CALF SHAPE AND PELVIC DIMENSIONS AFFECTING DYSTOCIA IN BEEF HEIFERS

by

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INTRODUCTION

Increased costs of production have forced the stockman to be concerned with efficiency of beef production. The cowman today is using performance data as the basis for his selection decisions. As we use rapid growth rates to select for maximum production efficiency, we increase calf birth weight and mature cow size (Dickerson et al., 1974). Heavier birth weight is positively correlated with dystocia and there are positive correlations of the growth traits (weaning weight, average daily gain and yearling weight) with percent calving difficulty and percent calf mortality (Burfening et al., 1978). There is also the economic loss from decreased rate of gain, lowered feed efficiency and permanently stunted animals that will never reach their potential level of performance.

Improving reproductive efficiency is also vital for rapid genetic progress in all performance traits. To make the most rapid genetic progress the livestock producer must strive to exert the largest possible selection differential on important performance traits while maintaining herd size. The immediate effect would be an increase in saleable livestock, with a long range effect of accelerating progress toward genetic superiority.

The increase in birth weight of calves could be minimized by selecting for smaller birth weight in conjunction with larger yearling weight. We need to develop the right combination for the largest manageable birth weight while minimizing the costly effects of dystocia and resultant calf loss.

In order to accomplish this, more information is needed on various factors that cause calving problems. This study was designed to study calving difficulty and specifically to determine the affect of a calf shape and pelvic dimensions on dystocia.

LITERATURE REVIEWED

Percent calf crop is an important measure of beef cow efficiency. Cunha and Warnick (1965) define calf crop as the number of calves weaned divided by the number of cows exposed to the bull in a given twelve month period, expressed as a percent. Several workers have shown a marked difference in average calf crop throughout the United States and the world. There also is as large or larger a variation in the figures from year to year.

Reproductive failures constitute the greatest reduction in potential calf crop weaned. Wiltbank et al. (1961) showed the largest losses are due to the 1- small percent of cows in estrus and bred in the first 21 days of the breeding season, 2- small numbers of cows conceiving at first service and 3- calf deaths at or near birth. Dearborn et al. (1973) claimed 31% of the heifers exposed to breeding failed to wean a calf. Two thirds represented a failure to conceive or an early embryonic loss. He also showed 18% of the second calf or older cows failed to wean a calf. Approximately 50% were not diagnosed pregnant. Nelson and Beavers (1982) showed condition score entering breeding pasture had an influence on pregnancy rate.

The important effect of perinatal calf mortality (losses occurring at or near the time of birth) has been stressed by several workers. Koger et al. (1967) reported calves which failed to survive from 3,408 calvings, 6.2% were aborted, 50.8% died within 24 hours of birth, 12.0% died between 24 and 72 hours of birth and the remaining 30.8% died after the first 3 days. Rice (1969) reported a 9% perinatal calf mortality rate in an Angus herd. Rasbech (1963) in a review of literature cited a range of 5 - 8% for calf mortality. Anderson and Bellows (1967) reported a 4.7% mortality rate. Upon necropsy, they found that 70.5% of the calves had non-functioning lungs. Post-mortem findings also showed 79.0% of deaths were due to injury incurred during prolonged parturition. Smith et al. (1976) showed calf mortality within 24 hours was 3.7 times greater with dystocic parturitions. There was no calving effect on mortality after 24 hours of age. Laster and Gregory (1973) reported an overall calf mortality rate of 8.6%. The mortality rate was shown to be 4 times greater in difficult parturitions, especially for male calves. Donald (1963) reported crossbreeding resulted in a decrease in perinatal calf mortality. An intermediate size of cow in her second or later parity was associated with the lowest perinatal calf mortality. Moore (1956) reported the heavier one third of heifers were .81 units lower in calving difficulty score than were the lighter two thirds of heifers. The heavier heifers also had calves averaging 3.3 pounds higher in birth weight. Koger et al. (1967) reported the weight of the cow had no influence on calf survival. Notter et al. (1978), Philipsson (1976), Gregory et al. (1978) and Laster et al. (1973) found similar effects of breed on perinatal calf mortality. Liboriussen (1979) reported breeds having calving difficulty also had a high perinatal calf mortality rate. Bar-Anan (1979) working with Israeli dairy cows found sire differences for calf survival were consistent within sire. He recommended selecting sires whose calves survived, quoting a heritability for perinatal calf mortality of .42 for heifers and of .13 in cows. Brinks et al. (1973) associated dystocia with 11% fewer first parity calves and 14% fewer calves for the second parity in Hereford heifers compared to the older cow herd. Calves born to 3 year old cows experiencing calving difficulty as heifers were born 13 days later and were 21 kilograms lighter at weaning compared to the herd average. They calculated heritabilities for dystocia as a trait of the calf for all ages of dam of .069, for 2 year olds of .126 and dystocia as a trait of the dam for all ages a heritability of .134 and for 2 year olds of -.003.

Sloss et al. (1967) classified dystocia as either maternal or fetal in nature. The most frequent maternal abnormality was failure of the cervix and uterus to dilate completely. Other cases observed included uterine inertia, uterine torsion, cervical prolapse, pelvic fracture, uterine rupture and presence of cervical neoplasms. The workers reported an overall dystocia rate of 9% with 24% due to maternal abnormalities with an associated 32% maternal death rate and 76% were fetal dystocias with a 13% maternal death rate. Fetal abnormalities such as relative or absolute fetal oversize were the cause of 46% of all dystocias and 60% of the fetal dystocias. This form of dystocia had the lowest maternal death rate (12%) of all fetal dystocias. Other fetal causes were malpresentation and miscellaneous fetal deformities. Rice (1969) claimed fetal malpresentations accounted for 46.9% of dystocia. The etiologies of malpresentation were cited as; (1) an increased calf size, (2) a decreased heifer pelvic area or (3) a combination of both. Mutiga (1981) reported that malpostures accounted for 50% of fetal dystocias and head deviations were most commonly to the left. This would be logical since the rumen located on the fetus' right would act as a pressure force. Endocrinologically, Erb et al. (1981) reported no hormone concentration differences between malpresentation and normal presentation dystocias.

Factors Of Dystocia

Immaturity is definitely a factor in the incidence of dystocia. Rice (1969) reported an 83% dystocia rate in Angus heifers calving at 94 weeks of age. Moore (1956) concluded the rate of dystocia depends on the heifer size and the calf size. He recommended breeding only the larger heifers to calve as 2 year olds in order to reduce calving difficulty and perinatal calf mortality. Laster et al. (1973) showed the 2 year old dystocia rate was 36.03% higher than in 3 year olds and the 2 year old rate was 44.62% higher than the calving difficulty rate seen in 4 and 5 year old cows. Bellows et al. (1969) published a 44.2% calving difficulty rate in Hereford heifers and a 50.5% calving difficulty rate in Angus heifers. Rice and Wiltbank (1972) claimed a dystocia rate of 35.6% in 2 year olds and they cited the causes as 1) vulval stenosis, 2) relative fetal oversize and 3) uterine inertia. Ward (1977) reported calving difficulty is seen to decrease as cow age, cow weight and cow pelvic area increases. Philipsson (1976) found a nonsignificant trend toward calving difficulty in extremely fat or thin heifers. Burfening et al. (1982) reported significant region effects on calving ease score. Previously, Burfening et al. (1978) presented a heritability estimate for calving ease score of .32 and heritability for percent assisted births was .21. Price and Wiltbank (1978) reported high correlations between the birth weight of the calf and dystocia rate of the dam ($r = .46$). Philipsson (1976) working with Swedish dairy cows reported an occurrence of calving difficulty and/or stillbirths caused an increase in the frequency of emergency slaughter, retained placentae and culling of heifers. Lower re-insemination and poorer conception rates were seen also. Seemingly milk production was unaffected. A heritability of -.15 for calving performance was presented. Patterson et al. (1981) demonstrated a history of cesaerean section, vaginal or uterine prolapse led to a significant decrease in a heifers' subsequent conception rate. However, no detrimental effects were seen with retained placentae.

Seasonal Effects

Olson (1971) showed calves were born later in the season with less difficulty. Philipsson (1976) reported fewest calving difficulties and less stillbirths in the spring through late summer; the frequency of calving difficulty and stillbirth was greatest in the winter. Philipsson suggested increased exercise and daylight effects under pasture conditions as an explanation. Pattullo (1973) reported a significant difference in calving difficulty between early and late calvers, and an increase in birth weight as the calving season progresses from spring to summer. Young (1970) reported calf birth weight increases 1.4 pounds for every 10 days later into the spring calving season.

Breed Effects

Monteiro (1969) found heavier breeds of dam had more calving difficulty. Gregory et al. (1978) reported the greatest calving difficulty in Maine-Anjou cross cattle, with a Hereford x Angus cross having the lowest percent calving difficulty. Liboriussen (1979), Philipsson (1976), Notter et al. (1978) and Nelson and Beavers (1982) also found similar effects of breed on dystocia. Singleton et al. (1973) claimed sire breed of the calf was the most important variable contributing to dystocia. Laster et al. (1973) showed that when birth weight was excluded, the sire breed and dam breed had significant effects on parturition score. Moore (1956) found no calving difficulty differences between Hereford and Angus sires, however he did demonstrate a body type effect. Type I, consisting of small Angus, medium Angus and small Hereford sires, produced 3.7 pounds less in birth weight, 1.58 units less in calving difficulty score and one-third to one-half percent as great as losses in the Type II sires. Type II were medium Hereford, large Angus and large Hereford sires.

Calf Sex

Olson (1971) and Gregory et al. (1978) found male calves were associated with an increased dystocia rate. Bellows et al. (1971) found male calves had a greater frequency of assists and higher calving difficulty scores than female calves (65.1% vs 30.7%, respectively). Laster et al. (1973) showed significant calf sex effects on dystocia score when birth weight was excluded. Male calves were 3.2 kilograms heavier and experienced 11.42% more dystocias. Moore (1956) also found a difference in calf birth weight and dam calving difficulty due to sex of calf. He reported males were 5 pounds heavier than females, had an increased mortality rate and on the average were one unit higher on the calving difficulty scale.

Calf Shape

Differences in dystocia rates among breeds with similar birth weight averages have led to a hypothesis of a calf shape effect. Laster (1974) measured the shoulder width, hip width, chest depth, wither height and body length of neonatal calves. He found calf shape measurements independent of birth weight were not related to dystocia. Ward (1977) also found calf shape was not significantly related to calving difficulty, however all the calves used were out of one sire. Olson (1971) measured calf heart girth and found no significant difference. He did observe male calves were larger and the ratio of the calf's size to the cow size seemed to be important.

Calf Birth Weight

Hindson (1978) used a digital circumference at the fetlock level and found a highly significant linear correlation with birth weight. Heritability estimates of birth weight range from .18 (Benyshek and Little, 1982) to .53 (Knapp and Clark, 1950). Koch and Clark (1955) calculated an estimate to account for maternal environment (h2 = .42). Willham (1972) suggested consideration of direct, maternal and grand maternal effects for heritability estimates. Ward (1976) and Webster et al. (1983) reported calving difficulty is correlated with calf birth weight. Bellows et al. (1971) showed calf birth weight is the number one factor affecting dystocia. The workers also showed a negative effect of precalving condition on calf birth weight. Burfening et al. (1978) agreed when they showed birth weight was the most important factor in dystocia; they stated as birth weight increases so does calving difficulty and also weaning weight increased. Rice (1969) stated calves born with abnormal posture were heavier at birth. He developed a correlation coefficient of .44 for calf birth weight and dystocia. In 1972, he reported dystocia calves were 2 kilograms heavier. Young (1970) demonstrated seasonal effects on birth weight. He also reported dystocia calves were 7 pounds heavier at birth. Moore (1956) discovered heavier heifers had calves averaging 3.3 pounds higher in birth weight. Nelson and Beavers (1982) demonstrated for each 1 kilogram of increase in birth weight, there was a 2.6% increase in percent calving difficulty with cow weight held constant. There also was a .4 unit increase in dystocia score recorded. Laster et al. (1973) showed crossbred calves have a 1.55 pound heavier birth weight. Burfening et al. (1982) showed a significant region effect in all birth weight analyses. Gregory et al. (1978) showed an age of dam effect on birth weight. Koch and Clark (1955) cited maternal effects accounting for 15% - 20% of the variation in birth weight. There was no effect seen on following generations. The additive genetic component was 10% - 15% (Koch, 1972); maternal dominance and permanent environment account for 10% of calf sex effect. Philipsson (1976) observed more calving problems with male calves due to an increased birth weight and an increase in gestation length. Nelson and Beavers (1982) reported calf sex affects birth weight with male calves averaging 1.7 kilograms heavier. With birth weight held constant, calf sex was shown to have no effect on dystocia or on the percentage of assisted parturitions. Smith et al. (1976) found dystocia increases linearly with birth weight. For each 1 kilogram increase in birth weight; calving difficulty increased 1.63%. Notter et al. (1978) demonstrated a significant curvilinear relationship between birth weight and dystocia. They also reported a significant curvilinear relationship between calf birth weight and perinatal calf mortality. Koger et al. (1967) showed a significant quadratic effect of birth weight on calf survival. The intermediate range of birth weight calves had an overall higher survival rate than either the low or high ranges of birth weights.

Pelvic Area

Philipsson (1976) reported an increased percentage of calving difficulty seen with smaller pelvic areas and a less than favorable pelvic area to calf birth weight ratio. Bellows et al. (1971) showed precalving pelvic area had a negative effect on calving difficulty. Rice (1969) reported Hereford heifers with pelvic areas measuring less than 200 square centimeters experienced 69% dystocia and conversely Hereford heifers with pelvic areas of greater than 200 square centimeters only had 28% calving difficulty. He conceded pelvic area was the second most important factor affecting dystocia. Young (1970) showed heifers having calving difficulty had an average of 15.6 square centimeters smaller pelvic areas. Singleton et al. (1973) reported anterior pelvic height is most highly related to dystocia score. Neville et al. (1978) showed pelvic width reaches a maximum at 36 months in Angus and 39 months in Polled Herefords and Simmentals; pelvic height reaches its maximum at 33 months in Polled Herefords and at 39 months in Angus and Simmental. Where pelvic area plateaus at 36 - 39 months (Angus and Polled Hereford), pelvic dimensions continued to increase after most of the hip height was reached. They showed breed differences, as well as differences in management and feeding techique effects for pelvic growth. Heritabilities for the Tipton and Reidsville herds are as follows: for pelvic width h^2 = .18 (Tipton), .22 (Reidsville); for pelvic height h^2 = .10 (Tipton), .38 (Reidsville); and for pelvic area h^2 = .04 (Tipton), .24 (Reidsville). Prentiss (1971) reported pelvic area growth was linear and hypothesized that with valid estimates of calf birth weight, pelvic area could be used to predict dystocia in 2 and 3 year olds. He also showed the sex of the calf gestated by the heifer had no effect on the pelvic area growth curve. Webster et al. (1983) showed 6 months prior to first calving, pelvic area growth was linear. In Angus heifers they reported pelvic area grew .30 cm^2 per day. The workers presented an equation for predicting pelvic area using heifer weight and wither height.

$$\text{Predicted Pelvic Area} = -446.1 + 12.42(\text{wither ht}) + .1347(\text{wt})$$

By subtracting the predicted pelvic area form the actual pelvic area measurement, a pelvic area deviation results. The value of the deviation would indicate heifers with larger than average pelvic areas regardless of the overall size of the heifer at time of measurement. Bellows et al. (1971) showed skeletal measurements, such as hip width, rump length and a skeletal component of birth weight were associated with pelvic area. A larger skeletal size may be indicative of a greater pelvic opening. Robertson (1967) showed the repeatabilty of pelvic dimension measurements to be high, however he found that pelvic area does not have a linear growth rate and it would be difficult to predict pelvic area for a 2 year old using yearling measurements. Rice (1969) took weekly measurements and showed the pelvis increased at a greater rate peripartum. He found considerable variation, however and concluded there was minimal accuracy for the prediction of pelvic area. A pelvic area heritability estimate was proposed by Benyshek and Little (1982) (h^2 = .53). Philipsson (1976) hypothesized the ideal brood cow conformation to be a roof formed rump with low placed thurls in relation to hip bones and sacrum. Also the cow should have good width between the hips. Bonsma (1965) claimed the pelvis of an animal has a larger opening if the ilium slopes downward. Laster (1974) used a subjective pelvic slope score of 1 to 3 and found no significant effects on dystocia.

MATERIALS AND METHODS

This study involved 160 two-year-old first calf heifers within the state of Kansas representing four breeds and from five herds. The Purebred Beef Unit at Kansas State University, Manhattan, under the direction of Dr. Miles McKee was the source for 11 Angus, 14 Horned Hereford, and 23 Simmental heifers. The Cow Calf Unit, also a Kansas State facility, under the direction of Dr. Robert Schalles, provided access to 11 Polled Hereford and 15 Simmental heifers. Dean and Iadonna Perkins of Blue Sky Farms, Barnes, Kansas allowed us to use their 14 Hereford heifers. Robert and Betty Schalles along with Calvin and Mary Louise Drake provided data on 13 Simmental heifers. Chris and Lorna Pelton, managers of Sutor Hereford Farms (Darrell Sutor, owner), Zurich, Kansas provided 59 commercial Hereford heifers for this study.

Precalving Data

Survey of Management Practices

The manager at each location provided information pertaining to herd management techniques. (table 1) The precalving and postcalving rations as well as procedures for care of the newborn were recorded. The scoring system for parturitions was standardized (table 2).

Heifer History and Condition Data

Data collection included herd location, breed, sire of heifer, birthdate of the heifer and available breeding dates. Approximately 1 mo before calving started the following measurements were taken: weight, hip height (using the Massey frame stick) and visual condition score (table 3). The ratio of precalving body weight to hip-height was used as an estimate of body condition. A hip length measurement was obtained by measuring the distance from the anterior edge of the ilium to the posterior point of the ischium in cm.

Heifer Pelvic Measurements

The vertical and horizontal measurements of pelvic cavity were taken using the Rice pelvimeter and pelvic area was calculated. A subjective visual rump score (1 to 9) was recorded, in which 1 represented drastic downward slope from hooks to pins and 9 an upward slope from hooks to pins. Measured angle of rump was taken using a carpenters square (see appendix, figure 1).

Parturition Data

At parturition the manager recorded the calving date, parturition score (table 2) and calf birth weight. A score for calf vigor was determined (table 4) and retained placentae were noted. The ratio of heifer precalving pelvic area to calf birth weight was used as an indicator of the degree of relative fetal oversize (Short et al., 1979). Data from the Kansas State University housed calves were used for calf body shape measurements which included average forelimb fetlock circumference, hock to dewclaw length, hip width and shoulder width (see appendix, figure 2).

Cow Performance Data

The heifers were diagnosed for pregnancy the following fall and conception dates were determined for heifers artificially inseminated. A post-partum interval to conception was calculated. The weaning weight of the calf was adjusted for breed and age.

Statistical Analysis

The data were analyzed using Statistical Analysis Systems (SAS). General linear model procedures were used for analysis of variance, estimating variance components, determining least square means and regression coefficients. The stepwise procedure was used for model building and the correlation procedure developed the simple phenotypic correlations (SAS Manuals, 1982 ed). Heritabilities and genetic correlations were calculated using Becker's Manual of Quantitative Genetics (1975 ed).

Table 1. Management Survey Results

	Sutor Hereford Zurich, KS	Blue Sky Farm Barnes, KS	Schalles & Drake Manhattan, KS	KSU Purebred Unit Manhattan, KS	Cow Calf Unit Manhattan, KS
Precalving Diet	25# sorghum silage 5# corn & 8# alfalfa	2.5# oats, 2.5# milo and adlib brome hay	10# grain mix* 17# prairie hay	10# milo 13# alfalfa	8-10# milo 12# alfalfa
Post-calving diet	4# milo, 5# corn 25# sorghum silage 12# alfalfa hay	same as above	10# grain mix* 15# alfalfa hay	10# milo 15# alfalfa	12# grain mix 15# alfalfa
Plan'd Calve-out location	small 2-3 A lots	small pasture	small pasture	small lots then to pens in barn	small lots, then barn
How Often Checked	every 4 hrs (every 2 hrs when 20 F)	every 4 hours	6am, noon, 6pm & 11 pm, nightfeeding	every 2 hrs	every 2 hrs
Criteria for Assistance	only after no progress was made	as soon as heifer was dilated	only after no progress was made	as soon as feet appeared	as soon as feet appeared

* Schalles grain mix

59% corn	.5% trace mineral salt
34% milo	5% molasses
1% limestone	150 mg/day Rumensin

Table 2 Parturition Score Scale

1 = no assistance necessary

2 = easy assist

3 = a medium amount of traction necessary

4 = a great deal of traction required and/ or use of a mechanical calf puller

5 = calf taken by cesaerean section

6 = abnormal or breech presentation.

Table 3. Visual Condition Score Scale

1 = Extreme emaciation. Ribs, hip bone and tailhead projecting very prominently. No fat deposition detectable in any area. Transverse processes and neural spines easily distinguished and sharp to the touch.

2 = Very thin and devoid of fatty tissue deposition in all regions. However, the prominent muscular atrophy characteristic of condition 1 is not evident. All areas of the skeletal structure are visible and feel sharp upon palpation.

3 = Thin, but no evidence of muscular atrophy. Slight feeling of fat deposition over the ribs. Hip bone and tailhead regions are less prominent than condition 2, but spinous processes still sharp to the touch and no fat present around tailhead.

4 = Prominent features of hip bone, tailhead and ribs still evident, but overall less obvious and demonstrating some fat deposition, particularly in the area of the ribs. Spinous processes can be individually palpated and give slight indication of rounding. Tissue cover in the tailhead region is slight to the touch.

5 = Overall features of skeletal structure less discernible. Smooth appearance over the rib area. Spinous processes can be identified individually, but feel rounded to the touch. Some fat tissue is evident and can be felt around the tailhead.

6 = Overall skeletal features of hip bone and tailhead can be visualized but give a smooth appearance. Spinous processes are only slightly evident and rounded to the touch with firm pressure. Rib area is smooth with palpable evidences of fat. Some initial appearances of fat deposition on either side of the tailhead.

7 = Generalized protusion of the hip bone and tailhead can be seen, but increased fat deposition gives the animal a smooth appearance. Spinous processes cannot be visualized and are felt only with firm pressure. Rib area appears completely smooth with fat cover on either side of the tailhead being easily felt.

8 = Smooth appearance throughout with definite evidences of fat deposition over the hip bone and tissue covering both over and filling the area between the ribs. Fat cover around tailhead evident as slight swells and somewhat soft to the touch. Beginning of some fat deposits in the flank area can be noted and the initial development of a fat fold in the rear immediately below the vulva can be seen.

9 = Extremely fat animal giving an overall blocky appearance. Skeletal features of tailhead and hip bone difficult to perceive due to extensive fat cover. Rib area shows bulging of fat with patches of fat evident in the flank and over the pin bones. Large roll of fat also apparent immediately below the vulva.

Table 4. Calf Vigor Score Scale

1 = calf that stands and suckles on his own immediately (< 30 min)

2 = calf that is slow in standing and suckling (> 30 min)

3 = calf that requires help to suckle and is weak

4 = calf that dies within 3 d after birth

5 = calf that dies after 3 d of age

RESULTS AND DISCUSSION

One hundred forty-three heifers records were used for analysis. Data sets on 17 heifers were omitted because of missing records. A stepwise regression procedure was utilized to determine the parameters which account for variation in heifers parturition scores. Dystocia can be regarded as a trait of the calf or of the dam (Olson 1971). The calf shape model (Model I) has the dependent variable of parturition score of the calf. The independent variables included heifer precalving weight, hip length, weight:hip-height ratio, horizontal pelvic measurement, pelvic area (horizontal times vertical), visual rump score and calf birth weight, sex, hip width and shoulder width. Breed and herd were partially confounded and herd was not included in the model. Sire and maternal grandsire within breed were the random effects. There were only 43 complete records for this model (R^2 = .911). Birth weight was the most significant calf trait in the model (P=.002). This agrees with Bellows et al. (1971) who showed that birth weight was the number one factor affecting parturition score. Calf hip width was more important than calf shoulder width (p=.006 vs p=.019), both indicating a calf shape effect. This disagrees with Laster (1974) who found no calf shape effect on calving ease independent of birth weight. Longer hip length and less sloped rump were also important in reducing parturition score (P=.022 and .004, respectively). Larger internal pelvic inlet area was significant (P=.023) in reducing dystocia (table 5). The partial correlation between pelvic area and parturition score was -.353 (P=.15) where calf size and cow size traits were held constant. When calf shape effects are removed, pelvic area becomes important in reducing parturition score.

The cow traits model (Model II) was developed similarly. The dependent variable was parturition score. The independent variables were heifer precalving weight, hip length, weight:hip-height ratio, condition score, horizontal pelvic measurement, pelvic area, visual rump score, calf birth weight and sex. There were 93 complete records for this model (R^2 = .830). In model II heifer condition estimates i.e. precalving weight, weight:hip-height ratio and condition score were important (P=.042, .007 and .025, respectively). Less rump slope reduced dystocia (P=.020), but heifer hip length was not a factor (P=.145). Pelvic inlet measurements, horizontal, vertical or pelvic area, were not significant (P=.409, .464, .501 respectively). The partial correaltion for pelvic area and parturition score was -.037 (P=.82) when calf size and cow size measurements were held constant. Calf birth weight was an important factor in parturition score (P=.064) (table 6).

Using Model II, the least squares means of condition score and calf sex were calculated. There was more dystocia for a condition score of 4, as compared to scores of 5, 6, or 7. Philipsson (1976) also detected a nonsignificant trend toward calving difficulty in extremely fat or thin heifers. Condition score 4 had the longest postpartum interval to conception and condition score 7 had the shortest postpartum interval. We can conclude that a heifer in good condition before calving will calve easier and breed back quicker than a heifer in fair or poor condition before calving (table 7). No difference in parturition score was detected between male and female calves (table 8). This agrees with Nelson and Beavers (1982) who reported no calf sex effect on calving score or on percentage of assisted parturitions when birth weight was held constant.

Least square means were calculated for heifer pelvic area, postpartum interval to conception, calf birth weight and weaning weight using parturition score as an independent variable. Pelvic areas did not differ between parturition scores. Postpartum interval from calving to conception was longest for calving difficulty score 4. However there were only three observations for parturition score 4. Score 5 had a heavier weaning weight than any other parturition scores (table 9). Least square means were also calculated between breeds. There were no differences in heifer pelvic area and calf birth weight between Angus, Hereford and Simmental cattle. Angus calves had lighter weaning weights than Hereford and Simmental calves (table 10).

Simple phenotypic correlations were calculated for all 20 variables using all breeds and by breed for Hereford and Simmental heifers and calves. All the body measurements were significant and positively correlated. Cattle size increased with fatter cattle. All traits were positively correlated suggesting larger body dimensions (table 11). Condition score was correlated to weight: hip-height ratio (r=.71) only in Herefords (table 13). The Simmental weight: hip-height ratio was not a good estimator of condition score (r=.169, P=.247). This may be due to the Simmentals being considerably taller. A suggestion would be to account for the increased height of the Simmental breed, due to the difference in growth curves, with an adjustment factor.

Visual rump score was negatively correlated to angle of rump measurement in both Herefords and Simmentals (r= -.363 and -.45, respectively) (table 14). This is due to the definition of the measurements. In visual rump score a 1 is a very drastic downward slope and a 9 is an upward sloped rump. Angle of rump measurement is the reverse. The larger the number the more slope exists from hooks to pins. Visual rump score was positively correlated with all cow dimensions. This leads to the conclusion that larger cows have a more level rump. Visual rump score seemed to be more accurate measurement for pelvic slope than the measuring tool. The rump measurement was dependent on the stance of the heifer in the chute. Her legs could be too far underneath or too stretched out as when pulling against the headgate and it changed the readings drastically. The visual rump score was given as the heifer walked out freely and the researcher watched her for a few seconds before assessing the score. Neither angle of rump measurement or visual rump score were highly correlated to ease of calving. More observations are needed and future studies should include cattle with some Bos Indicus breeding to provide extremes in rump slope.

Pelvic area was positively correlated to visual levelness of rump (table 11). Parturition score was less with larger pelvic areas in Herefords (r= -.234) (table 14) and was not related in Simmentals. Pelvic area:birth weight ratio was negatively correlated to parturition score in both Herefords (r=-.389) (table 17) and Simmentals (r= -.633) (table 18). Larger pelvic area to birth weight ratios calved easier than did the smaller ratios. A decrease in pelvic area and(or) an increase in calf birth weight tended to be a more difficult calving.

Calf birth weight was positively correlated to parturition score for both male (r=.62) and female calves (r=.38) (table 8); in Simmental and Hereford calves and for all breeds of calves (r= .721, .326 and .559, respectively). This supports Rice (1969) and Burfening et al. (1978) who reported that as calf birth weight increases so does the value of the parturition score (tables 15, 16, & 17). All the calf body measurements were positively correlated. Ankle circumference was highly correlated to calf birth weight (r=.70). This is substantiated by Hindson (1978) who reported a correlation of .94 for ankle circumference and calf birth weight. Larger calves had more dystocia. Hereford calves experiencing dystocia were less vigorous (table 17).

Interval from calving to conception was positively correlated to cow size measurements and negatively correlated to condition score. Larger cows took longer to breed back especially if in poor condition. There was a positive correlation of parturition score to postpartum interval and calf birth weight. Calf birth and weaning weight were positively correlated to cow size measurements also. Larger cows had larger calves. This supports Moore (1956) who found heavier heifers had calves higher in birth weight and .81 units lower in parturition score. Weaning weight was negatively correlated to precalving condition score. An explanation would be a condition score 4 is a more efficient cow compared to a conditon score 7. Thinner cows give more energy to production during gestation and lactation compared to a fat cow. Adjusted weaning weight had high positive correlations with parturition score and calf birth weight. Burfening et al. (1978) agreed when they stated as calf birth weight increases so does calving difficulty and subsequent calf weaning weight. Large birth weight calves, even though they had trouble at birth, still weaned heavier (table 19).

Heritabilties were calculated using the sire component of variance as an estimate of the calf's ability to be born. Parturition score had a heritability of .355. This is similar to Burfening et al. (1978) report of $h^2 = .32$ for calving ease score. The maternal grandsire component of variance was used to estimate the ability of the heifer to have a calf. The only realistic heritability calculated was for pelvic area ($h^2 \doteq .719$). The other traits showed either a negative heritability or one that was greater than 1.00. In these cases the error variance was larger than the mean squares for the heifer's sire and a negative maternal grandsire variance resulted (table 20). Although the model used was effective (R^2=.830), they did not explain enough variation to decrease the error term sufficiently. Philipsson (1976) also reported a negative heritability (h^2 = -.15) for calving performance. Olson (1971), in a master's thesis, calculated heritabilities for dystocia as a trait of the calf for two-year old dams and as a trait of the two-year old dam (h^2 = .126, -.003, respectively). The calculated genetic correlation for parturition score and calf birth weight was .376.

Thinner cows had more trouble calving and a longer time span from calving to conception. Their calves had heavier weaning weights also. This study substantiated the hypothesis that birth weight was the most important factor in reducing parturition score. Calf hip and shoulder width did affect calving score (P=.006, .019, respectively). When calf shape is held constant, pelvic area becomes important in reducing dystocia. A sloped rump was not related to ease of calving in these beef breeds.

Table 5. Regression Coefficients on Parturition Score

Calf Model

Birth Weight	.07481364***
Rump Score	-.75016150***
Calf Hip Width	-1.12876007***
Calf Shoulder Width	1.42275926**
Hip Length	.99679942**
Pelvic Area	-.06337840**
Horizontal	1.04496268
Precalving Weight	-.00483167
Calf Sex	-.23142575
Weight Height Ratio	.19393305

* = p < .1

** = p < .05

*** = p < .01

Table 6. Regression Coefficients on Parturition Score

Cow Model

Weight Height Ratio	.86884951***
Rump Score	-.45692325**
Condition Score	-.56046666**
Precalving Weight	-.01066111**
Birth Weight	.03403409*
Calf Sex	-.55978195*
Hip Length	.36343991
Horizontal	-.30014777
Pelvic Area	-.00871941

* = p < .1

** = p < .05

*** = p < .01

Table 7. Least Square Means of Condition Score.

	4	5	6	7
No. of observations	45	64	31	2
Parturition Score	$2.39 \pm .22^{a}$	$1.99 \pm .19^{b}$	$1.81 \pm .27^{b}$	$.92 \pm .83^{b}$
Postpartum Interval	103.9 ± 6.2^{a}	95.2 ± 5.8^{b}	91.7 ± 6.9^{b}	61.5 ± 19.0^{c}

a,b,c = means with different superscripts are different ($P < .05$)

Table 8. Calf Sex Least Square Means and Correlation.

	Male	Female
No. of observations	69	71
Parturition Score	$1.88 \pm .28^{a}$	$1.68 \pm .28^{a}$
Calf Birth Weight	91.07 ± 2.7^{a}	92.23 ± 3.2^{a}
Correlation of Parturition Score and Birth Weight	.62 (p=.0001)	.38 (p=.0012)

a = no significant difference

Table 9. Least Square Means of Parturition Score.

	1	2	3	4	5
No. of observations	53	46	28	3	13
Pelvic Area	$229.45 \pm .37^{a}$	$230.57 \pm .36^{b}$	$229.73 \pm .47^{ab}$	228.79 ± 1.2^{a}	$230.81 \pm .68^{b}$
Postpartum Interval	80.56 ± 5.0^{a}	79.99 ± 6.3^{a}	82.0 ± 7.0^{a}	102.02 ± 24^{a}	95.78 ± 9.9^{a}
Birth Weight	83.99 ± 3.9^{ab}	88.60 ± 3.0^{abc}	94.44 ± 4.0^{bcd}	98.84 ± 9.0^{bd}	101.31 ± 4.9^{d}
Weaning Weight	415.1 ± 16.7^{a}	453.9 ± 11.5^{a}	434.6 ± 19.3^{a}	479.1 ± 61.5^{a}	494.1 ± 22.2^{b}

a,b,c,d = means with different superscripts are different ($P < .05$)

Table 10. Least Square Means of Breed.

	Angus	Hereford	Simmental
No. of observations	11	80	49
Pelvic Area	$230.51 \pm .86^{a}$	$230.12 \pm .39^{a}$	$228.98 \pm .60^{a}$
Birth Weight	94.75 ± 5.3^{a}	94.48 ± 4.0^{a}	91.10 ± 2.9^{a}
Weaning Weight	422.9 ± 26.4^{a}	471.5 ± 16.5^{b}	471.7 ± 16.1^{b}

a,b = means with different superscripts are different ($P < .05$)

Table 11. Simple Phenotypic Correlations for All Breeds - Cow Traits.

	Precalve Weight	Hip Height	Weight/ Height	Hip Length	Vertical	Hori- zontal	Pelvic Area	Rump Score
Precalve Wt	1.0000							
Hip Height	.81145**	1.0000						
Weight/Height	.95711**	.60880**	1.0000					
Hip Length	.76804**	.70649**	.69388**	1.0000				
Vertical	.17452**	.23335**	.11753	.21817**	1.0000			
Horizontal	.53463**	.55776**	.44614**	.40583**	.52935**	1.0000		
Pelvic Area	.46298**	.50227**	.37545**	.38604**	.78033**	.94184**	1.0000	
Rump Score	.37967**	.28510**	.36810**	.35085**	.16436*	.36258**	.33024**	1. 0000

* = significant at the .1 level.
** = significant at the .05 level.

Table 12. Simple Phenotypic Correlations - Simmental Cow Traits

	Precalve Weight	Hip Height	Weight/ Height	Hip Length	Vertical	Hori-zontal	Pelvic Area	PelvArea/ Birth Wt
Precalve Weight	1.0000							
Hip Height	.54873**	1.0000						
Weight/ Height	.93605**	.22048	1.0000					
Hip Length	.66247**	.65232**	.49535**	1.0000				
Vertical	.28112*	.37932**	.15342	.29814**	1.0000			
Horizontal	.53668**	.27558*	.49694**	.33936**	.26551*	1.0000		
Pelvic Area	.54207**	.39844**	.44715**	.40636**	.69196**	.87932**	1.0000	
PelvArea/ Birth Wt	.08406	.19877	-.00266	.12538	.25800*	.34320**	.38611**	1.0000

* = significant at the .1 level.

** = significant at the .05 level.

Table 13. Simple Phenotypic Correlations - Hereford Cow Traits

	Precalve Weight	Hip Height	Hip Length	Condition Score	Weight/ Height	PelvArea/ Birth Wt
Precalve Weight	1.0000					
Hip Height	.64686	1.0000				
Hip Length	.68465	.59050	1.0000			
Condition Score	.66039	.23244	.36982	1.0000		
Weight/ Height	.96356	.41987	.60861	.70607	1.0000	
Pelv Area/ Birth Wt	-.44953	-.27601	-.20027	-.43119	-.44456	1.0000

All correlation coefficients are significant at the .05 level.

Table 14. Simple Phenotypic Correlations - Hereford Pelvic Traits

	Vertical	Horizontal	Angle of Rump	Rump Score	Pelvic Area	Parturition Score
Vertical	1.0000					
Horizontal	.71223**	1.0000				
Angle of Rump	-.21568*	-.30725**	1.0000			
Rump Score	.06223	.20332*	-.36332**	1.0000		
Pelvic Area	.91031**	.93688**	-.28633**	.15406	1.0000	
Parturition Score	-.23237**	-.21578**	.09533	-.06052	-.23436**	1.0000

* = significant at the .1 level.

** = significant at the .05 level.

Table 15. Simple Phenotypic Correlations - Calf Traits

	Birth Weight	Ankle Circum.	Hip Width	Shoulder Width	Hock to Dewclaw	Parturition Score
Birth Weight	1.0000					
Ankle Circum.	.69648**	1.0000				
Hip Width	.41911**	.37593**	1.0000			
Shoulder Width	.52719**	.57107**	.85178**	1.0000		
Hock to Dewclaw	.62393**	.65666**	.61396**	.65283**	1.0000	
Parturition Score	.55900**	.53049**	.12933	.32028**	.35560**	1.0000

** = significant at the .05 level

Table 16. Simple Phenotypic Correlations - Simmental Calf Traits

	Birth Weight	Parturition Score	Ankle Circum.	Hock to Dewclaw	Pelv Area/ Birth Wt
Birth Weight	1.0000				
Parturition Score	.72072	1.0000			
Ankle Circum.	.65033	.57196	1.0000		
Hock to Dewclaw	.59167	.46968	.47527	1.0000	
Pelv Area/ Birth Wt	-.84873	-.63335	-.36083	-.48597	1.0000

all are significant at the .05 level.

Table 17. Simple Phenotypic Correlations - Hereford Calf Traits

	Birth Weight	PelvArea/ Birth Wt	Parturition Score	Vigor Score
Birth Weight	1.0000			
PelvArea/ Birth Wt	-.71850**	1.0000		
Parturition Score	.32592**	-.38854	1.0000	
Vigor Score	.15274	-.11237	.58809**	1.0000

** = significant at the .05 level.

Table 18. Simple Phenotypic Correlations - Cow and Calf Traits

	Precalve Weight	Hip Height	Wt Ht Ratio	Hip Length	Vert-ical	Hori-zontal	Pelvic Area	Angle of Rump
Birth Weight	.67790**	.62597**	.61951**	.47968**	-.03439	.37090**	.26058**	.06900
Ankle Circum.	.58479**	.48434**	.52873**	.34265**	.37955**	.70944**	.70711**	-.36453**
Hip Width	.39523**	.23759*	.40368**	.26568*	.16803	.36699**	.34617**	-.29420**
Shoulder Width	.44614**	.26114*	.46046**	.26158*	.29048**	.46139**	.46669**	-.35860**
Hock to Dewclaw	.65135**	.48455**	.60514**	.52195**	.28683*	.60059**	.58293**	-.54730**

* = significant at the .1 level.
** = significant at the .05 level.

Table 19. Cow Performance Correlations.

	Postpartum Interval	Adjusted Weaning Wt
Precalve Weight	.21230**	.25058**
Hip Height	.20260**	.23293**
Weight/ Height	.18673**	.21408*
Condition Score	-.56767**	-.34132***
Parturition Score	.40917**	.38663***
Calf Birth Weight	.41664***	.42740***

* = significant at the .1 level
** = significant at the .05 level
*** = significant at the .01 level

Table 20. Heritabilities

	Sire Component of Variance	Maternal Grandsire Component of Variance
Pelvic Area		.719
Parturition Score	.355	1.155
Angle of Rump		-.216
Rump Score		-.023

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APPENDIX

Figure 1. Measured Angle of Rump Tool.

Place end of tool at anterior edge of ilial crest (hooks).

Balance the level bubble at center of horizontal bar.

Set metal dowel at posterior edge of ischial crest (pins).

Take reading where dowel crosses the scale on the vertical bar.

Figure 2. Calf Width Tool.

Use sliding caliper action to measure width of calf at shoulders and at hip.

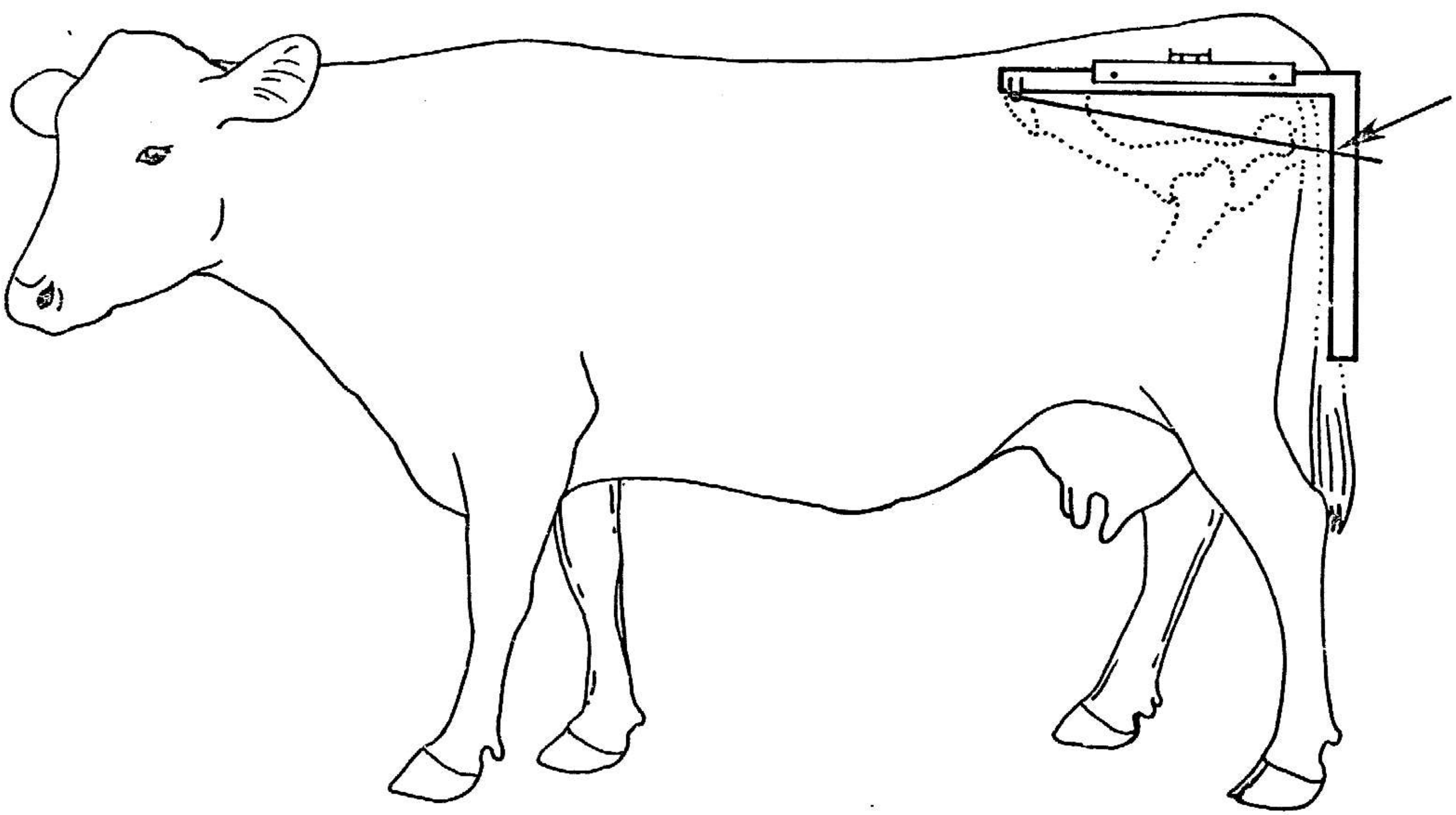

Figure 1

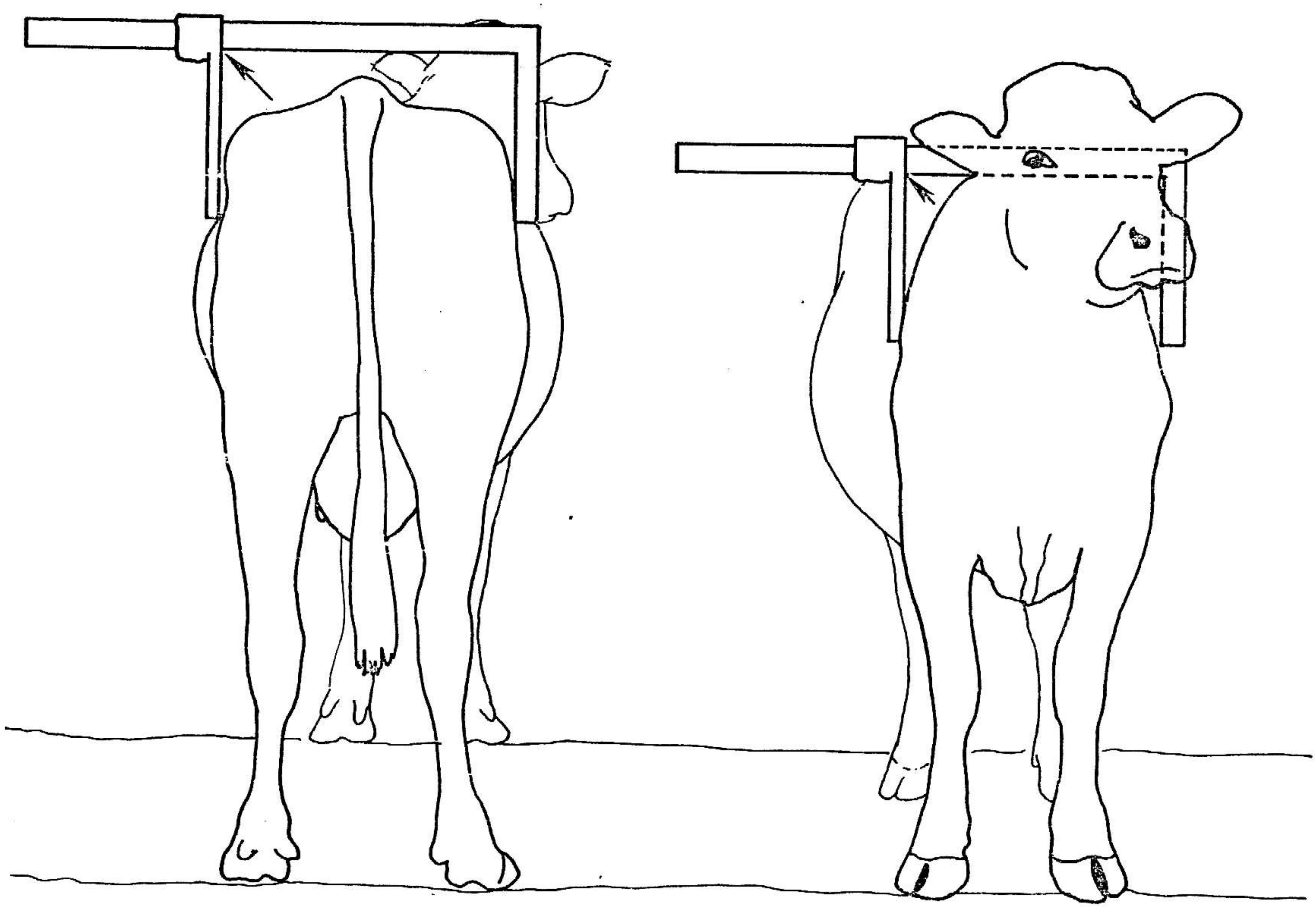

Figure 2

CALF SHAPE AND PELVIC DIMENSIONS
AFFECTING DYSTOCIA IN BEEF HEIFERS

by

COLLEEN KAY CLARKE

B.S., California State University, Fresno, 1982

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

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KANSAS STATE UNIVERSITY

Manhattan, Kansas

1983

Records from 143 heifers were analyzed to determine the affect of calf shape and heifer pelvic dimensions on dystocia. Heifer data collection from five herds included location, breed, sire of heifer, birthdate, breeding dates, weight, hip height and hip length. Pelvic dimensions including horizontal and vertical pelvic cavity dimensions, a visual rump score (1 to 9) and measured angle of rump were also taken approximately 1 mo before calving. At parturition, the herd manager recorded date, parturition score, vigor score and birth weight of the calf. Forelimb fetlock circumference, hock to dewclaw length, hip width and shoulder width were taken on 54 calves. The subsequent postpartum interval to conception and calf adjusted weaning weight were calculated.

Regression coefficients were calculated for a model involving calf measurements (R^2 = .911) and a model of cow measurements (R^2 = .830). Heritabilities were calculated using sire component of variance for parturition score (h^2 = .355) and using maternal grandsire component of variance for parturition score (h^2 = 1.155), for pelvic area (h^2 = .719), for visual rump score (h^2 = -.023) and for measured angle of rump (h^2 = -.216). The genetic correlation for parturition score and calf birth weight was .376.

Birth weight was the most important factor affecting calving ease. Pelvic dimensions were important in explaining variations in parturition score. Calf hip and shoulder width did affect parturition score (P=.006, .019, respectively). A sloped rump was not related to ease of calving in Angus, Hereford and Simmental cattle.