Bovine postpartum reproductive performance after obstectrical assistance

by Daniel Edward Doornbos

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

Abstract:
Sixty-two 2-year-old heifers and 65 cows, 4 to 7 years of age were used at the Livestock and Range Research Station, Miles City, Montana in 1976 to study effects of precalving feed level (FEED) and obstetrical assistance at birth (ASST) on postpartum interval (PPI), percent of females exhibiting estrus the first 21 days of breeding (CY21), first service pregnancy rate (PGlS), pregnant the first 21 days of breeding (PG21) and total pregnancy rate after a 45 day AI season (PG45). Sixty days prior to the median calving date all females were scored for body condition (CS) and separated by age (2 and mature). Females within each age and feed group were fed either 135% (H) or 110% (M) of NRC (1976) in feedlots and assigned within age and feed group to either early (E) or late (L) obstetrical assistance. Early females received assistance as early in stage 2 of parturition as possible. Late females calved unassisted unless emergency assistance was required to deliver a live calf. Eighty-two percent of E females were assisted while 15% of L females required assistance. After calving, females went on range supplemented with hay and a salt-grain mix until adequate forage (May 1). For the remainder of the study they were on range forage only. Pregnancy and weaning data were collected at the termination of the study in October. Least-squares independent variables were: age of dam (AGE), FEED, ASST, sex of calf, AGE x FEED, AGE x ASST, FEED x ASST. Dependent variables were PPI, CY21, PGlS, PG21, PG45 and calf weaning weight (WWT). Assistance at birth affected PGlS ($P<.10$), PG21 ($P<.05$) and PG45 ($P<.10$) but had no significant affect on PPI or CY21. PPI, CY21, PGlS, PG21 and PG45 for E and L 2-year-old heifers were (x) 61.2, 64.0 days; 82.2, 72.2%; 72,2, 42.7%; 63.5, 33.9%; 87.7, 68.4%, respectively; for E and L mature cows were 45.2, 44.9 days; 92.4, 82.2%; 78.2, 72.4%; 73.9, 60.8%; 89.1, 82.7%, respectively; and for H and M fed females were 52.4, 55.2 days; 81.8, 82.7%; 65.8, 69.5%; 55.9, 60.1%; 76.8, 87,1%, respectively. Calf birth weight and weaning weight for H and M fed females were 33.8, 33.6 kg; 171.3, 175.3 kg, respectively, Duration of labor (interval from onset of stage 2 to birth) was 30.5 minutes less in L mature cows than in L 2-year-olds ($P<.05$). Eighty percent of mature cows were in stage 2 thirty minutes or less with a maximum of 60 minutes. Maximum length of stage 2 in 2-year-olds was 120 minutes with 41% in stage 2 thirty minutes or less. A one minutes increase in duration of labor lengthened PPI .2 days ($P<.10$), lowered CY21 .7% ($P<.05$) and decreased PG45 .6% ($P<.10$). This study suggests: (1) early obstetrical, assistance improved reproductive performance and (2) a negative relationship exists between duration of labor and reproductive performance.

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Signature Daniel E. Doornbos

Date July 28, 1978

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AFTER OBSTETRICAL ASSISTANCE

by

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A thesis submitted in partial fulfillment
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ABSTRACT

Sixty-two 2-year-old heifers and 65 cows, 4 to 7 years of age were used at the Livestock and Range Research Station, Miles City, Montana in 1976 to study effects of precalving feed level (FEED) and obstetrical assistance at birth (ASST) on postpartum interval (PPI), percent of females exhibiting estrus the first 21 days of breeding (CY21), first service pregnancy rate (PG1S), pregnant the first 21 days of breeding (PG21) and total pregnancy rate after a 45 day AI season (PG45). Sixty days prior to the median calving date all females were scored for body condition (CS) and separated by age (2 and mature). Females within each age and feed group were fed either 135% (H) or 110% (M) of NRC (1976) in feedlots and assigned within age and feed group to either early (E) or late (L) obstetrical assistance. Early females received assistance as early in stage 2 of parturition as possible. Late females calved unassisted unless emergency assistance was required to deliver a live calf. Eighty-two percent of E females were assisted while 15% of L females required assistance. After calving, females went on range supplemented with hay and a salt-grain mix until adequate forage (May 1). For the remainder of the study they were on range forage only. Pregnancy and weaning data were collected at the termination of the study in October. Least-squares independent variables were: age of dam (AGE), FEED, ASST, sex of calf, AGE x FEED, AGE x ASST, FEED x ASST. Dependent variables were PPI, CY21, PG1S, PG21, PG45 and calf weaning weight (WWT). Assistance at birth affected PG1S ($P<.10$), PG21 ($P<.05$) and PG45 ($P<.10$) but had no significant affect on PPI or CY21. PPI, CY21, PG1S, PG21 and PG45 for E and L 2-year-old heifers were ($\bar{x}$) 61.2, 64.0 days; 82.2, 72.2%; 72.2, 42.7%; 63.5, 33.9%; 87.7, 68.4%, respectively; for E and L mature cows were 45.2, 44.9 days; 92.4, 82.2%; 78.2, 72.4%; 73.9, 60.8%; 89.1, 82.7%, respectively; and for H and M fed females were 52.4, 55.2 days; 81.8, 82.7%; 65.8, 69.5%; 55.9, 60.1%; 76.8, 87.1%, respectively. Calf birth weight and weaning weight for H and M fed females were 33.8, 33.6 kg; 171.3, 175.3 kg, respectively. Duration of labor (interval from onset of stage 2 to birth) was 30.5 minutes less in L mature cows than in L 2-year-olds ($P<.05$). Eighty percent of mature cows were in stage 2 thirty minutes or less with a maximum of 60 minutes. Maximum length of stage 2 in 2-year-olds was 120 minutes with 41% in stage 2 thirty minutes or less. A one minutes increase in duration of labor lengthened PPI .2 days ($P<.10$), lowered CY21 .7% ($P<.05$) and decreased PG45 .6% ($P<.10$). This study suggests: (1) early obstetrical assistance improved reproductive performance and (2) a negative relationship exists between duration of labor and reproductive performance.

INTRODUCTION

Percent calf crop and the weaning weight of calves are two traits of primary importance to producers. Factors which affect these two traits influence production and the net return from a herd of cattle. Reproductive performance has a direct effect on calf crop produced and if reproductive performance is improved then calf crop can be increased. Improved reproductive performance can be achieved by getting cows to exhibit estrus and become pregnant early in the breeding season. Cows that breed and conceive early will calve early, resulting in older and heavier calves at weaning.

It is known that pre- and postcalving nutrition play important roles in postpartum reproduction. What levels of nutrition during these two periods are required for satisfactory postpartum reproductive performance, and what levels will increase that performance?

Dystocia is another factor that has been shown to increase calf losses and lower postpartum reproductive performance. Proper management of dystocia can increase calf crop, but some important questions arise when deciding what "proper management" of dystocia is in a herd of cattle. When dystocia occurs, how should it be managed? Is it the dystocia or how it is handled that lowers performance of the cow? Does obstetrical assistance at birth actually cause the lower performance?

Objectives of this study were:

1. Determine the effect of obstetrical assistance at birth on postpartum reproduction and calf production.

2. Study the effect of two levels of precalving nutrition on postpartum reproductive performance.

REVIEW OF LITERATURE

More calves are lost at the time of birth than in the period from birth until weaning. Calf losses at birth ranged from 4 to 14%, which were 2 to 6% higher than losses from birth to weaning (Bellows, 1972; Temple, 1973). In a six-year period at the U. S. Range Livestock Experiment Station, Miles City, Anderson and Bellows (1967) reported that 79% of the calves lost were anatomically normal and injury due to dystocia was the most common cause of death. Laster and Gregory (1973) postulated that the higher loss during both periods was due to added stress on the calf as a result of dystocia. If dystocia occurs then improved management and proper obstetrical assistance should reduce calf losses from dystocia by 50% (Bellows *et al*., 1971b; Bellows, 1972).

Parturition

Normal parturition or birth in the cow is a continuous process, but can be divided into three stages, (Arthur, 1966; Roberts, 1971; Hafez, 1974). The first or preparatory stage is characterized by dialation of the cervix and rhythmic contractions of the uterine muscles which position the fetus for delivery. Initially the contractions occur about every 15 minutes and last for approximately 20 seconds. They gradually increase in strength and frequency as labor progresses. When stage 1 is completed, the cervix will be fully dialated and, in a normal presentation, the head and feet of the calf will be entering the pelvic inlet. The fetus and chorioallantois are forced into the anterior pelvic inlet, the chorioallantois ruptures and the allantoic fluid flows from the vulva. This is followed by the second stage which terminates with expulsion of the fetus. The amnion, feet, legs and head of the fetus are forced into the birth canal by uterine contractions. Contractions of the diaphragm and abdominal muscles of the cow are then stimulated and the combined force pushes the fetus toward the vulva and finally to the outside. Expulsion of the fetal membranes composes stage 3, the final stage of parturition. Uterine contractions expel the placenta after the cotyledon attachments have separated from the uterus.

The amount of time required in any of the three stages varies among breeds and individuals within a breed, but usually falls within certain ranges (table 1). Young (1968b) cautions that for delivery of a live calf, heifers should not be left alone longer than 4 hours after appearance of the amniotic sac or a fetal extremity before giving assistance.

TABLE 1. TIME (HOURS) REQUIRED FOR VARIOUS STAGES OF PARTURITION IN THE COW

	Prepratory state	Expulsion of fetus (es)	Expulsion of placenta (s)
Range	0.5-24	0.5 to 4	0.5-8
Averge	2-6	0.5-1	4-5
Trouble if more than	6-12	in multiparous 2-3	12

(Taken from Roberts, 1956)

The initiation of parturition is very complex and not well defined, especially in cattle. At the time close to parturition in sheep there is a rise in fetal corticosteroids and a fall in maternal blood progesterone (Liggins, 1973). The exact mechanism which stimulates the fetal hypothalamus to trigger this chain of events is not known. An increase in progesterone catabolism in the ewe due to rising glucocorticoid levels could be responsible for the decline in progesterone seen in the last few days of gestation (Anderston et al., 1974). The rise of fetal corticosteroids in sheep, especially cortisol, produces an increase in estrogen secretation which stimulates myometrial production of $PGF_{2}\alpha$ resulting in the prepartum peaks of estrogen and $PGF_{2}\alpha$ (Liggins, 1972). In preparation for expulsion of the fetus, relaxin, secreted by the ovaries, has softened the cervix and relaxed the pubic ligaments to facilitate dialation of the reproductive tract and passage of the fetus (Turner and Bagnara, 1971; Ganong, 1975). Estrogen and possibly $PGF_{2}\alpha$ stimulate uterine contractions and start expulsion of the fetus (Liggins, 1973). Either $PGF_2\alpha$ (Liggins, 1973) or the neural stimulus of the fetus pressing against the cervix (Hafez, 1974), or both, stimulates oxytocin release in the later stages of labor to increase the frequency and magnitude of uterine contractions that combine with the abdominal contractions to expel the fetus.

If the first two stages of parturition are prolonged beyond the normal ranges it is a good indication that some type of difficulty in presentation is occurring. Abnormal presentation of the fetus is responsible for part of the incidence of difficulty at parturition but even in normal presentations difficulty is encountered. This has become more so with the increased use of sires of the larger breeds that increase calf size (Sagebiel et al., 1969; Laster et al., 1973). There are also major differences among sires within a breed in their potential to increase calving difficulty. Wiltbank (1972) found Hereford sires differed by as much as 27% and Angus sires by 31% in incidence of calving difficulty when bred to heifers.

Dystocia

Dystocia will be defined in this thesis as difficult or delayed parturition and can have an economic impact in several ways. Dams experiencing dystocia often require obstetrical assistance. When obstetrical assistance is given by a producer or a veterinarian and a live calf is delivered there is an added labor cost against the return from that calf. If assistance is necessary but the calf and/or the cow are lost the economic impact is great (Foulley et al., 1976). Even if the calf does not die as a result of dystocia there are other detrimental effects. Although Konnerman et al. (1969) reported no effect on milk production in dams experiencing dystocia, Foulley et al. (1976) found that in French breeds where dystocia required caesarean delivery a reduction of as much as 33% occurred in milk production. When milk production is already limiting as in two-year-old primiparous heifers or in breeds of lower milking ability the effect of dystocia would result in fewer pounds of calf weaned. Subsequent fertility is also reduced and results in lower pregnancy rates in females requiring caesarean delivery. Depending on the degree of dystocia, French workers (Foulley et al., 1976) indicated a decrease of 8.7 to 33.7% in pregnancy rate due to dystocia in the French breeds (table 2).

Of equal economic importance to the producer is the reduction or loss of future calf production by the cow due to dystocia (Brinks et al., 1973; Laster et al., 1973). Brinks et al. (1973) determined that Hereford heifers experiencing dystocia as two-year-olds weaned 11% fewer calves their first year and 14% fewer calves the second year when compared to contemporaries having no dystocia as two-year-olds. Of the cows weaning calves as three-year-olds those that had dystocia as two-year-olds calved later and weaned lighter calves than those having no dystocia at two years of age. Laster et al. (1973)

TABLE 2. FRENCH BEEF BREEDS (PERCENT OF PREGNANT MAINE-ANJOU, CHAROLAIS AND LIMOUSIN HEIFERS AND COWS, INSEMINATED DURING 60 TO 70 DAYS, IN PURE AND CROSS, ON NATURAL OESTRUS FOR MORE THAN 80%)

Calving condition	1972		1973				Overall	
	1st calving at 2 years		1st calving at 3 years		2nd calving at 3 years		Number	Percent
	Nb	%	Nb	%	Nb	%		
Without help	38	92	17	94	42	76	97	85.6 (0)
With help	69	76	15	80	46	78	130	76.9 (-8.7)
Caesarian	31	61	7	29	14	43	52	51.9 (-33.7)
Number =	138		39		102		279	

{Data from the crossbreeding experiment between French beef breeds, BOURGES - (I.N.R.A.)}
Taken from Foulley *et al*. 1976.

showed that in Hereford and Angus dams bred to the large European sire breeds dystocia reduced the percentage of cows detected in estrus in a 45-day AI season by 14.4% and resulted in a 15.6% lower pregnancy rate to AI. The effects were more pronounced for the two-year-old heifers than the three-, four- and five-year-old cows.

Dystocia is a result of many factors contributed by both the cow and calf (Bellows et al., 1971a and 1971b; Prentiss, 1971; Rice and Wiltbank, 1972; Bellows, 1976). The major factor affecting dystocia is a disproportion in the size between the fetus and the pelvic area and birth canal of the dam (Wright, 1958; Lindhe, 1966; Williams, 1968; Young 1970; Rice and Wiltbank, 1972, Price, 1974). The single most important cause of this disproportion is the birth weight of the calf (Bellows et al., 1971b; Rice and Wiltbank, 1970a and 1970b; Bellows, 1976; Foulley et al., 1976). Sloss et al. (1967) found three times as many dystocias caused by fetal factors than maternal effects. Thus, the effects of variables contributing to calving difficulty are expressed through birth weight of the calf and size of birth canal of the dam.

Fetal Factors

The factors affecting dystocia that are associated with the calf include sire and dam of calf, gestation length, sex of calf and birth weight. Laster et al. (1973) analyzed sire breed, dam breed, dam age and calf sex without including birth weight and found a significant effect on dystocia for all variables considered. However, when birth weight was added as a covariate then dam age was the only significant main effect, suggesting that the others had their effect through an influence on birth weight. Body measurements of the calf other than birth weight have not been shown to be significantly related to dystocia (Laster, 1974) although they are highly correlated with birth weight (Boyd and Hafs, 1965; Wilson, 1973). Laster (1974) explained that increased birth weights were apparently a result of an increase in soft tissue rather than larger skeletal size. The five calf shape measurements used (shoulder width, hip width, chest depth, wither height and body length) had no effect on dystocia score when considered independent of birth weight.

The effect of sire and dam of calf on dystocia is genetically determined at the time of fertilization (Bellows, 1976) and will be expressed in the birth weight and size of the calf (O'Mary and Coonrad, 1972; Joandet et al., 1973; Sagebeil et al., 1973; Long and Gregory, 1974; Foulley et al., 1976). The larger European breeds of sire used in crossbreeding programs tend to increase birth weights and consequently increase dystocia (Laster et al., 1973; O'Mary and Hillers, 1976; Smith et al., 1976). However Bellows (1976) pointed out that calving difficulty and resulting losses were present before the imported breeds were introduced. An explanation given for this was that common selection indexes for economically important traits, such as weaning weight, yearling weight and 18-month weight also indirectly select for increased birth weight. Heritability of birth weight was 0.48 and sires with high birth weights tend to produce calves with high birth weights. Since increased birth weights result in more dystocia, the selection indexes used by many producers have indirectly selected for increased calving difficulty. This was in agreement with Dickerson et al. (1974), who further expanded this to show that for every kilogram increase in birth weight there was a 1% decrease in calf crop. This decrease was a combination of higher calf mortality and decreased pregnancy rates due to more dystocia. The increased dystocia and higher calf losses increased the annual operating cost per cow by over 26%.

There is positive correlation between gestation length and birth weight. The longer the gestation length the heavier the birth weight (Jafer et al., 1950; Davis et al., 1954; Granola et al., 1972). Length of gestation varies among breeds and among sires within breeds (Boyd and Hafs, 1965). Crockett and Kidder (1967) also indicate that the sire contribution to the genotype of the calf significantly affects gestation length. The sire appears to influence birth weight and gestation length more than the dam (Everett and Magee, 1965) although calves from younger cows have a shorter gestation than those from older cows (Anderson and Plum, 1965) and primiparous heifers have calves with lighter birth weights than older cows (Tyler et al. 1947).

The effect of gestation length on calving difficulty has been shown to be through an increase in the birth weight due to longer gestation (Bellows, 1976).

Assistance at birth was required more frequently for male than female calves (Bellows et al., 1971b; Wilson et al., 1976) and male calves tended to have a longer gestation length and be heavier at birth than females. Koonce and Dillard (1967) reported similar results for the relation between sex of calf and gestation length. Laster et al. (1973) reported a difference of 3.0 kg in birth weight and 11.4 % in calving difficulty between male and female crossbred calves. Other research has documented the effect of calf sex on birth weight reporting males to be 1 to 3 kg heavier than females (Gregory et al., 1950; Koch et al., 1959; Lasley et al., 1961; Ellis et al., 1965; Franke et al., 1965; Long and Gregory, 1974). Likewise, male calves have consistently been shown to have a higher precentage of dystocia than female calves (Sagebiel et al., 1969; Bellows et al., 1971b; Nelson and Huber, 1971; Brinks et al., 1973; Tong et al., 1976).

Values of R^2 consistently indicated that less than half of the variation in birth weight and dystocia has been accounted for even though much work has been done in this area. Bellows et al. (171b) could only account for about 45% of the variation in dystocia scores and 37% and 22% of the variation in birth weight within Hereford and Angus dams. Laster (1974) reported 39% of the variation in percentage of dystocia was due to the factors studied. Brinks et al. (1973) studied calving difficulty first as a trait in the calf and then as a trait of the cow. When all calvings were considered, 17% of the variation in dystocia was due to the factors attributed to the calf and 16.1% was from the factors associated with the dam. Less than 40% of the variation in dystocia was accounted for in either study, indicating a need for more research to determine the cause of the other 60%.

Dam Factors

Important variables attributed to the dam include age (Brown and Galvez, 1969; Brinks et al., 1973; Laster et al., 1973; Foulley et al., 1976) and pelvic area (Bellows et al., 1969; Rice, 1969; Rice and Wiltbank, 1970a and 1970b; Bellows et al., 1971b, Rice and Wiltbank, 1972; Laster, 1974; Bellows, 1976; Foulley et al., 1976).

Age of the dam affects dystocia through birth weight and pelvic area. In Hereford and Angus cows, Brown and Galvez (1969) found nearly 6% of the total variation in birth weight was caused by age of dam. The effect of birth weight on calving difficulty is highly significant (Rice and Wilbank, 1970a and 1970b; Bellows et al., 1971b; Ward, 1971; Ward, 1973; Cundiff et al., 1975). As the birth weight increases the incidence of dystocia increases (Sagebiel et al., 1969; Nelson and Huber, 1971). However, when birth weights become too low calf survivability decreases (Hight, 1966; Koger et al., 1967). Laster et al. (1973) reported dystocia increases 2.3 ± 0.2% for each kilogram increase in birth weight. This increase in dystocia disappears as age of dam increases (Foulley et al., 1976).

Birth weights increase with age up to about six to seven years of age and then begin to decline slightly (Dawson et al., 1947; Flower et al., 1963; Ellis et al., 1965). The largest increase in birth weight is observed between the first and second calf (Burris and Blunn, 1952; Koch and Clark, 1955). However, lighter birth weights found in heifers and young cows does not necessarily result in less dystocia (Laster and Greogry, 1973). Dystocia in two-year-old cows was approximately 36% higher than in three-year-olds and about 45% higher than in four- and five-year-old cows (Laster et al., 1973). Tong et al. (1976) also reported older cows experienced fewer difficult births. Brinks et al. (1973) stated that two-year-old dams experienced the most dystocia of any age group, and three- and four-year-olds had more difficulty than mature cows. After 10 years of age the incidence of dystocia increases again. Even though birth weights are larger in mature cows the incidence of dystocia is much less than in young cows.

Rice and Wiltbank (1972) found that dystocia was high (69%) in Hereford heifers with pelvic area of less than 200 cm^2. Price (1974) found that beef heifers with small pelvic openings had a higher rate of dystocia regardless of calf size. However, heifers with large pelves experienced high rates of dystocia when delivering very large calves. Laster (1974) stated that even though large two-year-old cows have larger pelvic openings they also tend to have calves with heavier birth weights. This relationship was reported by Young, 1968a; Bellows et al. 1969; Prentiss, 1971. Bellows (1976) pointed out that a heifer with a small pelvic opening at breeding would still have a relatively small pelvic opening at calving. In growing heifers, pelvic area was influenced by age but as the animal matured this became less important (Rice and Wiltbank, 1970b). Stimulating skeletal growth in heifer calves increased pelvic size but this tended to disappear with time (Lesmeister et al., 1972). The pelvis of the primiparous heifer continued to grow up to the time of parturition although the growth in the last 50 days of gestation was not significant (Prentiss, 1971; Fitshugh et al., 1972).

Generally larger and/or older cows have calves with heavier birth weights (Gregory et al., 1950; Bellows, 1976) and larger pelvic size (Singleton et al., 1973). Bellows et al. (1965 and 1971a) found that body size of three-year-old primiparous Hereford heifers, as measured by body weight, hip width and rump length, accounted for 36% of the variability in pelvic area. Body weight was the largest source of variation in pelvic area, which agreed with the results of Laster (1974). As calf size increases there must be a corresponding increase in pelvic area or the level of dystocia will increase. Reducing birth weight while maintaining cow pelvic size would reduce dystocia

(Monteiro, 1969).

Dystocia has been scored numerically to indicate degree of difficulty (Rice, 1969; Sagebiel _et al._, 1969; Bellows _et al._, 1971b; Prentiss, 1971; Brinks _et al._, 1973; Laster _et al._, 1973; Price, 1974). However, if little or no calving difficulty was encounted then only one discrete class with no variation was available. O'Mary and Hiller (1976) used timed intervals during the calving process to have continuous variation in degree of difficulty in a herd of Angus cows known to have little dystocia. They found breed of sire had an effect on calving time, gestation length and birth weight. Charolais sired calves took longer to be born, had longer gestation length and heavier birth weights than calves from Angus sires. Male calves were heavier at birth than females but sex of calf had no effect on calving time. No information was presented on the subsequent reproductive performance of these animals.

<u>Nutrition and Dystocia</u>

Attempts to control dystocia through alteration of the gestation feed level have shown that reducing feed level prior to calving has little or no effect on calving difficulty (Bellows, 1976). Wiltbank _et al._ (1965) markedly decreased birth weight in heifers fed a low energy level compared to a high and medium energy level, but did not decrease calving losses. The low energy level was calculated to maintain body weight while the high level heifers were fed _ad libitum_.

Calf losses at birth in heifers on the high energy level were not due to increased birth weight but rather to excessive fat in the pelvic area and high incidence of posterior presentation at birth (table 3). Similar results were obtained by Young (1970) who decreased birth weight by approximately 2.5 kg, and Corah et al. (1975), where birth weights were reduced by 2.0 kg. Corah et al. also reported a 7% increase in calf losses at birth in the dam on restricted energy levels.

TABLE 3. LEVEL OF ENERGY AND CALF LOSSES (TWO-YEAR-OLD COWS)

	Level of energy		
	High	Medium	Low
Heifer weight after calving (kg)	493	392	277
Condition at calving	Extremely fat	Good flesh	Thin
Number of cows calving	22	22	18
Calves living at birth	18	21	17
24 hours	12	21	17
2 weeks	10	21	17
Weaning	9	21	17
Avg birth weight (kg)	28	28	21
Gestation length (days)	278	277	280

(From Wiltbank, 1974).

Comparison of low, medium and high protein levels in the same study (Wiltbank et al., 1965) gave little evidence that decreasing protein levels prior to calving will decrease calving difficulty. However, when the feed level was restricted in young heifers, they were smaller at calving due to reduced body growth, which included skeletal size and pelvic area (Bellows, 1976). This in turn led to increased incidence of dystocia (table 4). On the other extreme, Arnett et al. (1971) fed heifers to obesity and observed 50% more dystocia in the obese heifers than in the "normal" heifers. Obese heifers averaged 219 kg heavier than their "normal" contemporaries at first calving as three-year-olds. In addition to this the "normal" heifers required fewer services per conception, lost fewer calves at birth and weaned more calves. Wiltbank et al. (1965) postulated that breeding heifers to bulls that would sire calves with smaller birth weights would be a more effective approach than restricting feed for reducing dystocia.

TABLE 4. EFFECTS OF REARING NUTRITION ON REPRODUCTION, PELVIC AREA AND CALVING DIFFICULTY IN HEIFERS

	Winter gain group[a]	
Item	Low	High
No. heifers	30	59
Avg daily gain-winter (kg)[b]	.3	.6
Avg daily gain-summer (kg)[c]	.6	.5
October pregnancy (%)	50	86
Precalving pelvic area (cm^2)	240	252
Calving difficulty (%)	46	36

[a]All heifers handled the same after winter period.
[b]December 6 to May 6.
[c]May 7 to October 17
(Bellows, 1976).

Nutrition and Postpartum Reproduction

Wiltbank et al. (1973) stated that two of the important causes of reproductive failure in three different regions of the United States were: (1) the number of cows in estrus the first 21 days of the breeding season and (2) the number of cows conceiving at first service. These two factors have a direct effect on the number of cows becoming pregnant during the breeding season.

The length of the interval from calving to first estrus, or the postpartum interval, determines whether or not a cow will exhibit estrus early or at all in the breeding season and consequently whether ot not she will become pregnant. Casida (1968) reported postpartum intervals in beef cows ranging from 46 to 104 days. Factors influencing the length of this interval included nutrition, suckling, age of dam and calving date.

Restricting prepartum feed levels resulted in a reduction in the number of cows exhibiting estrus early in the breeding season (Wiltbank et al., 1965; Bellows, 1976). Low levels of energy both before and after calving can markedly affect reproduction in cows suckling a calf (Wiltbank et al., 1962 and 1964; Dunn et al., 1969; Zimmerman et al., 1961) by increasing the length of the postpartum interval and reducing the percentage of cows in estrus early in the breeding season. Likewise, cattle on a continuous low level of protein, disregarding level of energy, will have a longer postpartum interval and many cows will fail to exhibit estrus during the breeding season (Vetter and Weber, 1974). Wiltbank (1973) explained that low levels of protein caused a decrease in appetite which resulted in a decrease in energy intake. However, too high a protein diet may decrease overall fertility and life span (Pinney et al., 1962) Although no explanation was offered as to why this might occur.

Heifers restricted in protein or energy intake prior to calving but fed a compensatory high postpartum ration showed no difference in conception rate compared to heifers fed for continuous growth (Bond and Wiltbank, 1970). Whitman (1975) reported that cows gaining weight before calving had a higher likelihood of exhibiting estrus at 50 days postpartum than cows losing weight before calving. Dunn et al. (1969) also showed that the postpartum interval could be shortened by feeding a high precalving energy level. Mature cows gaining weight after calving have been shown to have higher overall pregnancy rates than cows losing weight, regardless of prepartum feed levels (Schilling and England, 1968; Wiltbank, 1973).

The decrease in pregnancy rates due to low postcalving levels of energy or protein was caused by cows failing to show estrus (Wiltbank et al., 1962; Vetter and Weber, 1974). This delay in postpartum estrus had been explained by Wiltbank et al. (1964); Casida (1968); Oxenreider and Wagner (1971); Gombe and Hansel (1973); Dunn et al. (1974) as a possible reduction in follicular growth and ovarian activity.

The suckling stimulus also prolongs the postpartum interval (Wiltbank and Cook, 1958; Short et al., 1972; England et al., 1973). Nutrient requirements for lactation appear to be in competition with the requirements for reproduction (Wilbank, 1973) and when requirements for both are not met then reproduction is adversely affected. This is especially true in young cows because of the added requirement for body growth as well as lactation and reproduction (Crockett, 1973; Wiltbank, 1974). As crossbreeding introduced more milking ability into range cows, the postpartum interval was prolonged and conception rates were lower unless sufficient levels of nutrients were supplemented to compensate for the added requirements (Holloway et al., 1975). Short et al. (1972) found that even after feed levels had been adjusted for lactation requirements, nonsuckled and mastectomized females still had shorter postpartum intervals, indicating an effect other than just nutrition. The interval from calving to first estrus in lactating females was longer in younger than in older cows (Wiltbank et al., 1961). However, if cows were fed according to the nutritional requirements of their respective age then the postpartum intervals were similar for all age groups (Warnick, 1955; Wiltbank et al., 1964; Dunn et al., 1969).

The later in the spring a cow calves, the shorter her postpartum interval (Warnick, 1955; L. W. Varner, unpublished data). One explanation offered for this was that cows calving later in the spring were closer to green grass and meeting their nutritional requirements, especially if they were on winter range with no supplement. On the other hand, if they were supplemented during the winter then later calving cows would be on the supplemental feed longer, which would tend to shorten the postpartum interval (R. A. Bellows, personal communication). This is not to say that it would be desirable for cows to calve late in the season. It has been shown that first service conception rate increases until approximately 90 days after calving (table 5) indicating a longer interval between calving and breeding would improve conception rates at first service. Shannon _et al_. (1952) concluded a minimum of 50 days postpartum resulted in best fertility. Therefore, it would be desirable to have cows calve early in the season to allow them this longer interval and keep them on a 12-month calving interval. Perhaps some optimum calving date could be reached that would take advantage of the shorter postpartum intervals and not adversely affect conception rates.

TABLE 5. CONCEPTION RATE AT FIRST SERVICE AFTER PARTURITION

Days postpartum	Percent first service conception	
	Dairy cattle	Beef cattle
0-30	39	33
31-60	53	58
61-90	62	69
91-120	62	74

(Casida, Hauser and Tyler, 1968)

If insufficient forage was the cause of the longer postpartum intervals then supplementation should increase reproductive performance (Speth et al., 1962; Reynolds et al., 1964). The effects of supplementation have been reviewed (Lamond, 1970), but when adequate levels of nutrition were already available reproductive performance was not increased by supplemental energy (Loyacano et al., 1974). Pendlum et al. (1976) reported similar results in growing heifer calves. Bellows and Thomas (1976) actually found a decrease in pregnancy rates by supplementing cows on range forage adequate for optimum reproductive performance. Feeding the supplemental grain reduced grazing time and subsequent forage intake and served as a substitute for range forage rather than a supplement.

Body condition of cows had an effect on nutritional requirements and reproductive performance (Wiltbank, et al., 1962 and 1964; Dunn, 1964; Whitman, 1975). Increased body condition at calving increased the probability of a cow exhibiting estrus at an early date (Whitman, 1975). Cows that were maintained in "optimum" condition did not show a change in postpartum interval due to different levels of precalving nutrition nor did they show a reduction in conception rate when fed low postcalving energy levels (McGinty and Ray, 1973). Wiltbank et al. (1962) stated that for mature beef cows the recommended NRC (1958) energy levels were adequate to promote reasonably high levels of reproductive performance.

Since body condition was not easy to measure, Klosterman _et al_. (1968) suggested that a weight-to-height ratio may be an objective estimate of body condition. Whitman (1975), in three separate unrelated studies found the following: (1) Body condition at calving affected the length of the postpartum interval. Cows in the first study in better condition had shorter intervals, (2) Weight-to-height ratio could be used in the second study to describe relative condition of mature beef cows. (3) Cows with higher weight-to-height ratios had shorter postpartum intervals in the third study.

MATERIALS AND METHODS

The study was conducted in 1976 at the Livestock and Range Research Station, Miles City, Montana. One hundred twenty-seven beef females of mixed breeding ranging in age from two to seven years of age were randomly assigned within age (two and mature) and predicted calving date to a 2^3 factorial arrangement of two precalving feed levels and two obstetrical assistance groups (table 6). Pregnant dams were assigned to their precalving feed treatment 60 days prior to the predicted median calving date of the group and females remained on treatment until they calved. The study was concluded in early October after weaning and pregnancy data were collected.

TABLE 6. FACTORIAL DESIGN (2^3) WITH NUMBER OF COWS USED IN THE STUDY

Time of obstetrical assistance	Feed Level: High, Early	High, Late	Moderate, Early	Moderate, Late	Total
Age of cow					
Two-year-old	18	14	15	15	62
Mature	17	15	17	16	65
Total	35	29	32	31	127

Dams had been bred in 1975 to either one Angus sire by artificial insemination or in one of two Hereford sire groups. One Hereford sire group consisted of Miles City Line 1, bred natural service, while the other was bred artificially to one of six Hereford sires. Breeding dates were known only for the artificially inseminated cows. Calving started on March 4, 1976. Heifers had been bred to calve two weeks earlier than cows resulting in a 70-day calving season.

On January 22, 1976, 60 days prior to the median predicted calving date, females were separated into their respective precalving feed groups. Each female received 3 million I.U. vitamin A at this time. All females were held in feedlots and group fed either a high or moderate feed level throughout the precalving period. These levels supplied 135 and 110%, respectively, of the requirements for pregnant beef females (NRC, 1976). The ration consisted of mixed grass alfalfa haylage with approximately 20% corn silage to allow it to pass easily through a mixer-feeder truck (table 7).

Amounts fed to females on the high precalving level were adjusted to maintian a slight weight gain in addition to the projected increasing weight of the fetus (table 8). Females on the moderate precalving feed level were fed 80% of the amount fed high level females. A mineral mix of 49% iodized salt, 49% dicalcium phosphate, 2% trace mineral and enough wheat bran to prevent caking was fed free choice throughout the entire study.

TABLE 7. PROXIMATE ANALYSIS OF RATION

Sampling week	D.M. %	Ash %	Ether extract %	Crude protein %	Crude fiber %	N.F.E. %
3/27 to 4/2	32.6	11.1	4.1	14.0	26.9	43.7
4/3 to 4/9	34.1	8.2	3.9	14.5	28.5	44.7
4/10 to 4/16	31.4	8.2	4.2	14.3	30.6	42.5
4/17 to 4/23	33.7	8.4	5.9	14.0	27.8	43.6
4/24 to 4/30	32.5	8.8	5.7	13.7	29.2	42.5
5/1 to 5/8	39.1	8.4	6.1	14.6	28.6	42.1
5/9 to 5/14	38.7	10.3	2.5	14.8	28.3	43.9
Mean	34.6	9.1	4.6	14.2	28.6	43.3

TABLE 8. AMOUNT OF RATION FED FOR EACH TREATMENT GROUP

Feed level	Cow age	Dry matter kg	T.D.N. kg	M.E. Per feeding	Fed from
High	Mature	11.0	6.6	23.9	1/22 to 2/5
Moderate	Mature	8.8	5.3	19.2	1/22 to 2/5
High	2	10.2	6.1	22.1	1/22 to 2/5
Moderate	2	8.1	4.9	17.7	1/22 to 2/5
High	Mature	11.8	7.1	25.7	2/6 to 2/26
Moderate	Mature	8.8	5.3	19.2	2/6 to 2/26
High	2	10.5	6.3	22.8	2/6 to 2/26
Moderate	2	7.9	4.7	17.0	2/6 to 2/26
High	Mature	14.2	8.5	30.7	2/27 to 3/12
Moderate	Mature	10.7	6.4	23.1	2/27 to 3/12
High	2	12.6	7.6	25.5	2/27 to 3/12
Moderate	2	9.4	5.7	20.6	2/27 to 3/12
High	Mature	13.2	7.9	28.6	3/13 to 3/22
Moderate	Mature	9.9	5.9	21.3	3/13 to 3/22
High	2	11.8	7.1	25.7	3/13 to 3/22
Moderate	2	8.8	5.3	19.2	3/13 to 3/22
High	Mature	13.2	7.9	28.6	3/23 to end of calving
Moderate	Mature	8.8	5.3	19.2	3/23 to end of calving
High	2	11.8	7.1	25.7	3/23 to end of calving
Moderate	2	7.9	4.7	17.0	3/23 to end of calving

Cow weight and condition scores were obtained for all females on Dec. 17, 1975 (before going on treatment), Jan. 22, 1976 (on treatment) and again on Feb. 11, 1976 and Feb. 26, 1976, and Mar. 31, 1976 on females that had not yet calved. All females were scored for body condition by palpating for fat over the back and ribs and scoring according to the method described by Bellows et al. (1971a), from 1 (thinnest) to 10 (fattest). The score was recorded as the sum of two independent scores given by two technicians. Cows were held off water 12 to 18 hr before each weighing. In addition, cow hip height and body length were measured on Feb. 11, 1976. Hip height was measured as the distance from an overhead board to the backbone midway between the hooks. This was later converted to centimeters of height from the floor. Body length was the distance from the highest point on the withers, along the back to the posterior surface of the pin bones. Pelvic height and width were also determined on Feb. 26, 1976 by pelvimeter measurements by the procedure described by Rice (1969). At approximately the middle of the calving season, March 31, all females that had not calved were again weighed, condition scored and pelvic measurements obtained in order to have data obtained closer to the actual calving date.

Cows were kept in feedlots and observed 24 hr daily throughout the calving season. When a cow was determined to be in stage 1 of parturition (exhibiting nervousness, kicking at her stomach in response to labor pains or showing other signs of impending parturition) she was watched closely to determine when stage 2 began. A female was considered in stage 2 of parturition whenever she started the abdominal press and/or the feet and membranes became visible, and lasted until the calf was on the ground. The length of stage 2 in minutes was then recorded as the duration of labor for the late assisted group.

Females assigned to the early obstetrical assistance group were moved to a calving stall at the first observed onset of stage 2 (as described above), restrained and obstetrical assistance used to deliver the calf regardless of real or potential dystocia. Dams in the late obstetrical assistance group were allowed to remain in labor until the calf was born or until a sufficient amount of effort had been expended by the female so that it appeared she could not deliver a live calf without obstetrical assistance. Need for assistance in the females was based on the opinion of experienced herdsmen.

All calving information was recorded at parturition. This included the date, time of day, duration of labor in minutes, calving difficulty score and vigor score were recorded. Calving difficulty was scored as:

1) No assistance
2) Minor obstetrical assistance, no calf puller used
3) Difficulty, calf puller used
4) Extreme difficulty including caesarean section
5) Abnormal presentation

Calf vigor was scored as:

1) Alive, normal and vigorous
2) Alive, but weak
3) Calf dead or died shortly after birth

Calves were number tagged for identification immediately after birth and their navel iodined. The cow and calf were weighed within 12 hr after calving and the calves were branded, number tattooed in both ears, dehorned with caustic paste, and male calves castrated with an elastrator band. If both the cow and calf were healthy, they were moved from the lots to a crested wheatgrass pasture within 24 hr after birth.

After calving, cows were fed alfalfa hay free choice with consumption averaging approximately 6.8 kg/day/head. In addition, a salt-grain mix (table 9) was fed as a supplement in self feeders (table 10) until terminated May 1 when sufficient forage was available. After May 1 cows were on range forage only for the remainder of the study. Percentage of salt in the ration was varied in an attempt to control consumption of the supplement. Free access to water and a salt-mineral mix was provided at all times.

TABLE 9. RATIONS FOR SALT-GRAIN SUPPLEMENT

Ration Component	20 Percent salt %	16 Percent salt %	12 Percent salt %
Ground barley	57.5	61.5	65.5
Bran	20.0	20.0	20.0
Dicalcium phosphate	2.0	2.0	2.0
Iodized salt	20.0	16.0	12.0
Trace minerals	0.5	0.5	0.5

TABLE 10. APPROXIMATE SUPPLEMENT CONSUMPTION

Added to self feeders				
Date 1976	Amount kg	Salt %	Approximate No. of animals[a]	Consumption kg/head/day
3/11	90.0	20	19	0.8
3/17	545.5	12	61	0.6
4/1	227.3	12	94	0.3
4/9	1909.1	12	112	2.4
4/15	227.3	20	124	0.5
4/19	454.5	12	130	1.2
4/22	454.5	16	142	0.5
4/28	227.3	20	145	0.8
4/30	454.5	20	147	1.5

[a]Number of animals was based on calving dates and varied from animals being added to pasture.

Postpartum estrus was detected by visual observation, morning and evening, with the aid of sterilized bulls with marking harnesses, and the dates recorded. All females were maintained together in the same pastures until the beginning of the breeding season.

On June 8, 1976 all dams and calves were weighed and the dams scored for body condition. Calves were vaccinated for blackleg and dams for vibriosis. Any dam not previously recorded as exhibiting estrus was palpated rectally to determine ovarian acitivity. If a corpus luteum was present, an estimated estrus date was assigned by palpable consistency of the corpus luteum, and the postpartum interval and the percent exhibiting estrus prior to the start of the breeding season calculated accordingly.

The herd was moved to the breeding pasture on June 11 and allowed several days of adjustment before breeding began on June 15. Dams were assigned at random to be bred to one of three Angus sires, one reference sire and two test sires in a 45-day artificial insemination season. Visual estrus detection was employed during all the daylight hours for the entire breeding season. Females in standing estrus between 10 pm and 10 am were bred at 6 pm the same day. Females in standing estrus between 10 am and 10 pm were bred at 6 am the next morning. All females were to receive 3 sec clitoral stimulation following artificial insemination but this was not started until the 10th day of the breeding season due to an oversight. This difference was ignored in analysis of the data.

Five pastures were used during the breeding season with the entire herd moved from pasture to pasture as forage became limited.

Dams were weighed and condition scored and calves weighed the day after the breeding season ended (July 30, 1976). All animals were treated with pour-on[a] pesticide for grub and lice control. Calves were vaccinated with Electroid "7" and IBR-PI_3.

The dams and their calves remained on native pastures until October 6 at which time the calves were weighed and weaned. Dams were weighed and condition scored and hip height and body length determined at weaning as described previously. Pregnancy rates were determined by rectal palpation.

[a]Rulene 25-E.

Statistical Analysis

The data were analyzed using least-squares analysis of variance with unequal subclass numbers (Harvey, 1960). Homogeneity of regression and standard partial regression coefficients were calculated according to Steel and Torrie (1960).

Independent variables in the least-squares analysis included obstetrical assistance at birth (early and late), precalving nutrition level (high and moderate), age of dam (two and mature) and sex of calf. Calving date, on treatment dam body condition score and calf birth weight were included as covariates. Calving date was used as a covariate to adjust all females to a constant calving date. Calf birth weight was used in an attempt to account for calving difficulty effects because actual calving difficulty was difficult to measure in the early assisted dams. When calving date and condition score were found to be significant for some of the reproductive parameters, precalving weight change (precalving WCHG), weight change from calving to start of breeding (WCHG 1), weight change from start to end of breeding (WCHG 2) and weight to height ration (WHR) were included as covariates in an attempt to account for more of the variation in reproductive parameters. All interactions for the main effects were included in a preliminary analysis of the data, but were removed if not a significant source of variation. The interactions of age of dam x precalving nutrition level, age of dam x assistance at birth and precalving nutrition x assistance at birth were included in all analysis because of hypothesis under test.

Variables used to measure postpartum reproductive performance were length of postpartum interval (PPI), percent exhibiting estrus (CY21) and pregnant (PG21) the first 21 days of breeding, first service pregnancy rate (PG1S) and total percent pregnant after a 45 day AI season (PG45). Production was measured by percent of calves alive at or near birth, percent of calves alive at weaning and calf weaning weight.

Dystocia was scored using the same scale in both early and late assisted females. However, since females assigned to the early assistance treatment would have a minimum score of 2, a score was created in a number of the females thus possibly causing a bias in the data for calving difficulty. There was no way of knowing if a dystocia score of 2, in an early assisted female would have occurred if she had been allowed to calve unassisted. Therefore it was necessary to make an individual least-squares analysis for the late assisted females to determine the incidence of dystocia and its relation to the reproductive parameters.

In addition, duration of labor in the late assisted females was added as a covariate in a least-squares analysis to determine if it had an influence on reproductive parameters.

Data from three-year-old females were analyzed separately due to their noticeably poorer body condition which was a result of different management prior to assignment to this study. These differences were reflected in their postpartum reproductive performance. Data are shown in appendix tables 1 and 2 without comment.

RESULTS AND DISCUSSION

Postpartum Reproduction and Calf Production

Least-squares analysis of variance (Table 11) indicated that obstetrical assistance at birth had no significant effect on length of postpartum interval (PPI), percentage of cows exhibiting estrus the first 21 days of breeding (CY21), or weaning weight of the calf (WWT, Table 12). The analysis did indicated that obstetrical assistance effected first service pregnancy rate (PG1S, P<.10), the percentage of cows becoming pregnant in the first 21 days of breeding (PG21, P<.01), and overall pregnancy rate (PG45, (P<.10).

Although PPI for females that had been assisted early in stage 2 of parturition was not different from females receiving only emergency assistance, 53.2 vx 54.5 days, respectively, other reproductive parameters differed according to how the female was managed during parturition. Ten percent more early assisted females exhibited estrus in the first 21 days of breeding and first service pregnancy rate was 15.1% higher. This resulted in a 21.3% increase in the percent pregnant the first 21 days of breeding for the early assisted females. This improvement combined with their higher pregnancy rate during the remainder of the 45 day AI season, resulted in a 12.8% increase in the total pregnancy rate (PG45) of the early assisted females (Table 13). Obstetrical assistance at birth accounted for 0.1, 1.7, 2.5, 4.5 and 2.8% of the variation in PPI, CY21, PG1S, PG21 and PG45, respectively.