Lactation curves and milk production in beef cattle with varying degrees of crossbred influence

by David George Casebolt

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Animal Science
Montana State University

Abstract:
The majority of today's research appears to be toward the ascertainment of which breeds of cattle or breed crosses function in a more efficient manner under range conditions. It was the purpose of this study to provide a segment of the information required to adequately evaluate the genotypic groups involved. A beef breed and several beef breed crosses were evaluated on the basis of their ability to produce milk under range conditions, and a more quantified lactation curve for each genotypic group was developed. Data were collected from Hereford (HH), Angus x Hereford (AH), 25% Simmental x 75% Hereford (1S3H), Simmental x Hereford (1SlH), and 75% Simmental x 25% Hereford (3S1H) cows at the Northern Agricultural Research Center at Havre, Montana. In order to minimize the variability in milk production attributed to age of dam, only 4- and 5-year-old cows were used. A total of 545 observations were collected on 76 cows during 1982. Least squares analysis of variance using the fixed effects model was used to determine the effect of independent variables and two-way interactions on milk production. Breed of dam, age of dam, sex of calf, pregnancy status, and the sex of calf x age of dam and pregnancy status x age of dam interactions were significant sources of variation for milk production. Mean 24 h milk production estimates for HH, AH, 1S3H, 1S1H, and 3S1H were 8.8, 11.6, 10.2, 12.6, and 11.3 kg, respectively. Peak milk production for the HH, AH, 1S3H, 1S1H, and 3S1H cows was achieved at day 40, 46, 34, 48, and 37 of the lactation period, respectively. Hereford cows gave 2.7 kg less milk per day than the crossbred cows grouped together ($P < .05$). There was no significant difference in the milk production of the AH and 1SlH cows (Fl) and no significant difference was detected between the 1S3H and 3S1H cows (backcross). The Fl cows gave 1.2 kg more milk ($P < .05$) than the backcross cows. It appeared that crossbred cows maintained a more persistent lactation as compared with their straightbred contemporaries. Heterosis appeared to have a positive effect on the level of milk produced by the dam. Considering this, crossbreeding conceivably would be a means of improving milk production in a relatively short period of time.

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Date 24 September 1984

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ABSTRACT

The majority of today's research appears to be toward the ascertainment of which breeds of cattle or breed crosses function in a more efficient manner under range conditions. It was the purpose of this study to provide a segment of the information required to adequately evaluate the genotypic groups involved. A beef breed and several beef breed crosses were evaluated on the basis of their ability to produce milk under range conditions, and a more quantified lactation curve for each genotypic group was developed. Data were collected from Hereford (HH), Angus x Hereford (AH), 25% Simmental x 75% Hereford (1S3H), Simmental x Hereford (1S1H), and 75% Simmental x 25% Hereford (3S1H) cows at the Northern Agricultural Research Center at Havre, Montana. In order to minimize the variability in milk production attributed to age of dam, only 4- and 5-year-old cows were used. A total of 545 observations were collected on 76 cows during 1982. Least squares analysis of variance using the fixed effects model was used to determine the effect of independent variables and two-way interactions on milk production. Breed of dam, age of dam, sex of calf, pregnancy status, and the sex of calf x age of dam and pregnancy status x age of dam interactions were significant sources of variation for milk production. Mean 24 h milk production estimates for HH, AH, 1S3H, 1S1H, and 3S1H were 8.8, 11.6, 10.2, 12.6, and 11.3 kg, respectively. Peak milk production for the HH, AH, 1S3H, 1S1H, and 3S1H cows was achieved at day 40, 46, 34, 48, and 37 of the lactation period, respectively. Hereford cows gave 2.7 kg less milk per day than the crossbred cows grouped together ($P < .05$). There was no significant difference in the milk production of the AH and 1S1H cows (F1) and no significant difference was detected between the 1S3H and 3S1H cows (backcross). The F1 cows gave 1.2 kg more milk ($P < .05$) than the backcross cows. It appeared that crossbred cows maintained a more persistent lactation as compared with their straightbred contemporaries. Heterosis appeared to have a positive effect on the level of milk produced by the dam. Considering this, crossbreeding conceivably would be a means of improving milk production in a relatively short period of time.

INTRODUCTION

Unlike the days of the open range when grass was abundant and a cattleman's main concern was maintaining as much weight as possible on his steers, today's producer is continually being pressured to operate in a more efficient manner. Whether a producer in today's economy will be a success or not is determined by the ability of that producer to develop a quality product, in this case lean red meat, in a manner that maximizes the use of his available resources and by his ability to market that product.

Today's producer has at his disposal a large variety of breeds and breed crosses. Researchers at the present appear to be centering their attention on finding out which breeds function in a more efficient manner under a variety of environmental conditions. Efficiency in this case is the ability of the cow to convert low quality forage into amount of calf weaned. To maximize production efficiency, the evaluation of different crossbred types under different environmental conditions becomes very important. It has been well documented that milk production is one of the most important environmental factors influencing the rate of growth of the calf during the preweaning stage of development, thus rendering milk production a major component of efficiency. This study provides some insight as to the milk production aspect of efficiency.

Five genotypic groups of beef cattle (Hereford, Angus-Hereford, Simmental-Hereford, 25% Hereford-75% Simmental, and 75% Hereford-25% Simmental) were studied under range conditions. The objectives of this study were to (1) determine if differences in milk production existed among the genotypic groups involved in the study, (2) develop a more quantified lactation curve for each of the genotypic groups, and (3) investigate the relationships between milk production and various preweaning growth traits of the calf.

LITERATURE REVIEW

Mammary Gland Development (Fetal)

Several texts have been written dealing with the development of the mammary gland. The following is a summary of the reviews of a few of these texts (Cowie and Tindal, 1971; Schmidt, 1971; Anderson, 1974; Cowie and Buttle, 1974; Frandson, 1974) on the development and hormonal control of the mammary gland. The first sign of development of the mammary gland in the bovine occurs at a very early stage of fetal growth. A layer of cuboidal cells originating from the ectoderm differentiate from the underlying mesenchyme forming the mammary band in the inquinal region. During the 4th and 5th week of fetal development, several layers of cells develop from the lower layer of the ectoderm (Malpighian layer) collectively referred to as the mammary lines. With further differentiation the mammary lines progressively develop into the mammary crest. This stage of development is immediately followed by a second intermediate stage, the formation of the mammary hillock. The mammary hillocks give rise to the mammary buds. Two mammary buds form on each mammary line, and these are the precursors to the rear and fore quarters of each half of the udder. The mammary bud then inundates the mesenchyme until the entire bud has receded into the mesenchyme with the exception of a small opening at the outermost edge causing a depression referred to as the mammary pit. At this stage of development the stromal tissue is well developed.

Prolific development of the mesenchume tissue surrounding the mammary bud during the second month of embryonic life marks the beginning of the formation of the teat. The mammary bud is forced above the surface of the surrounding epithelium in conjunction with the forming of a slight opening in the distal end of the bud.

A progressive invagination of Malpighian layer of cells during the end of the first trimester of pregnancy forms the primary mammary cord. The primary mammary cord proceeds along a path of least resistance as it invaginates the mammary bud. The primary mammary cord ultimately develops into the teat cistern, the gland cistern, and major ducts in the udder. Canalization of the primary mammary cord occurs at a fetal age of approximately 100 d (Schmidt, 1971) with the separation of cells at the center of the primary mammary cord. This separation of cells begins at the proximal end and progresses toward the distal end forming the teat lumen.

At 4 mo of fetal age the tip of the mammary bud is opened, the cells of the mammary bud have developed characteristics similar to that of the epidermal layer of the skin, and the gland cistern has become well defined. Continual separation of cells towards the distal end results in the formation of the teat cistern. The streak canal is the final part of the primary mammary cord to become canalized.

At approximately 13 wk of fetal age several secondary sprouts branch off of the terminal end of the primary mammary cord. These ultimately give rise to the duct system in the mature mammary gland. Further development of the duct system becomes quiescent at this time in the fetus.

It is believed that the development of the mammary gland during the fetal stage of development is completed by 6 mo (Schmidt, 1974). At birth the teats are well developed, the teat and gland cisterns are well defined, secondary mammary cords are present, the nonsecretory tissue of the udder is well developed, and vascular systems of the udder are comparable to that in the adult.

Mammary Gland Development (Birth to Puberty)

There is very little new development is the mammary gland from birth to puberty. Most of the growth during this stage of development is attributed to an increase in connective tissue and deposition of adipose tissue in the mammary gland. The growth of the mammary gland during the early postnatal period is thought to be isometric with that of the growth of the body. The udder continues to develop to some extent in that the ducts continue to grow and attain the shape of those characteristic of the mature udder. The capacity of the udder increases during this time frame. The quarters continue to grow until the front and rear quarters become attached at the base.

Mammary Gland Development (Puberty)

Approximately 2 mo prior to the first estrus marks the bebinning of a time of rapid parenchymal proliferation (Cowie and Buttle, 1974). Sinha and Tucker (1969) observed that during the immediate 2 mo period following birth the deoxyribonucleic acid content of the mammary gland in 65 Holstein heifers increased 1.6 times faster ($P < .01$) than body weight. At 5 to 9 mo of age Sinha and Tucker (1969) noted the comparable value increased to 3.5 and then declined to 1.5 at 9 to 12 mo of age. Between d 20 and the day of estrus during the estrous cycle an increase of 118% was observed in the deoxyribonucleic acid content of the mammary gland but declined thereafter (Sinha and Tucker, 1969). This development of the mammary gland after puberty with each estrous cycle is attributable to the hormones of the ovary (estrogen and progesterone) in conjunction with prolactin and somatatrophin (STH) from the anterior pituitary (Turner and Gardner, 1931). Sinha and Tucker (1969) observed that the highest sustained levels of prolactin in the pituitary gland occurred within 3 d prior to ovulation with minimal levels occurring during the time of ovulation. It is during the first estrous cycle of puberty and subsequent estrous cycles that accelerated growth of buds and branches from the sides and ends of the secondary and tertiary sprouts is observed. This final bud resulting from the branching and rebranching is thought to be the precursors to the alveoli (Schmidt, 1971). Swanson and Poffenborger (1979) suggest that this continuous development of the mammary gland associated with puberty and recurring estrous could result in mammary glands of heifers of advanced sexual maturity at conception starting development more advanced than mammary glands of heifers which conceive at a more immature stage of sexual development.

Histologically, at estrus the alveolar lumina are filled with a secretion. The epithelium of these small ducts are cuboidal in shape. During the progestation phase (diestrus) the lumina are void of any secretion and the epithelium is columnar in shape.

The majority of tissue making up the udder during this time frame of development is adipose tissue. This suggests that there is some regression proliferation of mammary cells associated with estrus during the later portions of the cycle (progestational phase).

Mammary Gland Development (during Pregnancy)

It is during pregnancy that the major portion of mammary growth is achieved and further development of the duct system occurs. The amount of growth is dependent upon the amount present at the initiation of the pregnancy. Cowie and Buttle (1974) state that the intensity of the growth of the duct system during pregnancy is dependent on the age of the individual animal since in older animals a considerable amount of duct growth will have occurred prior to conception. Hammond (1927) observed that contradictory to the above there was very little development in the length of the ducts in the mammary gland during the gestation period. The further development of the duct system augmented by the extension and branching of the duct system present prior to conception leads to the emergence of small interlobular ducts and eventually the alveoli. The lobulo-alveolar system progressively displaces the adipose tissue of the stroma in the mammary gland. Development of the secretory tissue becomes evident during the fourth month of pregnancy (Schmidt, 1971; Cowie and Buttle, 1974). During the last trimester of pregnancy secretory tissue continues to develop with the emergence of new alveoli (hyperplasia) and through hypertrophy as the alveoli begin to display secretory activity. The noted enlargement of the mammary gland during the last 2 mo of pregnancy is a result of the alveoli becoming enlarged from the accumulation of secretory material.

With each successive pregnancy there is further development of the mammary gland up to the point that mature size is attained. This probably is the reason that maximum milk production is not achieved until the third or fourth lactation (Wada and Turner, 1959; Klett et al., 1962; Christian et al., 1965; Melton et al., 1967b; Todd et al., 1969; Rutledge et al., 1971). Figure 1 graphically shows the dynamics of mammary growth during pregnancy, lactation, and the drying period.

Mammary Gland Development (during Lactation)

Though most of the development of the secretory tissue is completed prior to parturition, additional growth does take place during the early portion of the lactation. This additional growth continues up until the peak of lactation, when the DNA content of the mammary gland is at its maximum level (Schmidt, 1971). Very little growth takes place after the peak lactation period.

Hormonal Control of Mammary Growth

Lasfargues and Murray (1959) concluded that growth hormone was involved with the development of the mammary epithelium during the embryonic stage of development in mice. Of the several other hormones evaluated by Lasfargues and Murray (1959), prolactin appeared to be responsible for stimulating the adipose tissue and the epithelium to prepare for lactation. Estradiol stimulated the adipose tissue and progesterone was responsible for promoting the degeneration of