breeds is in accord with other work.

The two-year-old heifers on the average were the most inefficient breeding group, while the highest breeding efficiency was found in the eight to nine-year-old cows. This probably indicates that as the cow ages, culling of the non-breeders is increased. Whether the lower efficiency in two-year-olds was due to undiscovered non-breeders or other reasons was not determined. Similar results with two-year-olds were found by Lashley and Bogart (1943) in analyzing range cattle breeding records. Baker and Quesenberry (1944) also found the highest breeding efficiency in Hereford females at nine years of age.

The increase in services per conception of the Shorthorns at three and five years of age was not explainable unless the variation was a chance happening because of the small number of cows studied within that breed.

Four to seven-year-old bulls when mated to seven to ten-year-old cows were the most efficient mating group with 1.14 services per conception.

Another efficient mating combination and probably a more representative group because of the greater numbers studied, was the two and three-year-old bulls mated to the four to seven-year-old cows. This group required 1.37 services per conception.

Tanabe and Salisbury (1946) reported similar results with dairy cattle in their artificial insemination study and a tendency for bulls over three years of age to be poor breeders of two and three-year-old heifers.

Significant differences in breeding efficiency, however, were found only when seven to nine-year-old bulls were mated to the various age cow groups. The 3.00 services per conception of the seven and eight-year-old bulls when mated to two to three-year-old heifers, was the most inefficient group studied. This difference may be due largely to the lower breeding efficiency of heifers coupled with lowered fertility of the bull as his age increases.

The fall bred cows were the most efficient breeders, which might have been due to their better physical condition and the increased fertility of the bulls in cooler weather. In all breeds except the Shorthorn, the lowest conception rate was during the summer months. The lowered breeding efficiency of the Shorthorns in the winter is puzzling, but may be the chance result of the small numbers studied.

Several authors with different classes of livestock have reported this downward trend of breeding efficiency during the hotter summer months.

The difference in conception rate due different years of breeding has been noted by many authors but of course is unpredictable and would have no value except to explain certain conditions of the past.

Other workers have mentioned the difference in breeding efficiency of individual bulls but no significant differences between bulls appeared in this study. This might be due to the similar age group in each breed, as all the bulls were from two to eight years old.

In comparing the breeding efficiency of different aged sires it appears that two to four-year-old bulls were the most efficient breeders with around 1.55 services per conception while the seven and eight-year-olds averaged 2.21 services per conception. There was the general trend of lowered efficiency of breeding with an increase in age except for the Shorthorn bulls which were least efficient at four and five years of age. Miller and Graves (1932) showed this same general trend of breeding efficiency for dairy bulls.

Breed differences in gestation lengths agree in general with those presented by other workers. The exception to this is the 284.4 days gestation in the Angus herd. This differs considerably from the figures of 272.8 days by Rife et al. (1943), 276.4 days by Long et al. (1948), and 282.5 days by Livesay and Bee (1945). A possible explanation for this difference may be in the large percentage of Angus bull calves born. In this study bull calves on the average were carried in dam 2.1 days longer than females, and 3.5 days longer in the Angus breed. Since the ratio of Angus bulls calves to heifers was 61.9 percent to 38.1 percent the longer gestation period may be partially due to this high percentage of bull calves.

An average 286.1 day gestation found in Herefords, is similar to figures of 289, 285.2, and 286.3 days reported by Rife et al., Livesay and Bee, and Long et al., respectively.

The gestation periods reported for Shorthorns of 283.0 days by Spencer (1840), 280.8 days by Knapp et al. (1940), and 281.1 days by Dawson et al. (1947) are close to the 282.0 day period found in this study.

Gestations of the three breeds were significantly different at the one percent level. Shorthorn gestations were the most uniform throughout the study with a standard deviation of only 8.05 days. The gestation period of the Angus was the most variable as shown by a standard deviation of 10.11 days. This, also, may have been due to the excess of bull calves born in that breed.

Age of the dam was found to have no effect on the length of gestation. This is contrary to the general statement by Snapp (1946) that beef heifers tend to carry calves shorter periods than older cows. Other authors did not report any age effect on gestation length.

The season of conception had a highly significant effect on length of gestation. Cows bred from June to August averaged 286.1 days in gestation, while cows bred in winter, spring, and fall averaged only 283 days in gestation. Herefords did not show this difference as much as the other breeds. Lush (1945) states that the time of the year the female is bred may influence the gestation, but other work did not confirm this.

The 2.1 days difference in gestation due to sex of the calf, is a higher estimate than most figures given, but the variation was not significant at the five percent level. Long et al. (1948) and Spencer (1840) gave sex differences in beef cattle of 1.3 and 1.0 days, while McCandlish (1922) and Fitch et al. (1924) observed 1.3 days difference in dairy cattle.

The sex ratios of the three breeds are given in Table XIX, but no explanation is available for the variation found between the different breeds.

SUMMARY AND CONCLUSIONS

1. Conception rates and gestation periods were studied in the Angus, Hereford, and Shorthorn beef breeds of cattle at Oklahoma A. & M. College. Four hundred and two conceptions were analyzed from the breeding records of 1941 to 1948.

2. The average number of services per conception was 1.69 with no significant differences among the breeds.

3. Age of dam was shown to affect the conception rate significantly. Two-year-old heifers were the poorest breeders with 2.04 services per conception while eight and nine-year-old cows conceived most readily with about 1.2 services per conception.

4. Four to seven-year-old bulls bred to seven to nine-year-old cows required the lowest number of services per conception of the mating groups. Bulls over three years of age did not settle two to three-year-old heifers as efficiently as did younger bulls.

5. Bulls from two to four years old were the most efficient breeders but the efficiency diminished with an increase in age.

6. No significant differences in fertility were found between the bulls studied.

7. Summer was the least efficient season of conception and fall the most efficient.

8. A gestation average of 284.1 days was found for the three beef breeds studied. The averages were 284.4 ± 1.60, 286.1 ± 1.44, and 282.0 ± 1.49 days for the Angus, Hereford, and Shorthorn breeds respectively.

9. Age of dam had no significant effect on the length of gestation.

10. The gestation period was longest when cows were bred in the

summer months (286.1 days) and shortest when bred in the spring (282.3 days).

11. Bull calves were carried on the average 2.1 days longer in utero than heifer calves.

12. Bull calves comprised 54.1 percent of all the calves born.

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Typist: Mary Wallace Spohn