MONTANA STATE UNIVERSITY

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
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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 (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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Date July 28, 1978

BOVINE POSTPARTUM REPRODUCTIVE PERFORMANCE
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.

Nutrition and Dystocia

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

Item	Winter gain group[a]	
	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

	Feed Level				
Time of obstetrical assistance	High		Moderate		
	Early	Late	Early	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.

TABLE 11. LEAST-SQUARES ANALYSIS OF VARIANCE FOR REPRODUCTIVE PARAMETERS OF HEIFERS AND COWS

Source of variation	d.f.	Mean squares				
		PPI	CY21	PG1S	PG21	PG45
Assistance (As)	1	48.7	3152.2	6996.9+	14020.6*	5109.9+
Precalving feed (F)	1	242.5	25.1	433.6	565.6	3391.0
Age of dam (A)	1	9753.4**	3219.3	7421.9+	10971.5*	1947.7
Sex of calf (S)	1	30.8	2714.9	2671.9	110.0	753.9
AxF	1	16.9	1129.4	2259.8	4164.9	1199.4
AxAs	1	72.1	.4	2634.6	2052.7	1260.9
FxAs	1	72.0	6617.9*	2509.9	8345.4+	4029.1+
Error	119	362.2	1378.7	2104.5	2257.9	1390.1

+P<.10
*P<.05
**P<.01

TABLE 12. LEAST-SQUARES ANALYSIS OF VARIANCE FOR CALF BIRTH WEIGHT AND WEANING WEIGHT

Source of variation	d.f.	Mean squares	
		Birth weight	Weaning weight
Assistance (As)	1	9.9	390.0
Precalving feed (F)	1	.5	482.0
Age of dam (A)	1	211.7**	30764.5**
Sex of calf (S)	1	45.9+	6518.1*
AxF	1	.0	315.1
AxAs	1	6.1	213.1
FxAs	1	.3	428.4
Error	117	14.4	1407.9

+P<.10
*P<.05
**P<.01

Although the assistance by age interaction was not significant the differences in pregnancy rates between early and late assisted females were greater in two-year-olds than in mature cows, 24.5 vs 5.8% for PG1S, 29.6 vs 13.1% for PG21 and 19.3 vs 6.4% for PG45, respectively, (Table 13).

TABLE 13. LEAST-SQUARES MEANS FOR EFFECT OF OBSTETRICAL ASSISTANCE ON THE REPRODUCTIVE PARAMETERS

Assistance and age of dam	No. of females	PPI (days)	CY21 (%)	PG1S (%)	PG21 (%)	PG45 (%)
Two-year-old						
Early	32	61.2	82.2	72.2	63.5	87.7
Late	29	64.0	72.2	47.7	33.9	68.4
Avg	62	62.6	77.2	59.9	48.7	78.1
Mature						
Early	34	45.2	92.4	78.2	73.9	89.1
Late	31	44.9	82.2	72.4	60.8	82.7
Avg	65	45.0	87.3	75.3	67.3	85.9
Pooled						
Early	67	53.2	87.3	75.2	68.7	88.4
Late	60	54.5	77.2	60.1	47.4	75.6
Avg	127	53.8	82.3	67.6	58.0	81.9

Precalving feed level had no effect on any reproductive parameters (Table 11) calf birth weight or weaning weight (Table 12). There was a 0.2 kg difference in birth weights and a 4.0 kg difference in weaning weights between calves from cows on the high and moderate feed levels (Table 14).

TABLE 14. LEAST-SQUARES MEANS FOR EFFECTS OF PRECALVING LEVELS OF NUTRITION ON REPRODUCTIVE PARAMETERS POOLED OVER AGE

Parameters measured	Precalving level of nutrition	
	High	Moderate
PPI (days)	52.4	55.2
CY21 (%)	81.8	82.7
PG1S (%)	65.8	69.5
PG21 (%)	55.9	60.1
PG45 (%)	76.8	87.1
WWT (kg)	171.3	175.3
BWT (kg)	33.8	33.6

Both precalving feed levels exceeded published (NRC, 1976) TDN requirements for pregnant beef heifers and cows. The results indicated females on the two treatments gained weight during the precalving period in addition to the weight of the growing fetus. This was determined by calculating the precalving weight change as the difference between the on treatment weight and the immediate postcalving weight obtained within 24 hours of calving. The assumption was made that weight losses at birth due to birth weight, fetal membranes and fluids would not be different due to feed treatment since no difference was found in birth weights of calves on the two feed treatments (Table 12). Birth weights from females on the high and moderate precalving feed level were 33.8 and 33.6 kg, respectively, (Table 14).

Recommended levels of energy for pregnant beef females (NRC, 1976) are for maintaining cow weight during the last trimester of gestation. The recommended rate of gain indicated is the average gain associated with fetal development while the cow maintains her body weight. Cows that are on a high precalving energy level should gain weight which should result in improved postpartum reproductive performance as measured by a shorter PPI and more cows exhibiting estrus during the breeding season (Dunn, 1964; Whitman, 1975). This in turn results in more cows becoming pregnant.

Precalving weight change in the present study was 15.7 kg for high fed dams and -.5 kg for moderate fed dams ($P<.01$, Table 15 and 16). Body weights were 428.1 and 431.2 kg ($P<.05$), for high and moderate fed females, respectively, when females were assigned to the precalving feed levels. This indicates that the slight weight gain desired in addition to the increase in weight due to the growing fetus was achieved on the high level of precalving nutrition but body weight was just maintained on the moderate feed level.

TABLE 15. LEAST-SQUARES ANALYSIS OF VARIANCE FOR WHR, CALVING DATE AND CONDITION SCORE, PRECALVING WEIGHT CHANGE (WCHG), WEIGHT CHANGE OF THE DAM FROM CALVING TO BREEDING (WCHG1) AND WEIGHT CHANGE OF THE DAM FROM THE START TO END OF BREEDING (WCHG2)

Source of variation	d.f.	Mean squares					
		WHR	Calving date	Condition score	Precalving WCHG	WCHG1	WCHG2
Assistance (As)	1	.06	19.5	10.0	178.7	3.5	102.2
Precalving feed (F)	1	.11	.8	2.7	8361.4**	5221.1**	209.9
Age of dam (A)	1	8.45**	1840.1**	121.8**	8833.8**	1070.2	170.4
Sex of calf (S)	1	.01	2634.2**	10.8	6172.4**	198.6	195.7
AxF	1	.04	23.1	1.2	176.4	22.7	39.6
AxAs	1	.01	337.9	.0	46.5	11.3	2032.3+
FxAs	1	.01	13.0	.1	75.2	446.2	44.4
Error	119	.07	248.3	5.3	616.2	434.0	566.8

+P<.10
*P<.05
**P<.01

TABLE 16. LEAST-SQUARES MEANS FOR COVARIATES USED IN THE ANALYSIS

Item	No.	Precalving WHR (units)	Precalving WCHG (kg)	Calving date (day of year)	Condition score (units)	Birth weight (kg)	WCHG 1 (kg)	WCHG 2 (kg)
Overall	127	3.5	7.6	93.8	8.2	33.7	20.7	9.8
Assistance								
Early	67	3.6	6.4	94.2	8.5	33.9	20.8	8.9
Late	60	3.5	8.8	93.4	8.0	33.4	20.5	10.7
Precalving feed								
High	64	3.6	15.7	93.8	8.1	33.8	14.2	11.1
Moderate	63	3.5	-.5	93.7	8.4	33.6	27.1	8.5
Age of dam								
Two	62	3.3	-.8	89.9	9.2	32.4	17.8	11.0
Mature	65	3.8	15.9	97.6	7.3	35.0	23.6	8.7
Sex of calf								
Male	61	3.5	.4	89.1	7.9	34.3	21.9	11.1
Female	66	3.6	14.8	98.5	8.5	33.1	19.4	8.6

The interaction of precalving level of nutrition with assistance at birth affected CY21 (P<.05), PG21 (P<.10) and PG45 (P<.10), (Table 11). The least-squares means for the interaction indicated a trend that was consistent for all traits. Females on the high precalving feed level and early obstetrical assistance had significantly higher reproductive performance than did those on the high precalving feed level - late obstetrical assistance while there was little difference in the dams from the moderate precalving feed group due to assistance (Table 17). The reason for this interaction is unknown.

TABLE 17. LEAST-SQUARES MEANS FOR THE INTERACTION PRECALVING LEVEL OF NUTRITION X ASSISTANCE AT BIRTH FOR REPRODUCTIVE PARAMETERS

Precalving feed level	Assistance at birth	No. or females	CY21 (%)	PG1S (%)	PG21 (%)	PG45 (%)
High	Early	35	94.1	77.8	74.7	88.9
High	Late	29	69.5	53.8	37.1	64.7
Moderate	Early	32	80.5	72.5	62.6	87.9
Moderate	Late	31	84.9	66.4	57.6	86.4

Length of postpartum interval was negatively correlated with CY21 (-.28; P<.01), PG21 (-.17; P<.05) and PG45 (-.21; P<.05). The correlation between CY21 and PG21 was 53 (P<.01) and PG45 was .25 (P<.01), Table 18. Thus showing estrus early in the breeding season was related to becoming pregnant early in the breeding season and becoming pregnant early or at all during the 45 day breeding season.

TABLE 18. RESIDUAL CORRELATIONS AMONG FACTORS STUDIED

	Precalving WCHG	Calving date	Condition score	Birth weight	WCHG 1	WCHG 2	PPI	CY21
WHR	.16	-.34**	.50**	.23**	-.03	.25**	-.12	.13
Precalving WCHG		.54**	-.17*	.10	.65**	-.03	-.24**	-.03
Calving date			.12	.25**	-.40**	.09	-.22*	-.18*
Condition score				.13	-.03	-.15	-.22*	.01
Birth weight					-.06	-.06	-.01	-.02
WCHG 1						-.09	.05	.20*
WCHG 2							.02	-.02
PPI								-.28**
CY21								
PG21								
PG45								
Cow weight								
Pelvic area								
Calf WWT								
Calf gain								

*P<.05
**P<.01

TABLE 18. (CONTINUED)

	PG1S	PG21	PG45	Cow weight	Pelvic area	Calf WWT	Calf gain birth to weaning	Duration of labor
WHR	-.14	-.02	-.05	.90**	.48**	.21*	.08	-.05
Precalving WCHG	.04	.03	.08	-.34**	-.17*	-.19*	-.03	.13
Calving date	-.02	-.09	-.04	.34**	-.26**	-.49**	-.22*	.12
Condition score	.07	.08	.03	.47**	.18*	-.09	-.12	-.03
Birth weight	-.20*	-.17*	-.21*	.05	.03	-.04	-.06	.11
WCHG 1	.03	.10	-.05	.17	.12	.20*	-.10	-.17
WCHG 2	.01	-.01	.04	-.04	-.12	-.12	.09	.02
PPI	-.11	-.17*	-.21*	-.15*	-.01	.13	.06	.16
CY21	.05	.53**	.25**	.15*	.06	.13	.08	-.45**
PG21		.76**	.66**	-.30*	-.08	.03	.06	-.03
PG45			.52**	-.15*	-.09	.05	.04	.01
Cow weight				-.01	.05	.03	.06	-.27*
Pelvic area					-.01	.01	-.01	.11
Calf WWT						.27**	.23**	-.33*
Calf gain							.94**	.03

*P<.05
**P<.01

PG21 was correlated with first service pregnancy rate, (.76; P<.01) and PG45, (.52; P<.01). These results agree with Wiltbank et al. (1973) who indicated that first service pregnancy rate and the proportion of cows exhibiting estrus early in the breeding season have a direct influence on the percentage of cows becoming pregnant during the breeding season.

Of the 127 two-year-old and mature females on the study, 125 or 98.4% weaned a live calf. Assistance at birth, whether early or late, had no effect on calf weaning weight (Table 12). Weaning weights were 175.1 kg for early assisted calves and 171.5 kg for late assisted calves.

Wiltbank (1961) indicated younger females have lower postpartum reproductive performance than older females unless they are fed for the difference in nutritional requirements due to age. In the present study, two-year-old dams had poorer postpartum performance than mature dams even though they were fed separately from the mature cows and their ration exceeded the requirements for pregnant first-calf beef heifers (NRC, 1976). Age of dam was a significant source of variation for PPI (P<.01), PG1S (P<.10), PG21 (P<.05), (Table 11) and calf weaning weight (P<.01), Table 12).

Age differences are shown in Table 19. PPI was 17.6 days longer in two-year-olds than in mature cows (P<.01). Ten percent fewer two-year-olds exhibited estrus the first 21 days of breeding and PG1S

was 15.4% higher in the mature cows (P<.10). PG21 and PG 45 were also higher in the mature cows, 18.7% (P<.05) and 7.8%, respectively. Calves from first-calf heifers were 31.5 (P<.01) kg lighter at weaning than calves from mature cows.

TABLE 19. LEAST-SQUARES MEANS FOR EFFECT OF AGE OF DAM

Trait	Mature	Two-year-old
Birth weight (kg)	35.0	32.4
Pelvic area (cm^2)	332.6	254.9**
PPI (days)	45.0	62.6**
CY21 (%)	87.3	77.2
PG1S (%)	75.3	59.9+
PG21 (%)	67.3	48.6*
PG45 (%)	85.9	78.1
WWT (kg)	189.1	157.6**

+P<.10
*P<.05
**P<.01

Since all females in the early assistance treatment were assigned at least a dystocia score of 2, it was difficult to determine how many of these females would have experienced dystocia if allowed to calve unassisted. Nineteen of 67 females (28%; P<.05) in the early assistance group required a calf puller for delivery, 17 of which (89%) were two-year-old heifers. However, in 60 females assigned to late obstetrical assistance, seven required a calf puller for delivery and all were two-year-olds. Thirty percent of the two-year-old dams

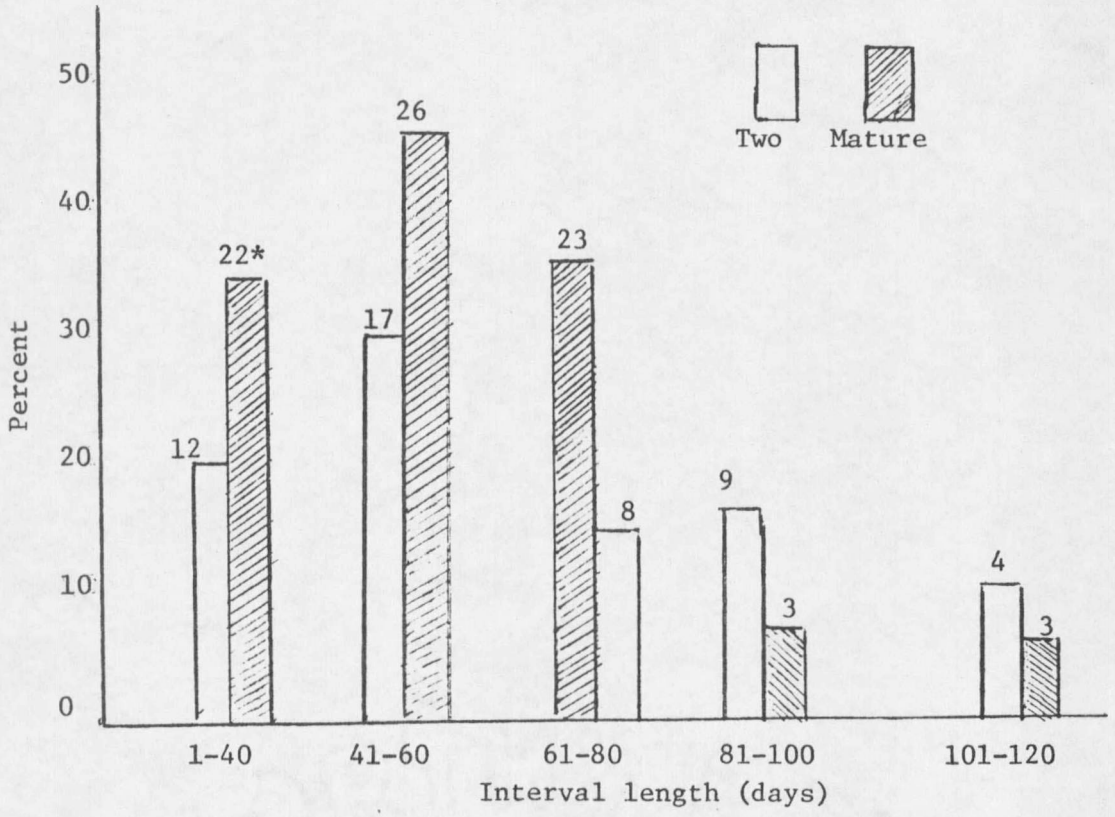
experienced dystocia while no mature cows had to be assisted in the late assistance group. The higher incidence of cows requiring a calf puller for delivery in the early assisted females could suggest that obstetrical assistance was given before the cow was completely ready for expulsion of the fetus. Even though the feet of the calf were visible or the cow was exerting the abdominal press the cervix may not have been completely dilated or the pubic ligaments completely relaxed, which could possibly result in requiring more force by the technician to deliver the calf.

Brinks et al. (1973) also found that two-year-old dams experienced the most dystocia of any age group. Laster et al. (1973) reported 45% more dystocia in first calf heifers than in mature cows. Brinks et al. (1973) found that heifers experiencing dystocia as two-year-olds calved later and weaned lighter calves than their contemporaries having no dystocia. In another study, percentage of cows detected in estrus in a 45 day AI season was reduced by 14% and pregnancy rate to AI in that season was lowered by 16% in cows experiencing dystocia (Laster et al. 1973). This evidence indicated that dystocia was related to poorer reproductive performance. However, in the present study, calving difficulty was included as a covariate in the analyses with no effect on postpartum reproduction differences when analyzed with both ages of dam and obstetrical assistance treatments in the model. Nor did dystocia score have a

significant effect when two-year-old and mature cows and early and late assistance groups were analyzed separately. Further analysis within assistance and age group yielded no significant effect of dystocia score either.

Even though calf birth weights were 2.6 kg lighter in the two-year-old dams, pelvic areas were 78 cm^2 smaller in two-year-olds than those of mature dams, (Table 19; $P<.01$). This indicated the disproportion between size of calf and pelvic area of the dam (Rice and Wiltbank, 1972) could have existed because two-year-old heifers had to deliver the calf through a significantly smaller pelvic opening. The higher incidence of dystocia in two-year-old dams supported this.

Figure 1 indicates the percentage of females having various lengths of postpartum intervals. Approximately 85% of all females had postpartum intervals of 80 days or less. Seventy-nine percent of the two-year-old females had a PPI of 80 days or less, while 90% of the mature cows were within this range. PPI of 80 days or less would be necessary for a female to maintain a 12 month calving interval.



* Total number of females in each group

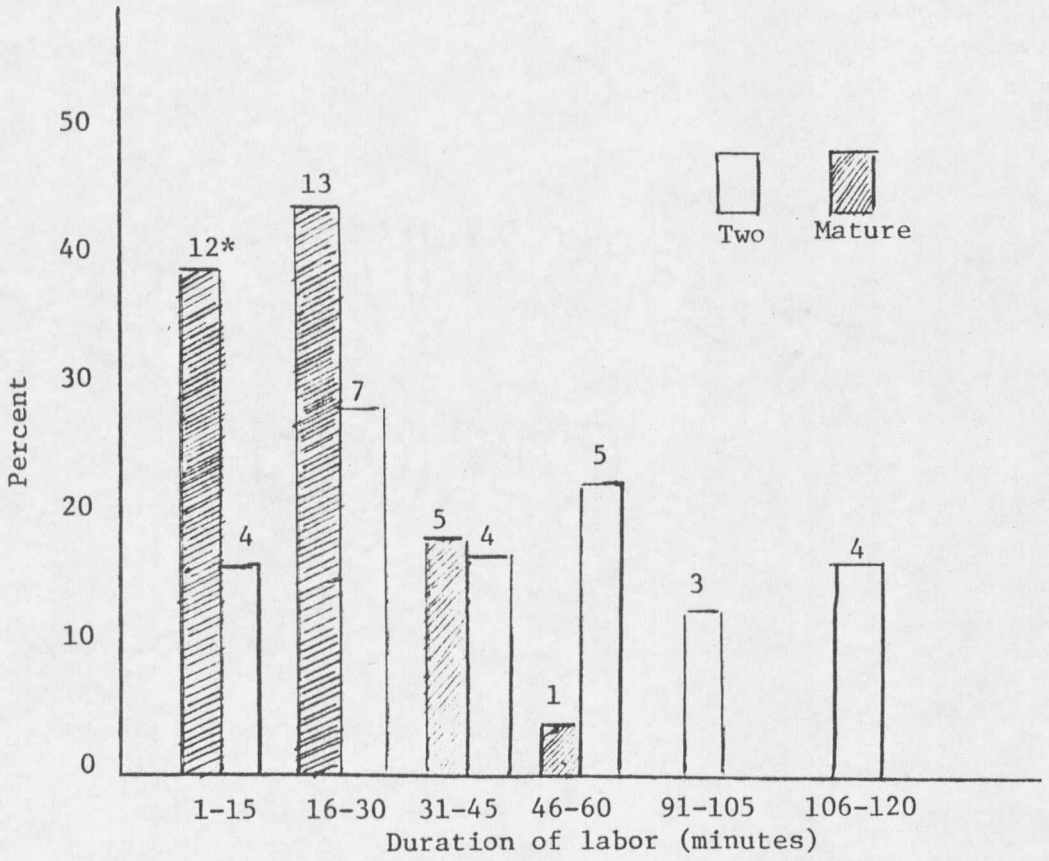
Figure 1. Percentage of mature and two-year-old females with various lengths of postpartum interval.

Duration of Labor, Dystocia and Postpartum Reproduction.

Dystocia has been found to reduce the percentage of cows exhibiting estrus during a 45-day breeding season and pregnancy rate (Laster et al. 1973). In order to determine if a similar effect occurred in the present study data from the late assisted females were analyzed separately since their dystocia scores reflected the actual occurrence of calving difficulty while dystocia scores in the early assisted females were created because early obstetrical assistance was imposed on them.

Duration of labor in stage 2 of parturition differed between late assisted two-year-old and mature cows (55.2 vs 24.7 minutes ($P<.05$), respectively). Two-year-olds averaged 30.5 minutes longer in this stage of parturition than did mature cows. Figure 2 shows the distribution of duration of labor for two-year-old and mature cows grouped in 15 minute increments. Stage 2 of parturition ranged from 5 to 60 minutes in mature cows, with 80% of these being 30 minutes or less. Stage 2 ranged from 10 minutes to two hours in the two-year-old dams. The number of two-year-olds in each group was fairly evenly distributed.

Calving difficulty score was included as a covariate in the statistical model, but no effect was found on any of the reproductive parameters in either two-year-old or mature cows. However, duration of labor affected PPI ($P<.10$), CY21 ($P<.05$) and PG45 ($P<.10$) in two-year-old dams. A one minute increase in duration of labor lengthened PPI by .2 days, lowered CY21 by .7% and decreased PG45 by .6%. No effect



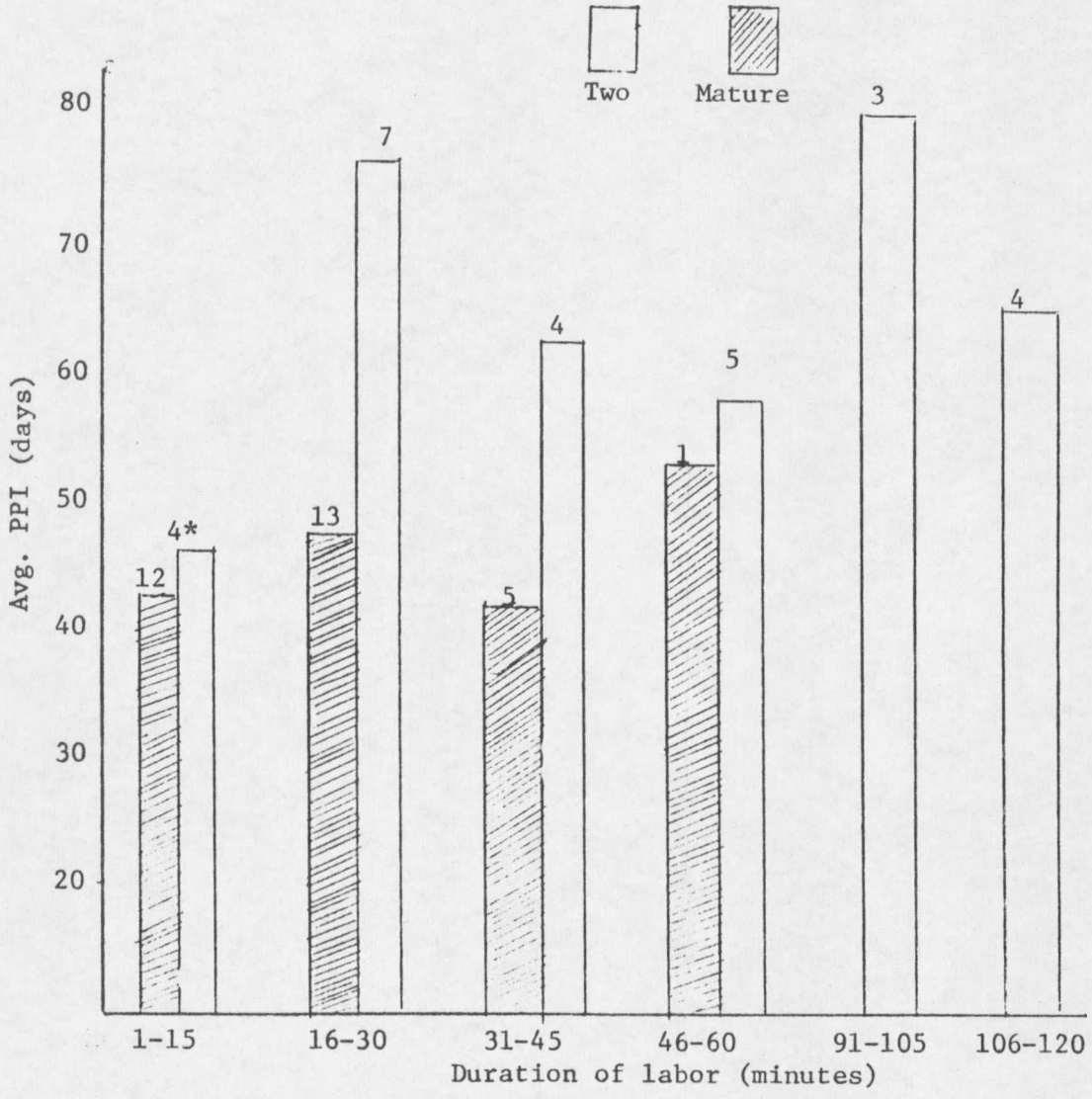
*Total number of females in each group

Figure 2. Distribution of late assisted mature and two-year-old females according to their duration of labor in stage 2 of parturition.

was seen due to duration of labor on reproductive parameters in mature cows. The relationship between postpartum interval and duration of labor in both mature and two-year-old females is shown in Figure 3.

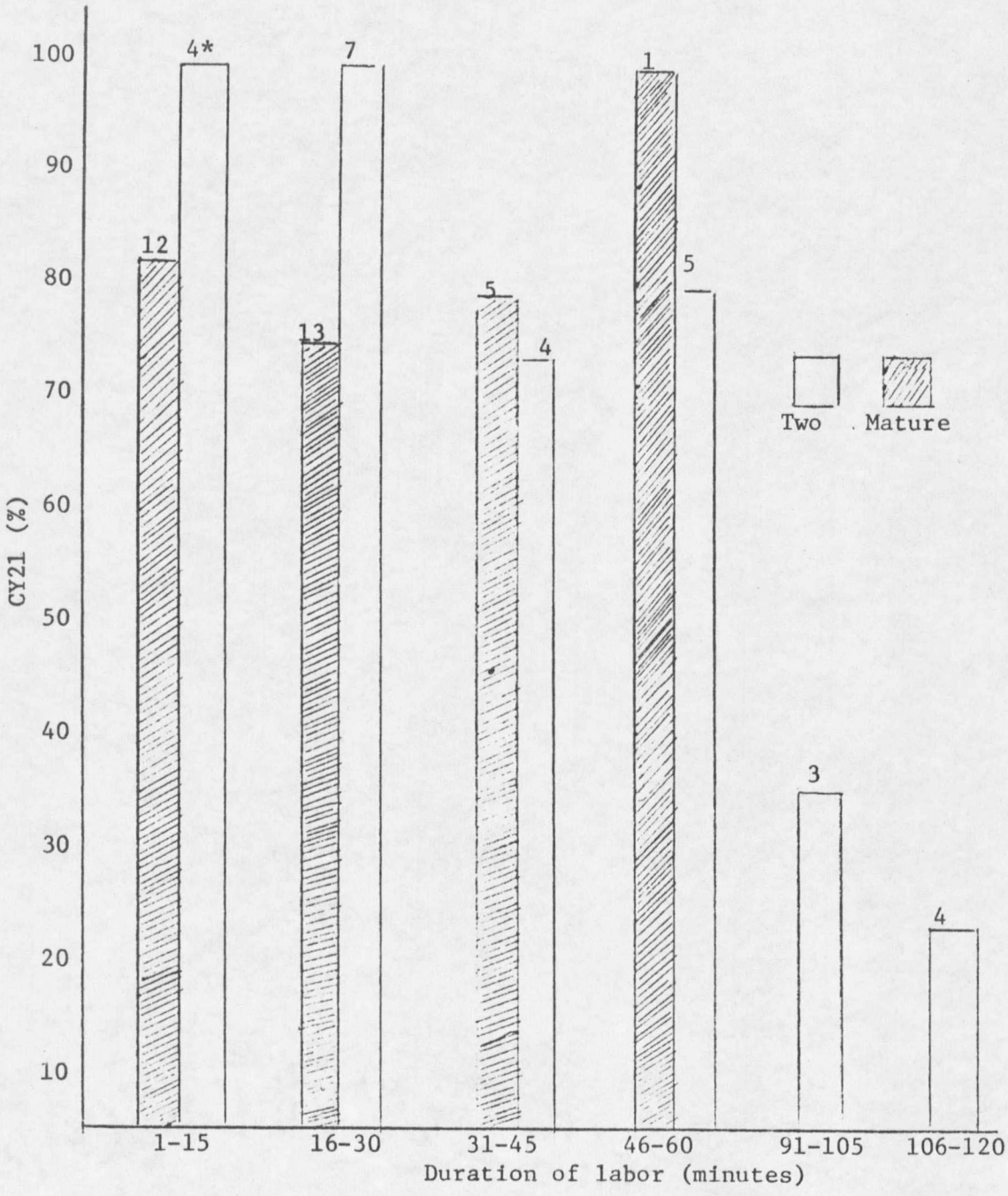
Figures 4 and 5 show the decrease in reproductive performance as stage 2 of parturition became longer in two-year-old dams. Mature cows did not appear to be affected by a longer duration of labor. Although the number of animals in each group was small, the data still indicate important detrimental effects due to prolonged labor in first-calf heifers.

The regression of duration of labor on birth weight in two-year-old cows and when ages were pooled was not significant, and the correlation between birth weight and duration of labor was low and nonsignificant in both analyses (.22 and .11, respectively). However, the correlation between duration of labor and pelvic area in two-year-old dams (-.41; $P<.01$) indicated an important relationship. First-calf heifers with smaller pelvic areas had a longer duration of labor. This relationship was not found in the mature cows. Incidence of dystocia was higher in those two-year-olds having the longest durations of labor. Therefore, it would appear that pelvic area and dystocia were closely related in the heifers which has been shown by Bellows et al. 1971; Rice and Wiltbank, 1972 and Price, 1974.



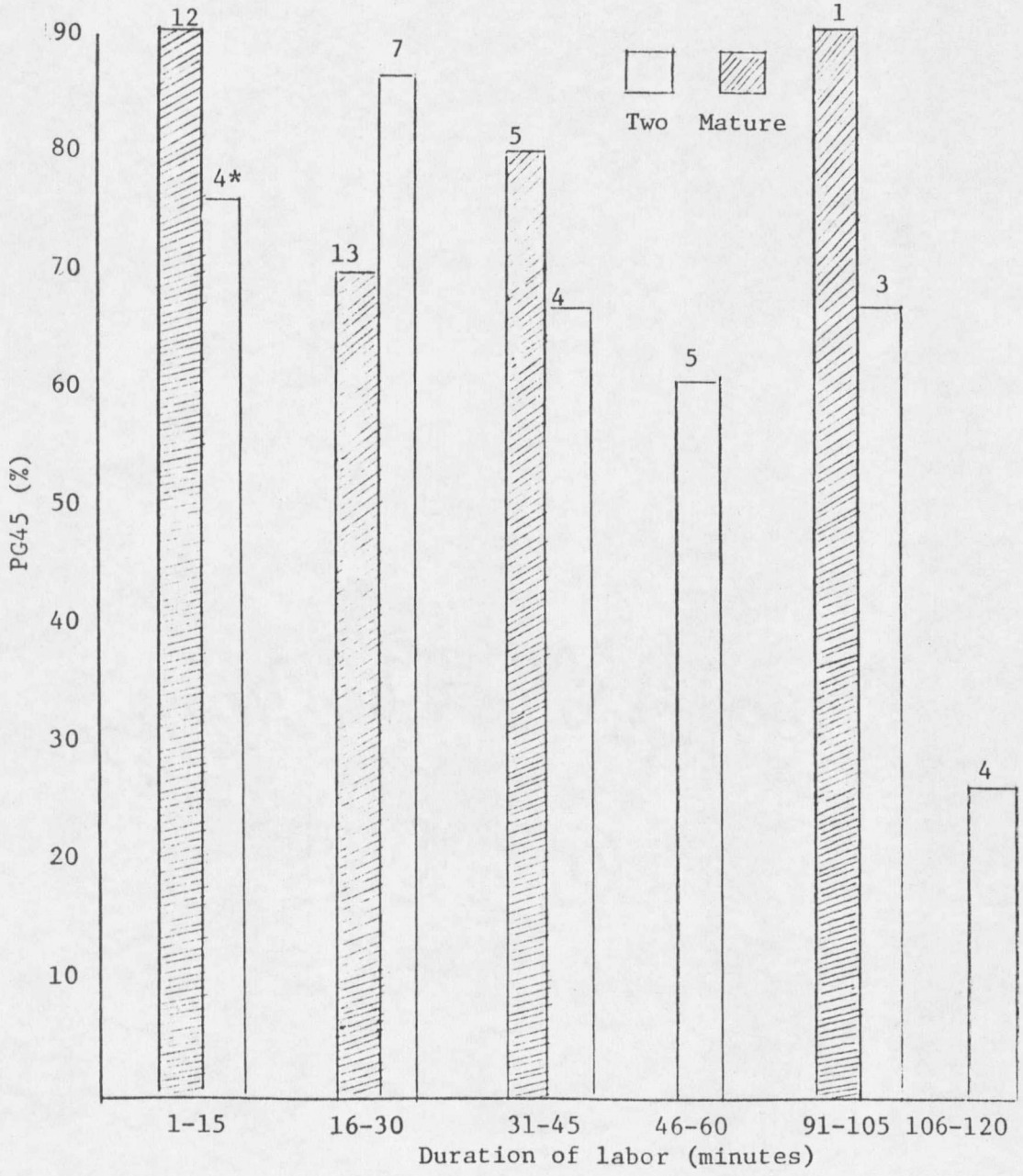
*Total number of females in each group.

Figure 3. Relationship of postpartum interval to duration of labor in mature and two-year-old late assisted cows.



*Total number of females in each group

Figure 4. Relationship of CY21 to duration of labor in late assisted mature and two-year-old cows.



*Total number of females in each group

Figure 5. Relationship of PG45 to duration of labor in late assisted mature and two-year-old cows.

Influence of Body Condition and Female Weight Change on Reproductive Performance.

Partial and standard partial regression coefficients are shown in table 20 and indicate initial condition score ($P<.01$), precalving WCHG ($P<.01$) and WCHG 1 ($P<.05$) were important sources of variation for PPI when pooled over age. However, partial and standard partial regression coefficients indicated the effect was more important in mature cows than two-year-olds. A one unit increase in initial condition score shortened the PPI by 3.0 days and a 1 kg precalving gain shortened it by .4 days while the same gain postcalving shortened the PPI by .4 days, also. Birth weight and WCHG 2 had the least effect. Two-year-olds were affected more by calving date, initial condition score, birth weight and precalving WCHG with WCHG 1 and WCHG 2 being relatively unimportant. The present analysis adjusted all dams to a constant calving date, initial condition score, calf birth weight, precalving WCHG, WCHG 1 and WCHG 2 and still mature cows had a shorter PPI than two-year-old cows. (45.0 vs 62.6 days, respectively).

It is important that dams exhibit estrus the first 21 days of the breeding season. Those that exhibit estrus during the first 21 days have a chance of becoming pregnant and subsequently calving earlier. This results in heavier calves at weaning because they are born earlier. Having an early calf allows a longer postpartum period for the dams to prepare for the next pregnancy. Another

TABLE 20. PARTIAL (b) AND STANDARD PARTIAL (b') REGRESSION COEFFICIENTS FOR REPRODUCTIVE PARAMETERS

Dependent variables	Age of female	Number	Calving date (day of year)		Initial condition score (units)	
			b	b'	b	b'
PPI (days)	2	62	-.2	-.17	-2.1	-.22
	Mature	65	-.2	-.17	-3.0**	-.49
	Pooled	127	-.1	.08	-2.7**	-.37
CY21 (%)	2	62	.0	-.01	-1.7	-.10
	Mature	65	-.9**	-.45	1.8	.14
	Pooled	127	-.6*	-.29	1.3	.09
PG1S (%)	2	62	.1	.04	1.5	.07
	Mature	65	-.1	-.02	3.3	.18
	Pooled	127	.0	.00	2.7	.15
PG21 (%)	2	62	.1	.03	.0	.00
	Mature	65	-.6	-.17	4.5	.23
	Pooled	127	-.4	-.16	3.5+	.19
PG45 (%)	2	62	-.1	-.03	.2	.01
	Mature	65	-.3	-.12	3.1	.21
	Pooled	127	-.2	-.08	1.7	.11

+P<.10
*P<.05
**P<.01

TABLE 20. (CONTINUED)

Independent variables	Age of female	Number	Birth weight (kg) b	Birth weight (kg) b'	Precalving WCHG (kg) b	Precalving WCHG (kg) b'	WCHG 1 (kg) b	WCHG 1 (kg) b'	WCHG 2 (kg) b	WCHG 2 (kg) b'
PPI	2	62	.8	.13	-.1	-.10	-.1	-.08	-.1	-.05
(days)	Mature	65	.1	.03	-.4**	-.84	-.4**	-.55	.0	-.08
	Pooled	127	.5	.12	-.3**	-.51	-.2*	-.30	-.1	-.07
CY21	2	62	-1.5	-.14	.6+	.41	.9+	.45	.6+	.24
(%)	Mature	65	.6	.07	.6*	.53	.7**	.49	.1	.08
	Pooled	127	.0	.00	.5*	.37	.6+	.33	.1	.07
PG1S	2	62	-3.1	-.23	.5	.24	.1	.04	.0	.00
(%)	Mature	65	-2.6+	-.24	.3	.20	.5	.27	.1	.06
	Pooled	127	-2.7*	-.24	.3	.21	.3	.14	.1	.03
PG21	2	62	-3.2+	-.27	1.1**	.60	.7	.34	.2	.08
(%)	Mature	65	-2.1	-.18	.5	.30	.8*	.36	.1	.09
	Pooled	127	-2.5*	-.22	.6*	.38	.6*	.26	.1	.05
PG45	2	62	-2.6+	-.24	.2	.10	-.2	-.09	.5	.17
(%)	Mature	65	-2.0	-.23	.5+	.42	.4	.27	.1	.05
	Pooled	127	-1.9*	-.21	.3	.21	.1	.05	.1	.06

+P<.10
*P<.05
**P<.01

advantage of exhibiting estrus the first 21 days of a 45-day breeding season is if conception does not occur at first service then there is sufficient time for the dam to complete another estrous cycle and be bred again before the breeding season is over. Calving date, pre-calving WCHG and WCHG 1 were important covariates for CY21 in both two-year-olds and mature cows. For each kilogram gained prior to calving, CY21 increased by .6% in both two-year-olds ($P<.10$) and mature cows ($P<.05$). A one kilogram increase in weight from calving to start of breeding also had a positive effect by increasing CY21 .9% ($P<.05$) and .7% ($P<.01$) for two-year-old and mature dams respectively. In addition to this a one kilogram increase in weight from start to end of breeding improved CY21 in two-year-old dams by .6% ($P<.10$). For each day later the mature cows calved, CY21 was lowered by .9% ($P<.01$).

Two-year-olds tended to be adversely affected by increased birth weight. A one kilogram increase in birth weight decreased GY21 by -1.5%. Larger birth weights in young cows were associated with more dystocia (Bellows et al. 1971b) and more dystocia resulted in lower postpartum reproductive performance (Laster et al. 1973). This same relationship was not as evident in mature cows because even though birth weights were larger in mature than young cows the incidence of dystocia was much lower (Brinks et al. 1973). Results from the present study are in agreement since there was no effect of increased birth weight on CY21 in mature cows.

Precalving WCHG continued to have an important effect on reproduction throughout the breeding season as indicated by the partial and standard partial regression coefficients in Table 20. Precalving weight gain improved PG1S by .5% (P>.01), PG21 by 1.1% (P<.01) and PG45 by .2% (P>.10), in two-year-olds, for each kilogram gained. In addition, precalving gain tended (P<.10) to increase PG45 in mature cows. A gain of one kilogram between calving and start of breeding (WCHG 1) improved PG21 by .7% (P>.10) in two-year-olds and .8% in mature cows (P<.05). Larger birth weight of the calf reduced PG1S by 3.1% (P>.10), PG21 by 3.2% (P<.10) and PG45 by 2.6% (P<.10) per kilogram in two-year-olds. Mature cows showed a reduction in PG1S of 2.6% (P<.10), in PG21 of 2.1% (P>.10) and in PG45 of 2.0% (P>.10) per kilogram increase in birth weight. The covariates included in the analysis had little other effect on PG1S and PG45 in mature cows. For each kilogram of precalving gain, there was a .5% increase in PG45 (P<.10). PG21 was affected by WCHG 1 (P<.05) but not by the other covariates. Increasing WCHG 1 one kilogram increased PG 21 by .8% (P<.05).

The six covariates were significant sources of variation for the reproductive parameter measured, but they accounted for less than half of the total variation in any one of the traits.

General Discussion

The results of this work indicated obstetrical assistance early in stage 2 of parturition prevented the detrimental affects of dystocia and therefore improved reproductive performance of females in this study. Although postpartum interval and percentage of females exhibiting estrus early in the breeding season did not show an improvement due to early obstetrical assistance, it can also be said it had no detrimental effect on these two traits either. The improved reproductive performance in early assisted females was evidenced by increased pregnancy rates at first service, the first 21 days of breeding and over the entire 45-day AI season. This would indicate that proper obstetrical assistance given at the right time can be an important management tool. Furthermore, it can be concluded from the results that when given correctly, obstetrical assistance as given in this work, is not the factor that lowers performance in dams that experience dystocia.

Percent calf crop is a result of the number of females in the breeding herd minus those that fail to:

1) Exhibit estrus during breeding
2) Become pregnant
3) Give birth to a live calf
4) Wean a live calf

The largest single reduction in calf crop in this study was due to females failing to become pregnant. Ninety-eight percent of the

females studied gave birth to a live calf, 96.7% exhibited estrus during the breeding season and 98% weaned a live calf. These figures represented a total reduction in the calf crop of 7.3%. Only 80% of the females became pregnant.

Becoming pregnant early in the breeding season is important because females that calve earlier have more time before breeding begins in order to physiologically prepare for another pregnancy. A longer interval from calving to first breeding improves pregnancy rate (Casida, 1968). In addition, females that calved early in the present study weaned heavier calves. The regression of weaning weight on calving date indicated older calves would be heavier at weaning. Therefore, although early obstetrical assistance did not directly affect weaning weight, by improving the percentage of females pregnant early in the breeding season it indirectly would result in more older and consequently heavier calves at weaning the following year. This same line of reasoning can be used to project the effects of improved first service pregnancy rate seen in the early assisted females since first service pregnancy rate is an integral part of becoming pregnant early in the breeding season. The actual physiological effect of early obstetrical assistance was not determined in this study. However, it could be a result of depletion of energy

reserves expended in delivering the calf over an extended period of time or even actual physical damage to the uterus in some way. Further investigation is needed to determine the manner in which the detrimental effects occur.

The duration of stage 2 of parturition for late-assisted females in this study was 30 minutes compared to 37 minutes reported by O'Mary and Hillers (1976) who studied a herd of Angus cows bred to Angus and Charolais sires. Roberts (1956) indicated that the average range of time for completion of this stage of parturition was 30 to 60 minutes and if it lasts longer than 2 to 3 hours in multiparous cows, then difficulty is occurring and assistance should be given. Young (1968b) recommended that stage 2 of parturition should not last longer than 4 hours for heifers before giving assistance. Longer duration of labor was indicative of dystocia in the present study as more dystocia occurred in two-year-olds, which also had longer duration of labor than mature cows. The recommendation regarding time elapsing before giving obstetrical assistance that could be made from the results of the present study would be more conservative than that of Young (1968b). The maximum duration of labor in the two-year-olds was 2 hours and three of the four two-year-olds having a 2 hour duration of labor were obviously having difficulty and required assistance with a calf puller for delivery of the calf. A guideline to follow in determining when

assistance should be given to heifers, as indicated by these data, would be to allow from 30 to 45 minutes after the heifer was judged to be in stage 2 before making an examination and assisting delivery. Recalling that assisting delivery early had a positive effect on postpartum reproductive performance, it would be advantageous to assist the heifer before it became an absolute necessity both in terms of increased calf survival and improved subsequent reproduction. If these time limits were exceeded some of the detrimental effect that dystocia had on the heifers reproductive performance would already have occurred.

Pre- and postcalving feed levels have been shown to influence postpartum reproductive performance in both two-year-old heifers (Dunn et al. 1969) and mature cows (Wiltbank et al. 1962 and 1964). However, Dunn et al. (1969) fed precalving energy levels that were below those recommended by NRC (1963). In the two studies by Wiltbank et al. (1962; 1964) the precalving energy intake was less than or equal to the level recommended by NRC (1958) and the postcalving energy levels varied above and below recommended NRC levels. In the present study, both precalving feed levels exceeded requirements for pregnant beef females (NRC, 1976) as did the postcalving feed treatment. Precalving feed level tended to affect PG45, with cows on the moderate level having a 10% higher pregnancy rate during the 45-day AI season. However, it must be noted that the effect of precalving nutrition was not significant and only indicated a trend.

It was not possible to determine why females on the moderate feed level tended to perform better than those on the high level. Further investigation along these lines should involve a wider difference in levels of nutrition.

The differences seen in postpartum reproductive performance between two-year-olds and mature cows could have been caused by many things. The nutritional requirements of two-year-olds are higher because they have a growth requirement in addition to that for maintenance and milk production (NRC, 1976). Dystocia, which has been found to lower postpartum reproductive performance (Brinks et al. 1973), occurred more often in two-year-olds (Laster et al. 1973). In the present study all females were on a higher level of nutrition before and after calving than the minimum recommended by NRC (1976), so the additional growth requirement in two-year-olds should have been met. Dystocia score had no effect on the postpartum reproductive performance in these females. In addition, when the covariates weight-to-height ratio, precalving weight change, weight change from calving to start of breeding, weight change from start to end of breeding, calving date, initial condition score and birth weight were all included in the analysis to adjust all females to a constant basis for each covariate, two-year-olds still had lower reproductive performance than mature cows. Data collected in this study did not explain all of the differences between two-year-olds and mature cows,

and indicate a need for more research as to what it would take to increase performance in these young females to the level of mature cows.

The seven covariates mentioned in the preceeding paragraph were all important sources of variation at one time or another, depending on age of cow and reproductive parameters in question. Even though least-squares analysis indicated importance, explanation of that importance is difficult. Weight-to-height ratio had an effect on several of the reproductive parameters but the exact relationship of weight-to-height ratio to postpartum performance was not determined here. Why does a cow with a large WHR perform differently than one with a smaller WHR? Klosterman et al. (1968) and Whitman (1975) indicated WHR could be used to indicate body condition, but the present study found body condition score to be important even when cows were adjusted to a constant WHR. More than just body condition was measured by WHR, but what more must be determined by additional research.

Pre- and postcalving weight change and calving date also had important effects on reproductive parameters, but the hypotheses mentioned in the literature review of being on the precalving supplemental feed levels longer, or calving closer to green grass and sufficient forage do not explain the negative effect of later calving date. Calving date still had a negative effect on PPI which indicated there was something in addition to weight change of the dam involved.

Perhaps a physiological change due to improved nutrition or even season of the year was responsible.

This study has indicated that early obstetrical assistance at birth could be a useful tool in preventing the detrimental effects of dystocia and therefore improving postpartum reproductive performance in beef cows, and was especially effective in two-year-olds, where the most dystocia was encountered. Not only was obstetrical assistance shown to exert a positive influence on several reproductive parameters, but it was also concluded that obstretical assistance had no harmful effects on any of the parameters measured. Obstetrical assistance, as referred to here, was given by well trained, experienced technicians, but not a veterinarian. A producer that employs proper procedures for handling and adequate sanitation during assisted parturitions could use obstetrical assistance as a tool for preventing the detrimental effects of dystocia on postpartum reproductive performance. The purpose of this study was not to determine if early obstetrical assistance should be recommended as a common practice, but rather to determine if it could be used to relieve dystocia without fear of doing additional damage and lowering subsequent performance. Before making a recommendation to use obstetrical assistance, it would be prudent to study the procedure used here in other herds of cattle under different management and breeding schemes.

SUMMARY

Traditionally there has been reluctance to use obstetrical assistance except where it was absolutely necessary to relieve dystocia. This reluctance was a result of not knowing whether it was the dystocia or the handling and obstetrical assistance that lowered postpartum reproductive performance in females that were assisted in delivery. This study had two major objectives: to determine the effects and interactions of obstetrical assistance at birth on postpartum reproduction and calf production; and determine the effects and interactions of two levels of precalving nutrition on postpartum reproductive performance.

Sixty-two, two-year-olds and 65 cows, 4 to 7 years of age were used to study the effects of precalving feed level and time of obstetrical assistance at birth on postpartum interval (PPI), percentage of dams exhibiting estrus and first 21 days of breeding (CY21), first service percent pregnant (PG1S), percent pregnant the first 21 days of breeding (PG21) and total percent pregnant after a 45-day AI period (PG45). Sixty days prior to the median predicted calving date all females were scored for body condition and separated by age (two and mature). Females within each age group were group fed either 135% (high) or 110% (moderate) of NRC (1976) in feedlots and assigned within age and feed group to receive either early or late obstetrical assistance at birth. Early-assisted females received obstetrical assistance as early in stage 2 of parturition as possible;

late-assisted females calved unassisted unless emergency assistance was required to deliver a live calf. After calving, females went on range supplemented with hay and a salt-grain mix until adequate forage (May 1). All females were together on range from May 1 to weaning (October 6).

Results indicated that early obstetrical assistance at birth had no detrimental effect on any of the postpartum reproductive parameters, or on calf production as measured by weaning weight. In fact, early obstetrical assistance increased the percentage of females exhibiting estrus the first 21 days of breeding by 10% and first service pregnancy rate 15.1% which in turn improved pregnancy rate the first 21 days of breeding 21.3%. Performance continued to be higher in early-assisted females resulting in a 12.8% higher total pregnancy rate in those females. Calf weaning weights were not influenced by early obstetrical assistance.

The positive effect of early obstetrical assistance on PG1S, PG21 and PG45 was greater in two-year-olds than mature cows. This indicated that since mature cows experienced essentially no dystocia, there was no advantage in giving early obstetrical assistance. However, a higher frequency of dystocia did occur in the two-year-olds and by receiving early obstetrical assistance, their postpartum reproductive performance was improved over two-year-olds in the late assistance treatment.

Weight-to-height ratio of the dam, precalving weight change of the dam, calving date, initial condition score, calf birth weight, weight change of the dam from calving to start of breeding and from start to end of breeding were all included as covariates to explain the variation in postpartum reproductive performance. Although these covariates were significant sources of variation for the five reproductive parameters their importance varied with age of cow.

In two-year-olds, a later calving date was associated with a shorter PPI as were higher condition scores while heavier birth weights lengthened PPI. Precalving weight gain and weight gain from calving to start of breeding and start to end of breeding improved percent exhibiting estrus the first 21 days of breeding. Precalving weight gain improved PG21 ($P<.01$) but not PG45. Increased calf birth weight decreased PG21 and PG45 ($P<.10$).

The same seven covariates had different effects in mature cows. Precalving weight gain ($P<.01$), higher initial condition score ($P<.01$) and larger weight gain from calving to start of breeding ($P<.01$) were associated with shorter PPI. An earlier calving date ($P<.01$), precalving weight gain ($P<.05$) and weight gain from calving to start of breeding ($P<.01$) increased CY21. Weight gain from calving to start of breeding also improved PG21 ($P<.05$). Weight gain from calving to start of breeding increased PG45 ($P<.10$). Heavier calf birth weights lowered PG1S in mature cows ($P<.10$).

An effect of precalving level of nutrition was seen only as a trend on the PG45 of two-year-olds. Two-year-olds on the moderate feed level had a 10% higher pregnancy rate at the end of a 45-day AI period. Both feed levels exceeded NRC (1976) requirements and females on both levels gained actual body weight prior to calving in addition to that of the developing conceptus. Differences in precalving feed level were not reflected in differences in calf birth weights or weaning weights. The interaction of precalving, feed level x assistance of birth affected CY21 ($P<.05$), PG21 ($P<.10$) and PG45 ($P<.10$). Females on the high feed level and late obstetrical assistance treatment exhibited a trend toward lower performance in all reproductive parameters, although this effect could not be explained.

In this study, two-year-olds consistently had lower pregnancy rates than mature cows. Twenty-one percent of two-year-olds had a PPI longer than 80 days while only 9% of mature cows were in that category which could result in a calving interval of over 12 months.

Calf sex had no effect on postpartum reproduction of its dam, although males were 1.3 kg heavier at birth than female calves.

Duration of labor (interval from onset of stage 2 to birth) was 40 minutes longer in late assisted two-year-olds than late assisted mature cows ($P<.05$). Two-year-olds that experienced dystocia also had a longer duration of labor and a longer duration of labor was associated with poorer postpartum reproductive performance.

Eight percent of mature cows were in stage 2, 30 minutes or less with a maximum of 60 minutes. Maximum duration of stage 2 in two-year-olds was 120 minutes with 41% in stage 2, 30 minutes or less. A 1 minute increase in duration of labor lengthened PPI .2 days ($P<.10$), lowered CY21, .7% ($P<.05$) and decreased PG45, .6% ($P<.10$).

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APPENDIX

APPENDIX TABLE 1. LEAST-SQUARES ANALYSIS OF VARIANCE FOR EFFECT OF OBSTETRICAL ASSISTANCE AT BIRTH ON REPRODUCTIVE PARAMETERS IN THREE-YEAR-OLD COWS

Source of variation	d.f.	Mean squares				
		PPI	CY21	PG1S	PG21	PG45
Assistance (As)	1	170.1	1215.9	624.1	1361.6	324.6
Precalving feed (F)	1	301.9	1343.2	608.3	190.5	2281.6
Sex of calf	1	112.9	9212.4+	.2	3608.2	1434.5
As x F	1	630.2	1871.9	1923.6	1397.4	4609.5
Regressions						
WHR	1	584.6	2984.9	5468.7	3936.6	6676.8
Precalving WCHG	1	723.6	7556.1	637.6	3266.4	2787.3
Calving date	1	1171.3	9257.9+	1753.9	6223.8	2946.3
Condition score	1	500.8	947.3	102.9	1435.1	6.9
Birth weight	1	1856.5+	1560.7	61.8	4.7	2424.7
WCHG 1	1	445.8	12697.2*	1181.0	2347.9	4106.4
WCHG 2	1	346.3	757.1	1115.5	898.6	3884.9
Error	13	493.9	2512.4	2411.2	3418.1	1850.0

+P<.10
*P<.05

APPENDIX TABLE 2. LEAST-SQUARES MEANS AND PARTIAL REGRESSION COEFFICIENTS (b) FOR REPRODUCTIVE PARAMETERS IN THREE-YEAR-OLD COWS

Item	No.	PPI (days)	CY21 (%)	PG1S (%)	PG21 (%)	PG45 (%)
Overall	25	59.3	69.4	69.9	60.2	75.2
Assistance						
Early	15	55.9	60.2	63.4	50.4	70.4
Late	10	62.8	78.7	76.6	70.0	80.0
Precalving feed						
High	12	63.5	78.3	75.9	63.5	86.7
Moderate	13	55.2	60.7	64.1	56.9	63.8
Sex of calv						
Male	14	61.9	45.9	70.1	45.5	65.9
Female	11	56.7	92.9	69.9	74.9	84.5
Assistance x feed						
Early-High	7	53.6	80.1	80.5	63.3	99.3
Early-Moderate	5	73.4	76.4	71.3	63.8	74.0
Late-High	8	58.1	40.3	46.2	37.5	41.6
Late-Moderate	5	52.2	81.0	81.9	76.3	85.9
Regressions		b	b[a]	b[a]	b[a]	b[a]
WHR		23.8	-53.8	-72.7	-61.7	-80.4
Precalving WCHG		-.3	1.1	.3	.7	.7
Calving date		-1.1	-3.2	-1.4	-2.6	-1.8
Condition score		-2.6	3.6	-1.2	4.4	.3
Birth weight		-2.6	2.4	.5	-.1	3.0
WCHG 1		-.2	1.3	.4	.6	.8
WCHG 2		-.2	.3	.4	.6	.7

[a]Values have been multiplied by 10^2

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