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I am submitting herewith a thesis written by Rodney H. Barnes entitled "Reproductive Efficiency in the Bovine Female: Dystocia." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

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5

REPRODUCTIVE EFFICIENCY IN THE BOVINE FEMALE: DYSTOCIA

A Thesis
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Degree
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Rodney H. Barnes

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ABSTRACT

The objectives of this study were to: (1) identify the factors which are closely related to dystocia, (2) identify the degree of relationship between these factors, and (3) develop a practical system of predicting the occurrence of dystocia.

One hundred and sixty-three primiparous beef heifers of Hereford or Angus breeding were studied at the Ames Plantation, Alcoa, Knoxville, and Oak Ridge stations. Data were collected on these heifers during the first, second and third trimester of gestation. Each heifer was observed and scored on the difficulty of her parturition. Measurements were taken on the calves within 24 hours of birth.

Regression analyses were conducted to determine the relationship of the various measurements to the occurrence of dystocia. Of the factors which could be measured or otherwise calculated prior to parturition, the width of the pelvic canal of the heifer was indicated to be the most influential. The sire of the heifer was found to be the next most significant factor in this analysis. Following closely behind the sire of the heifer in rank of importance were: height of the pelvic canal and the pelvic area per day of age.

Of the observations made postpartum, the length from hock to dew claws on the calf was the most closely correlated with dystocia. Following in order of relationship were: length of the cannon bone, width of the shoulders, width of the hips, and circumference of the heart girth of the calf.

In evaluating the three data collection periods, the data collected at breeding accounted for a far greater percentage of the variability in dystocia than that collected at the other periods. In this study, the data collected at breeding defined a maximum of 87 percent of the total variability compared to 76 percent at pregnancy determination and 75 percent immediately prior to the calving season.

It was not possible to designate one measurement which would predict dystocia to a satisfactory degree, using the limited number of observations available. Continued study on more heifers will be necessary. However, this study indicates that it may be possible to develop a technique which will enable cattlemen to accurately predict dystocia, at or before the time the heifer is bred.

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CHAPTER I

INTRODUCTION

Dystocia cost the cattlemen of Tennessee about 65,000 calves during 1975. This is a loss which the cattle industry can ill afford. Yet at this time not enough is known about dystocia to enable cattlemen to prevent it.

The occurrence of dystocia, i.e., difficult parturition, is common among primiparous females. In the average herd, 12 percent of the females will be heifers and well over half the cases of dystocia in the herd will be experienced by the heifers.

Only a limited knowledge of the factors involved in dystocia has been gained from previous studies. At the present time, dystocia cannot be predicted, much less prevented. Considering the nature of the problem, prediction might be synonymous with prevention.

Several factors have been identified which have an important role in the occurrence of parturition difficulty. However, research has failed to develop a test or measurement which can be conducted on a practical basis to allow cattlemen to know if a heifer will experience difficulty during parturition.

This study was undertaken for the purpose of: (1) identifying the factors which are closely related to dystocia, (2) identifying the degree of relationship of those factors, and (3) developing a practical system of predicting the occurrence of dystocia.

CHAPTER II

LITERATURE REVIEW

In the beef industry today, calving losses at parturition or shortly thereafter rank second only to conception failure as the chief factor in beef calf-crop reduction. This problem is rather poorly understood as is evidenced by the results of the relatively small amount of research which has been conducted in this area.

Perinatal mortality in cattle ranges from 5 to 15 percent of all births (Hafez, 1974). This is a tremendous loss which the beef industry can ill afford, especially in view of the fact that 80 percent of all calves lost at birth are anatomically normal and die from injuries resulting from difficult or delayed parturition (Singleton et al., 1973). The cattle numbers supplied by the Tennessee Crop Reporting Service of the Tennessee Department of Agriculture show that 65,000 calves were lost in Tennessee during 1975 due to dystocia.

Dystocia can cause other problems in addition to the loss of one calf. Dystocia can have harmful effects on the continued fertility of the dam. According to Brinks et al. (1973), two-year-old females experiencing dystocia not only weaned 11 percent fewer calves in Colorado in 1971, but also weaned 14 percent fewer calves the next year. These same workers also stated that those females experiencing dystocia calved an average of 14 days later the next year compared to their contemporaries that did not experience dystocia. Other studies have shown that heifers experiencing dystocia as two-year-olds had 4-1/2 percent more difficulty in calving as three-year-olds than did similar three-year-olds that had not experienced dystocia. Fourteen percent more of these heifers were open as three-year-olds than were their contemporaries. Laster et al. (1973) found that females, of all ages, experiencing dystocia had a 15.6 percent lower conception rate when bred artificially than did similar females that had not experienced dystocia. In their work, they also found that females experiencing dystocia had a 15.9 percent lower conception rate than females not experiencing dystocia when bred by natural service.

A problem which causes so much loss should be prevented or controlled. However, to do so requires a thorough understanding of the problem. Several important factors are involved in dystocia: presentation, shape, birth weight, and sex of fetus; weight, age, pelvic size, pelvic shape, and pre-calving energy level of dam; sire of calf; and breed or cross of breeds of dam and sire. In this report these factors will be discussed in three categories: maternal influence, fetal influence, and paternal influence.

Maternal Influence

Maternal influence on dystocia refers to the instances of dystocia which are the result of some factor or factors which are directly attributable to the dam. They are relatively important since 24 percent of all dystocia can be considered maternal (Sloss et al., 1967). The individual factor which is the direct cause of the dystocia may vary. However, certain factors are more prevalent in heifers than in mature cows and vice versa.

Slightly over half the incidences of sytocia in a cow-calf operation are observed in first-calf heifers (Ball, 1974). The factors causing dystocia, almost exclusively in primiparous females, may be quite varied. A complete understanding of these factors and the importance of their roles has not yet been gained. The factors which have presently been identified are: pelvic size and shape, age of dam, weight of dam, breed of dam, and pre-calving energy level.

The size and shape of the internal pelvic area of a primiparous female is of major importance since it has a correlation with dystocia of .32 (Rice et al., 1970). Bellows et al. (1971) found that pelvic size was the most important factor in maternal dystocia among heifers. Rice et al. (1972) found 68.7 percent of all two-year-old heifers having pelvic areas of less than 200 square centimeters experienced dystocia. In research conducted by Ward (1971), it was observed that only 38 percent of the two-year-old heifers had pelvic areas less than 225 square centimeters, yet this 38 percent accounted for over 50 percent of the calving difficulty.

The age and weight of the primiparous female is also of importance. These two factors are interrelated as well as closely related to the factor of pelvic size. A significant yet unpredictable correlation exists between a heifer's external measurements and weight and her pelvic area (Ward, 1971). Therefore, if a heifer is relatively small and light weight at her first parturition her pelvic area will not be sufficiently large enough for the passage of her calf. Several researchers agree that age at the first parturition correlates negatively with dystocia (Brinks et al., 1973; Brown et al., 1969; Laster et al., 1973; Laster et al., 1973; and Ward, 1971). This is basically due to the fact that chronologically younger heifers usually weigh less and are physically less mature.

The breed of the female also influences the frequency of dystocia. Some breeds exhibit physical maturity at a younger age and lighter weight. The females of these breeds exhibit less parturition difficulty than later-maturing breeds when bred at a standard chronological age (Brown et al., 1969, and Long et al., 1974). Crossbred heifers often exhibit characteristics that are a blend of the two or more breeds of which they are a cross. This is usually also true of their instances of dystocia. Although crossbred females may exhibit the results of heterosis upon some of their characteristics, heterosis ha no significant effect upon the instances of dystocia (Long et al., 1974).

The pre-calving energy level of the dam is also a factor in the problem of dystocia. However, this is one factor upon which many researchers cannot agree. Some researchers (Laster, 1974, and Pattula, 1973) state that feeding primiparous females substandard energy levels had no significant effect upon the incidence of dystocia. On the other hand, Bellows et al. (1971) reported that substandard energy levels often caused the females to experience difficulty in the rigorous activity of parturition due to slightly weakened condition. Most researchers (Ball, 1974; Bellows et al, 1971; and Laster, 1974) do agree that excessive energy levels during gestation correlate with an increased parturition difficulty. Ball (1974) stated that a female should be fed to gain at least 100 to 120 pounds during the last trimester of gestation since this is the amount which she will lose at parturition.

However, in none of the literature which was reviewed was there any direct mention of the correlation of fat with dystocia. No estimates were made as to the amount of internal or external fat which a female could possess without increasing the incidence of dystocia.

Some of the factors contributing to maternal dystocia may be the same for mature cows and heifers but some factors are present which are not generally noted in heifers. The additional factors are generally related to reproductive tract failure.

Dystocia due to reproductive tract failure is not completely understood. Often at the time of parturition the cervix will fail to dilate properly. This may be caused by an insufficient release of the proper amount of hormones or a failure to release these hormones. In other instances, contractions of the uterine walls may be weak or non-existent. Here again, this may result from improper hormone levels. These same symptoms may be the result of damage to the reproductive tract which was experienced in previous parturitions. The uterine walls may have experienced excessive stretching and been damaged during a previous pregnancy and parturition. This may result in a lack of, or weakened, contractions during parturition. To further complicate this matter is the fact that these symptoms may be the result of prolonged gestation or of heredity (Hafez, 1974).

Fetal Influence

Fetal dystocia refers to those cases of dystocia which are directly caused by the fetus. Fetal dystocia is the most common type of dystocia experienced by both heifers and mature cows (Anonymous, 1971;

Bellows et al., 1971; Laster et al., 1973; Rice et al., 1970; Rice et al. 1972; Sloss et al., 1967; and Ward, 1971). The factors directly involved in fetal dystocia are presentation, birth weight, sex, and shape.

Presentation is the most common factor in fetal dystocia among mature cows and a major factor in heifers. Calves can be born without difficulty either in a normal anterior or posterior presentation. In the anterior presentation the forelimbs of the fetus are extended toward the anterior of the calf with the head lying between and above them. The hind limbs are extended posteriorly. The forelimbs and head enter the pelvic canal first. In the posterior presentation the fetus lies in the same position except that the hind limbs enter the pelvic canal of the dam first. According to Woodward et al. (1959), 95 percent of all calves are born in an anterior presentation.

Difficulties arise when a deviation from the two aforementioned presentations occurs. The most common deviations are: anterior presentation with one or both forelimbs turned back, anterior presentation with the head turned back, posterior presentation with one limb turned back or breech presentation in which the fetus is attempting to enter the pelvic canal in a posterior position with both hind limbs turned back. At the present time, no known practical method of predicting the occurrence of these dystocia-causing presentations is available. The only solution is human assistance during the act of parturition.

Most researchers agree that calf birth weight is the most important cause of dystocia in heifers (Anonymous, 1971; Bellows et al., 1971; Koger et al., 1967; Laster, 1973; Rice et al., 1972; Sloss, 1967; and Ward, 1971). Rice et al. (1970) and Sloss et al. (1967), working in two separate areas of the world both found fetal oversize to be the cause of 46 percent of all dystocia experienced in heifers. This problem is becoming increasingly important due to the present trends in cattle breeding. At the present time, cattlemen are striving to produce animals with heavier weaning and yearling weights. Yet a small birth weight is desirable. This is extremely difficult to achieve since birth weight has a relatively high correlation with weaning weight. (r = .63) and to yearling weight (r = .40) (Koch et al., 1955). Excessively large fetuses often cannot pass through the pelvic canal of their dams without assistance. In addition to those calves which die due to their inability to pass through the pelvic canal, many undiagnosed calf losses are probably due to fetal oversize. Often an extremely large calf may be born and appear to be in good health, however, during a difficult parturition the calf may have received injuries which will result in its death, generally with the first 24 hours after birth (Bellows et al., 1971, and Koger et al., 1967).

Along with the oversized fetus, the factor of calf birth weight includes the extremely small fetus. A high percentage of small calves fail to survive the rigor of parturition (Bellows et al., 1971). Often times these extremely small calves that do survive parturition are extremely weak and lack vigor and many of them fail to survive the first 36 hours post-partum (Koger et al., 1967).

The sex of the fetus becomes an important factor when we consider the effect it has upon weight. Research has shown that male calves experience significantly more dystocia than do female calves (Laster, 1973, and Long et al., 1971). In addition, Woodward et al. (1959) stated that 62 percent of all stillbirths are male fetuses. This problem is much more obvious when we realize that bull calves weigh an average of five pounds more at birth than do heifers (Koch et al., 1959, and Singleton et al., 1959).

Calf shape cannot be completely separated from birth weight. The fetus must be of a shape which will pass easily through the pelvic opening of its dam. Measurements have been taken on new born calves in an attempt to determine which body measurements are critical in their relationship to dystocia. The body measurements which were found by Laster (1974) to have a correlation with dystocia are: shoulder width, hip width, chest depth, wither height, and body length. These factors are very important when we consider that a relatively light weight fetus can experience dystocia if for example it is excessively wide at the shoulders or hips. Conversely, an extremely heavy fetus can be born without difficulty if its body is shaped properly to pass through its dam's pelvic canal.

Paternal Influence

The paternal influence on dystocia refers to those incidences of dystocia which can be attributed to the sire. The sire's affect is in a sense indirect since he actually affects maternal and fetal dystocia. We are referring first of all to the sire of the fetus but also to the sire of the dam.

Various research has shown that the sire of the fetus has an important and significant effect upon both the weight and shape of the fetus (Brinks, 1969, and Brown et al., 1969). While using sires of several different breeds upon females of one breed, Laster (1973) determined that breed of sire had a significant effect upon the instance of dystocia. His experiments indicated that bulls of taller, thicker, heavier and later maturing breeds of cattle tended to sire thicker, heavier type calves which are more likely to experience a higher degree of dystocia than do calves sired by bulls of smaller earlier maturing breeds.

It has been shown that among several breeds of cattle that certain family lines within the breed experience less dystocia than others. Some research has been conducted (Ball, 1974) which indicates that by using bulls from the family lines which experience a minimum of dystocia problems, a significant reduction in the instances of dystocia can be achieved. Brinks et al. (1973) carried this concept one step further in their research. They found that bulls within a family line might have the ability to sire calves that experienced significantly more or less dystocia. They concluded that before one could be sure that a sire's influence would help lessen the dystocia problem the bull should be progeny tested.

The sire of the dam has a two-fold influence upon dystocia. The dam of the unborn fetus has inherited certain traits from her sire. One of these traits is pelvic size. Another is her contribution to the size of her fetus prior to birth. Thus the sire of the dam possesses an influence upon dystocia through the inherited traits of the dam.

Predictability of Dystocia

For knowledge of dystocia to be of value, it must be put to some practical use. The most valuable use would be to predict the probability of dystocia. Since 80 percent of the calves lost at birth could have been saved if closer observation and assistance had been provided, a benefit could be derived from some method of determining which females would experience dystocia (Anonymous, 1971, and Singleton et al., 1973).

Instances of dystocia can be reduced by using bulls that are proven sires of calves that cause little dystocia; however, this will not alleviate all the problem. Research has shown even such bulls do sire some calves that experience dystocia (Ball, 1974, and Brown et al., 1969). In addition, the effect of the sire upon the fetus is extremely difficult to predict under range conditions.

Since fetal effects and paternal effects cannot be practically determined under farm and ranch conditions, the solution to the problem, if attainable, must lie within determining the maternal effects. Most researchers have met with limited success in attempts to find a feasible method of predicting dystocia.

The vast majority of researchers have failed to succeed in accurately predicting dystocia. Some reports state that none of the maternal characteristics which can be measured yield a method of predicting dystocia with any degree of accuracy (Brinks, 1969; Laster, 1974; and Robertson, 1967).

Other researchers seem to have met with very limited success. Brinks et al. (1973) stated that all of the maternal factors which were measured enabled them to predict only 18 percent of the cases of dystocia

Rice and Wiltbank (1972) were able to predict dystocia with only 38 percent accuracy in their research.

Meacham et al. (1976) considered the problem from a slightly different viewpoint. They chose not to evaluate heifers in regard to their total pelvic area and body weight. Rather they divided the pelvic area and body weight by the age of the female. They were able to predict at 14 months of age a heifer's pelvic size at 24 months (her age at parturition) with 89 percent accuracy. They also conducted studies to determine the probability of dystocia occurring in heifers with various pelvic sizes. By combining the two studies they hope to be able to successfully predict dystocia in the near future.

CHAPTER III

EXPERIMENTAL PROCEDURE

Data were collected on a total of 163 beef females located at Ames Plantation, the Aluminum Company of America research unit at Alcoa, the Knoxville Research Station, and the Comparative Animal Research Laboratory farm at Oak Ridge. The females in this study were born in 1974 and 1975 and were all primiparous heifers of the Hereford or Angus breeds. Due to management procedures and the availability of labor at the various stations, the data collected varied slightly between stations; therefore, the experimental procedure for each station will be described separately. The heifers studied at each station are listed in Table I.

Ames Plantation

At Ames Plantation 56 purebred Angus heifers were included in the study. Two purebred Angus bulls were used in pasture mating the heifers. The heifers were assigned to their respective mating group and kept with the bull during April, May, and June of 1976. During the summer and fall, the heifers were maintained on mixed fescue, clover, and orchard grass pastures. Throughout the winter months, the available pasture was supplemented with mixed grass hay and a limited amount of corn silage.

Data were collected three times prior to parturition. The first period at the time of breeding; a second set of data was collected when

TABLE I

ANIMAL NUMBERS AND LOCATIONS

Location	No. Heifers Per Data Collection Period 1st	2nd	3rd	Parturitions Scored	Calves Measured
Ames Plantation	56	56	45	45	45
Alcoa			53	49	
Knoxville	17			15	
Oak Ridge			37	36	
TOTAL	73	56	135	145	45

the heifers were examined for pregnancy, during the second trimester; and a third set of data was collected just prior to the calving season. Data were also collected at parturition.

On June 22, 1976, during the breeding season, the first measurements were obtained. The heifers were weighed and weight per day of age was determined. The subcutaneous fat over the loin between the twelfth and thirteenth ribs was estimated by use of a somascope (an ultrasonic measuring device). The dimensions of the internal pelvic canal were measured by using a Rice Pelvimeter. A vertical measurement was made between the sacral vertebrae and the symphysis pubis. A horizontal measurement was made between the shafts of the ilium. See Figure 1.

To coincide with pregnancy determination, data were collected on August 30, 1976. The previously described procedure was repeated in all heifers which were determined to be pregnant. Twelve of the original 56 heifers were nonpregnant and were eliminated from the remainder of the study.

December 16, 1976 was chosen for the data collection data prior to the calving season. The previously described collection procedure was repeated at this time.

The parturition data were collected during the calving season which extended from December 27, 1976, through March 21, 1977. The heifers were observed at various times during each day to detect the onset of parturition. Each parturition was scored as follows:

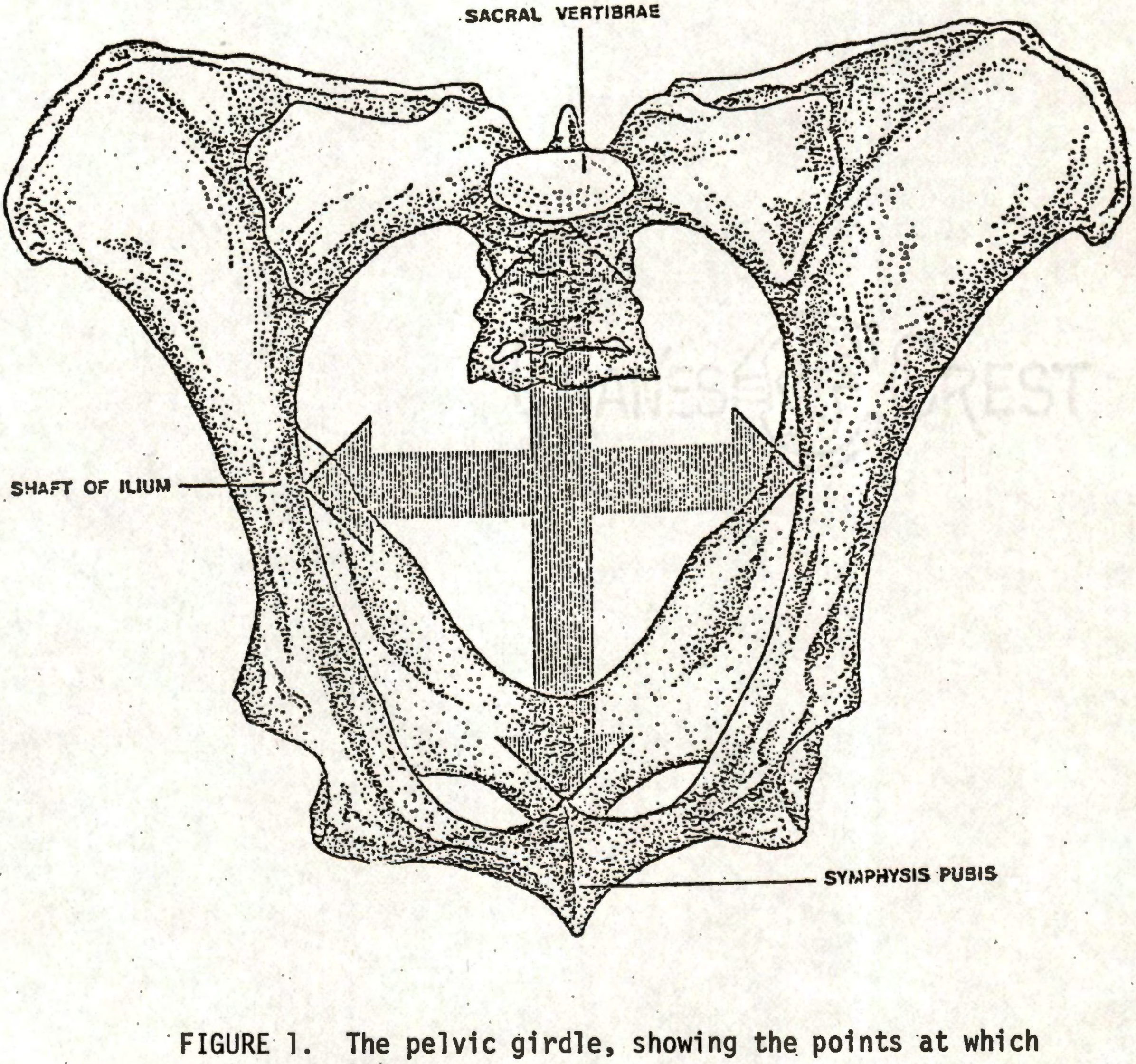

FIGURE 1. The pelvic girdle, showing the points at which measurements were taken.

Presentation	Difficulty
1 - Unknown, no attendance	1 - Unknown, no attendance
2 - Normal, anterior	2 - No difficulty
3 - Normal, posterior	3 - Little difficulty, assistance by hand only
4 - Malpresentation, anterior with head and/or one or both limbs posterior	4 - Moderate difficulty, assistance by hand only
5 - Malpresentation, posterior with one or both rear limbs anterior	5 - Major difficulty, assistance with equipment
	6 - Embryotomy
	7 - Caesarian section

Various measurements were made on the calf at birth. The measurements were collected in an effort to determine the calf's contribution to dystocia. The following calf data were collected: (1) tattoo number, (2) birth date, (3) sex, (4) birth weight, (5) width of head, measured at a point perpendicular to the poll, (6) width of the shoulders, measured at a point halfway between the withers and the point of the shoulders, (7) width of the hips, measured at the posterior side of the hooks, (8) circumference of the head, measured over the poll and posterior portion of the jaw, (9) circumference of the shoulders, taken with forelimbs extended anteriorly at the point of the shoulders, (10) circumference of the heart girth, measured immediately posterior to the muscle mass of the shoulder, (11) circumference of the hips, was measured at the posterior edge of the hook bones while the hindlimbs were extended posteriorly, (12) circumference of the cannon bone, measured at a mid-point between the knee (carpus) joint and the fetlock (metacarpo-phalangeal) joint, (13) length of head, measured from the tip of the nose to the poll, (14) length of the body, measured from the anterior side of the point of the shoulder to the posterior side of the pin bone, (15) length of cannon bone, measured from the fetlock (metacarpo-phalangeal) joint to the knee (carpus) joint, and (16) length from the hock to the dew claws, measured from the point of the hock (tuber calcis) to the proximal side of the dew claws.

Alcoa

At Alcoa, 17 purebred Hereford heifers and 36 purebred Angus heifers were used in the study. These heifers were divided into seven breeding groups according to breed, pedigree, conformation, and performance records and were pasture mated to seven purebred Hereford or Angus bulls. All heifers were mated to a bull of the same breed. The breeding season extended through April, May, and June. Two of the Angus heifers were found to be open and were not used in the later stages of the experiment. Also, two Hereford heifers developed other complications which necessitated their removal from the study.

The 53 heifers were pastured on mixed orchard grass, fescue, and clover pastures during the summer and fall. They were then divided into three groups for winter feeding in dry lot. Eighteen of the heifers were fed grass silage and grass hay *ad lib*. Seventeen of the heifers were fed only grass hay *ad lib*. The remaining 18 heifers were fed grass silage *ad lib*. The forage which was fed to these heifers was obtained by clipping excess pasture growth from pastures similar to the pastures on which the cattle spent the summer and fall.

Just prior to the beginning of calving season, the heifers were weighed and somascoped. In addition, each heifer's pelvic canal was measured by using the Rice Pelvimeter as described previously.

During the calving season which extended from December 13, 1976, to April 3, 1977, the heifers were carefully watched to note the onset of parturition. The parturition of each heifer was scored for presentation and difficulty using the scale used on Ames Plantation. At birth, each calf's weight, sex, and tattoo number were recorded.

Knoxville

Seventeen purebred Angus heifers were included in this study at The University of Tennessee Blount Farm. All 17 heifers were pasture mated to one purebred Angus bull during April, May, and June.

During the summer and fall months the heifers were pastured on mixed fescue, clover, and orchard grass pastures. During the winter and until the end of the calving season, the heifers were kept in dry lot and fed corn silage *ad lib*.

Weights and pelvic measurements were made during the later part of the breeding season on June 18, 1976.

Upon pregnancy determination it was found that one of the heifers was not pregnant. She was eliminated from the remainder of the study. It was also concluded from this palpation and later observations that four of the heifers had been accidently bred by a Hereford bull, next to which they had been pastured immediately prior to the breeding season.

During the calving season, which extended from December 21, 1976, to April 8, 1977, the heifers were scored on presentation and difficulty. At birth the calves' weight, sex, and tattoo number were recorded. The coloration of the last calf to be born indicated that he was not sired by the Angus bull to which the heifers were exposed. Since the sire of the calf was unknown, this heifer was not included in the statistical analysis of this study.

Oak Ridge

At the Comparative Animal Research Laboratory at Oak Ridge, 37 commercial Hereford heifers were studied. The heifers were pasture mated to three bulls. One of the bulls was a purebred Angus bull; one of the bulls was a purebred Polled Hereford; and the other bull was a grade Hereford bull. One of the heifers did not conceive and was eliminated from the remainder of the study.

The heifers were kept on fescue and orchardgrass pastures during the summer and fall. During the winter months, the heifers were on fescue pasture, which was supplemented with orchardgrass hay and corn silage ad lib.

On December 10, 1976, pelvic measurements, weights, and somascope measurements were taken. The procedure used was the same as that conducted at the three previously described stations.

During the calving season, from December 12, 1976, through March 27, 1977, the heifers were observed for parturition. Each parturition was scored using the same format as described for the other locations.

CHAPTER IV

RESULTS AND DISCUSSION

Due to the nature of the data, it was necessary to divide the information into groups of equal data collection periods. Of the 145 females which experienced parturition, it was necessary to delete three individuals from the data analysis due to confounding observations.

A correlation analysis was conducted to determine the relationships of each variable in the study to the other variables and to dystocia. The results of this analysis are shown in Table II. From these results, Model I (Figure 2) was developed to consider the variables in their relationship to dystocia.

Data collections made immediately prior to the calving season of 127 females at Ames Plantation, Alcoa, and Oak Ridge were studied using Model I. A series of regression analyses were used to study the relationship of dystocia to: the heifer's sire, the sex of the calf, the weight per day of age of the heifer, the pelvic area per day of age of the heifer, the fat thickness in millimeters, the birth weight of the calf, the vertical measurement of the pelvic canal and the horizontal measurement of the pelvic canal. The results of these analyses are listed in Table III.

The statistical model accounted for 51 percent of the variability in dystocia. Within the model, it was found that the value of the variables was not uniform. The width (horizontal measurement) of the

TABLE II

CORRELATIONS AMONG VARIABLES

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1. Sire of Heifer	-.218	.158	-.143	.137	-.296	-.180	-.100	-.230	-.200	-.093	-.089	-.142	.034	-.253	-.076	.014	-.122	.218	.213	-.122	-.189	.124	-.267	-.096	.376	-.392	-.331	.150	-.194
2. Sire of Calf		-.149	-.105	-.312	.192	.046	-.263	.168	.115	-.015	-.002	.139	-.171	.169	.130	.252	-.151	-.352	-.400	-.152	-.175	-.291	-.094	.207	-.024	.035	.548	-.152	-.019
3. Sex of Calf			-.102	.041	-.181	-.182	-.171	-.261	-.420	-.296	-.156	-.249	-.221	-.402	.293	-.111	.029	.018	.163	.029	-.211	-.046	.155	-.132	-.067	.146	-.102	.567	-.041
4. Birth Wt. of Calf				.166	.407	.399	.415	.730	.731	.699	.539	.397	.097	.716	-.136	.453	.085	.058	.117	.041	.281	.283	-.196	.189	-.028	-.205	.173	-.014	.250
5. External Fat Measurement					.033	.050	.091	-.166	.026	.090	-.065	-.247	-.051	.105	.025	-.072	.329	.454	.377	.309	.257	.239	-.414	.149	.431	-.360	.218	.003	-.144
6. Width of Head						.372	.390	.461	.280	.212	.299	.427	-.093	.259	-.141	.250	-.035	.043	.139	.005	.167	.281	.000	.200	.291	.063	.251	.296	.037
7. Width of Shoulders							.557	.458	.579	.470	.390	.379	-.178	.176	-.306	.239	.044	.081	.046	.325	.331	.375	.101	.187	.254	.042	.066	.238	-.243
8. Width of Hips								.335	.538	.499	.508	.331	-.126	.139	-.077	.061	.320	.226	.288	.462	.401	.403	-.027	.145	.309	-.166	-.092	.193	-.107
9. Circum. of Head									.608	.575	.508	.376	.035	.520	-.218	.191	-.056	-.023	.024	-.021	.126	.150	-.001	.101	.122	.024	.079	.049	.106
10. Circum. of Shoulders										.872	.649	.304	.053	.443	-.173	.300	.260	.144	.278	.303	.343	.279	-.065	.183	.257	-.149	.111	.275	-.171
11. Circum. of Heart Girth											.644	.184	.017	.409	-.149	.321	.320	.227	.404	.276	.411	.307	-.055	.255	.350	-.128	.100	.298	-.156
12. Circum. of Hips												.208	-.020	.348	.039	.315	.224	.219	.322	.249	.352	.389	.074	.338	.430	-.049	.083	.199	-.085
13. Circum of Cannon Bone													.169	.132	-.182	.410	-.127	.120	-.019	-.027	.094	.005	-.124	.001	-.019	-.181	.067	-.110	.187
14. Length of Head														-.019	-.273	-.083	.087	.074	.003	.009	-.171	.023	-.039	-.228	-.013	-.110	-.262	-.213	.110
15. Length of Body															.030	.361	.024	-.028	.062	.063	.206	.206	-.210	.235	.113	-.149	.390	.299	.194
16. Length of Cannon Bone																-.118	-.051	.198	-.003	-.160	.109	-.046	-.027	.109	.007	.036	.063	.078	-.070
17. Length from Hock to Dew Claws																	-.168	-.158	-.017	.038	.040	-.119	-.115	.115	-.086	-.105	.353	.205	.350
18. Height of Pelvic Canal at Breeding																		-.336	.744	.343	.332	.312	.164	.272	.282	-.224	-.218	.233	-.336
19. Height of Pelvic Canal at Preg. Determination																			.780	.415	.391	.396	-.139	.527	.543	-.362	-.015	.200	-.441
20. Height of Pelvic Canal Prior to Calving Season																				.257	.456	.412	-.234	.584	.508	-.412	.067	.287	-.247
21. Width of Pelvic Canal at Breeding																					.381	.491	.670	.159	-.270	.225	.033	-.282	-.407
22. Width of Pelvic Canal at Preg. Determination																						.779	-.224	.679	.618	-.221	.152	.443	-.257
23. Width of Pelvic Canal Prior to Calving Season																							-.004	.679	.320	-.070	.150	.067	-.322
24. Pelvic Area/Day of Age at Breeding																								.250	-.059	.874	.421	.208	-.258
25. Pelvic Area/Day of Age at Preg. Determination																									.687	.352	.525	.213	-.248
26. Pelvic Area/Day of Age Prior to Calving Season																										.384	.478	.245	.228
27. WDA at Breeding																											.505	.783	.077
28. WDA at Preg. Determination																												.834	-.056
29. WDA Prior to Calving Season																													-.105
30. Dystocia																													--

$$Y = bo + bx_1 + bx_2 + bx_3 + bx_4 + bx_5 + bx_6 + bx_7 + bx_8$$

Y = dystocia

x_1 = width of pelvic canal

x_2 = height of pelvic canal

x_3 = pelvic area per day of age of heifer

x_4 = sire of heifer

x_5 = external fat measurement

x_6 = weight per day of age of heifer

x_7 = birth weight of calf

x_8 = sex of calf

FIGURE 2. Model I.

TABLE III

THE VARIATION IN DYSTOCIA EXPLAINED BY VARIOUS COMBINATIONS OF TRAITS OBSERVED PRIOR TO THE CALVING SEASON AND PARTURITION

Model Number	Width Pelvic Canal	Height Pelvic Canal	Pelvic Area per Day of Age	Sire of Heifer	External Fat Measurement	Weight per Day of Age	Birth Weight of Calf	Sex of Calf	R^2	Increase of R^2
1	X								.104**	
2	X	X							.119	.015
3	X	X	X						.156	.037
4	X	X	X	X					.467	.311
5	X	X	X	X	X				.468	.001
6	X	X	X	X	X	X			.475	.007
7	X	X	X	X	X	X	X		.506*	.031
8	X	X	X	X	X	X	X	X	.506	.000

pelvic canal of the heifers was found to be the most influential factor and was statistically significant ($P < .01$) in its relationship to dystocia. The birth weight also exhibited a significant ($P < .05$) relationship to dystocia in this model. The sire of the heifer caused the greatest increase in the R^2 value. However, this is primarily due to an additive effect it had with the other variables, since the sire of the heifer was not significant in its relationship to dystocia.

Due to the limited number of dystocias experienced by the heifers in this experiment and the large number of variables being considered in the model, no other variables were found to be statisticall significant in this data analysis. However, a pattern was established by the probability estimates of the variables. It was observed that the sire of the heifer played a much more important role than indicated by the literature. The sex of the calf had a very minor role in this particular analysis since much of its effect is closely related to birth weight. Listed in order of decreasing importance, the variables are: width of pelvic canal, birth weight, sire of the heifer, height of pelvic canal, pelvic area per day of age, weight per day of age, fat thickness, and sex of calf.

The data collected at pregnancy determination were analyzed using the same model and type of regression analyses as was used for the previous data. The model accounted for 41 percent of the variation in dystocia. The height (vertical measurement) of the pelvic canal accounted for the greatest amount of variation. In this phase of the study, sire of heifer, birth weight of the calf, external fat, sex of calf, width of pelvic canal, weight per day of age of heifer, and pelvic area per day of age were next in amount of variation accounted for, in that order. These data are shown in Table IV. This analysis should be considered with the realization that it was computed on only 45 observations taken at Ames Plantation.

The combined data on 59 heifers at Ames Plantation and at the Knoxville station obtained during the breeding season were evaluated by regression analyses as in the two previous analyses. The same statistical model was used in this evaluation and accounted for 60 percent of the variability in dystocia ($P < .05$). Within the model, width of the pelvic canal, sire of the heifer, and birth weight of the calf were found to be the most important variables. The variables in this model are ranked in order of the variation in dystocia which they explain as follows: width of the pelvic canal ($P < .05$), sire of the heifer ($P < .05$), birth weight of the calf ($P < .05$), weight per day of age of heifer, height of the pelvic canal, pelvic area per day of age, external fat, and sex of calf. These results are listed in Table V.

In order to include the data which were collected on the calves at birth, a new statistical model was used to evaluate the data collected at Ames Plantation. The correlation analysis which has already been explained was used to develop the new model. Figure 3 for dystocia included: sire of heifer, sire of calf, sex of calf, weight per day of age, pelvic area per day of age, birth weight of calf, height of pelvic canal, width of pelvic canal, width of head, width of shoulders, width of hips, circumference of head, circumference of shoulders, circumference of heart girth, circumference of hips, circumference of

TABLE IV

THE VARIATION IN DYSTOCIA EXPLAINED BY VARIOUS COMBINATIONS OF TRAITS OBSERVED AT PREGNANCY DETERMINATION AND PARTURITION

Model Number	Height Pelvic Canal	Width Pelvic Canal	Birth Weight of Calf	Pelvic Area per Day of Age	Size of Heifer	External Fat Measurement	Weight per Day of Age	Sex of Calf	R^2	Increase in R^2
1	X								.195	
2	X	X							.203	.008
3	X	X	X						.254	.051
4	X	X	X	X					.256	.002
5	X	X	X	X	X				.377	.121
6	X	X	X	X	X	X			.390	.013
7	X	X	X	X	X	X	X		.398	.008
8	X	X	X	X	X	X	X	X	.407	.009

TABLE V

THE VARIATION IN DYSTOCIA EXPLAINED BY VARIOUS COMBINATIONS OF TRAITS OBSERVED AT BREEDING AND PARTURITION

Model Number	Width Pelvic Canal	Height Pelvic Canal	Birth Weight of Calf	Size of Heifer	External Fat Measurement	Pelvic Area per Day of Age	Weight per Day of Age	Sex of Calf	R^2	Increase in R^2
1	X								.256*	
2	X	X							.268	.012
3	X	X	X						.341*	.073
4	X	X	X	X					.535*	.194
5	X	X	X	X	X				.545	.010
6	X	X	X	X	X	X			.556	.011
7	X	X	X	X	X	X	X		.597	.041
8	X	X	X	X	X	X	X	X	.599	.002

$$Y = bo + bx_1 + bx_2 + bx_3 + bx_4 + bx_5 + bx_6 + bx_7 + bx_8 + bx_9 + bx_{10} + bx_{11} + bx_{12} + bx_{13} + bx_{14} + bx_{15} + bx_{16} + bx_{17} + bx_{18} + bx_{19} + bx_{20} + bx_{21}$$

Y = dystocia

x_1 = width of pelvic canal

x_2 = length from hock to dew claws

x_3 = height of pelvic canal

x_4 = birth weight of calf

x_5 = width of shoulders

x_6 = length of body

x_7 - sire of heifer

x_8 = circumference of cannon bone

x_9 = circumference of shoulders

x_{10}= circumference of heart girth

x_{11}= external fat measurement

x_{12}= length of head

x_{13}= width of hips

x_{14}= circumference of head

x_{15}= pelvic area per day of age of heifer

x_{16}= circumference of hips

x_{17}= weight per day of age of heifer

x_{18}= length of cannon bone

x_{19}= sex of calf

x_{20}= width of head

x_{21}= sire of calf

FIGURE 3. Model II.

cannon bone, length of head, length of body, length of cannon bone, and length from hock to dew claws.

Model II defined 87 percent of the total variability ($P < .01$). The results of these analyses are shown in Table VI. Within the model three of the variables accounted for a far greater amount of the variation than did the other variables: length from hock to dew claws ($P < .01$), sire of the heifer, and width of the pelvic canal ($P < .05$). Again, these results should be considered with the realization that only 45 observations were used to calculate this analysis.

The length from hock to dew claws explains an unexpectedly large amount of variation. The explanation of this can be surmised from Table II, page 22. It is noted that length from hock to dew claws is highly correlated with practically all of the calf measurements taken in this study. Therefore, it is a good indicator of the relationship between calf shape and dystocia.

When Model II (Figure 3) was used to evaluate the data collected at pregnancy determination, the regression analyses indicated that 76 percent of the variability was defined. Within the model, fewer of the variables approached significance than did those in the previous analysis. However, the order of importance was relatively the same. The variables which accounted for the most variation in dystocia were: wigth of pelvic canal, sire of the heifer, width of the shoulders ($P < .05$), length from hock to dew claws ($P < .01$), and circumference of shoulders. This analysis is shown in Table VII.

The third trimester data at Ames Plantation was analyzed using Model II and the same type of regression analyses as in the two

TABLE VI

THE VARIATION IN DYSTOCIA EXPLAINED BY VARIOUS COMBINATIONS OF TRAITS OBSERVED AT BREEDING AND PARTURITION

	Model Number																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Width of Pelvic Canal	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Length from Hock to Dew Claws		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Height of Pelvic Canal			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Birth Weight of Calf				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Width of Shoulders					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Length of Body						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sire of Heifer							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Circum. of Cannon Bone								X	X	X	X	X	X	X	X	X	X	X	X	X	X
Circum. of Shoulder									X	X	X	X	X	X	X	X	X	X	X	X	X
Circum. of Heart Girth										X	X	X	X	X	X	X	X	X	X	X	X
External Fat Measurement											X	X	X	X	X	X	X	X	X	X	X
Length of Head												X	X	X	X	X	X	X	X	X	X
Width of Hip													X	X	X	X	X	X	X	X	X
Circum. of Head														X	X	X	X	X	X	X	X
Weight per Day of Age															X	X	X	X	X	X	X
Birth Weight of Calf																X	X	X	X	X	X
Circum. of Hips																	X	X	X	X	X
Length of Cannon Bone																		X	X	X	X
Sex of Calf																			X	X	X
Width of Head																				X	X
Sire of Calf																					X
R^2	.296*	.411**	.412	.425	.490	.492	.681	.681	.700	.721	.730	.763	.786*	.792	.810	.811	.834	.861	.862	.870	.870
Increase in R^2		.155	.001	.013	.065	.002	.189	.000	.019	.021	.009	.033	.023	.006	.018	.001	.023	.027	.001	.008	.000

TABLE VII

THE VARIATION IN DYSTOCIA EXPLAINED BY VARIOUS COMBINATIONS OF TRAITS OBSERVED AT PREGNANCY DETERMINATION AND PARTURITION

	Model Number																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Height of Pelvic Canal	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Length from Hock to Dew Claws		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Width of Pelvic Canal			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Birth Weight of Calf				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pelvic Area per Day of Age					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Width of Shoulders						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Length of Body							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sire of Heifer								X	X	X	X	X	X	X	X	X	X	X	X	X	X
Circum. of Cannon Bone									X	X	X	X	X	X	X	X	X	X	X	X	X
Circum. of Shoulder										X	X	X	X	X	X	X	X	X	X	X	X
Circum. of Heart Girth											X	X	X	X	X	X	X	X	X	X	X
External Fat Measurement												X	X	X	X	X	X	X	X	X	X
Length of Head													X	X	X	X	X	X	X	X	X
Width of Hips														X	X	X	X	X	X	X	X
Circum. of Head															X	X	X	X	X	X	X
Circum. of Hips																X	X	X	X	X	X
Length of Cannon Bone																	X	X	X	X	X
Weight per Day of Age																		X	X	X	X
Sex of Calf																			X	X	X
Width of Head																				X	X
Sire of Calf																					X
R^2	.195	.275**	.285	.295	.295	.391*	.392	.519	.526	.593	.600	.623	.652	.685	.688	.688	.705*	.737	.746	.753	.757
Increase in R^2		.080	.010	.010	.000	.096	.001	.127	.007	.067	.007	.023	.029	.033	.003	.000	.017	.032	.009	.007	.004

previous analyses. The variables within the model showed less statistical significance, yet they fell into a similar ranking according to importance as did the two previous analyses. In order of influence the highest ranked variables were: sire of heifer, width of pelvic canal, length from hock to dew claws ($P < .05$), and width of shoulders. The results of this analysis are shown in Table VIII. Although fewer variables showed individual significance, the entire model was able to define 75 percent of the variability in dystocia.

In comparing the two models and the various analyses within each, we find that the model which includes calf measurements was able to define a greater percentage of the variation in dystocia. In both methods of analyses, it should be noted that the data collected during the breeding season identifies a larger degree of the variation than the data of the two later collection periods. This indicates that the most accurate time, during the gestation of those heifers studied, for prediction of dystocia was during the breeding season. The probable reason for this occurrence is the limited amount of change which can occur in the measurements of the heifer during gestation compared to the amount of change which could or should have occurred prior to breeding. This reasoning indicates that any prevention of dystocia must occur prior to the breeding of the heifer.

The width of the heifer's pelvic canal was the most highly related to the problem, of the variables which were recorded prior to parturition. Further study and refinement of technique may lead to a pelvic width measurement which will indicate the probability of a heifer experiencing dystocia, prior to her being bred.

TABLE VIII

THE VARIATION IN DYSTOCIA EXPLAINED BY VARIOUS COMBINATIONS OF TRAITS OBSERVED PRIOR TO CALVING SEASON AND AT PARTURITION

	Model Number																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Length from Hock to Dew Claws	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Width Pelvic Canal		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Height Pelvic Canal			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Width Shoulders				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pelvic Area per Day of Age					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Length of Body						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sire of Heifer							X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Circum. of Cannon Bone								X	X	X	X	X	X	X	X	X	X	X	X	X	X
Circum. of Shoulder									X	X	X	X	X	X	X	X	X	X	X	X	X
Circum. of Heart Girth										X	X	X	X	X	X	X	X	X	X	X	X
External Fat Measurement											X	X	X	X	X	X	X	X	X	X	X
Length of Head												X	X	X	X	X	X	X	X	X	X
Width of Hip													X	X	X	X	X	X	X	X	X
Circum. of Head														X	X	X	X	X	X	X	X
Weight per Day of Age															X	X	X	X	X	X	X
Birth Weight of Calf																X	X	X	X	X	X
Circum. of Hips																	X	X	X	X	X
Length of Cannon Bone																		X	X	X	X
Sex of Calf																			X	X	X
Width of Head																				X	X
Sire of Calf																					X
R^2	.123*	.262	.291	.346	.346	.372	.532	.542	.577	.582	.600	.634	.645	.690	.692	.698	.699	.743	.747	.747	.748
Increase in R^2		.139	.029	.055	.000	.026	.160	.010	.035	.005	.018	.034	.011	.045	.002	.006	.001	.044	.004	.000	.001

The sire of the heifer was found to be much more important than indicated by the literature. This variable is more difficult to utilize because it requires progeny testing in advance of any practical application. There is some speculation as to whether the females sired by "hard-calving" bulls possess a larger pelvic canal and thus experience less dystocia than their contemporaries. This theory has not yet been proven and will require further study.

The height of the pelvic canal and the pelvic area per day of age are less significantly related to dystocia than the two previously mentioned variables. However, they may be most useful in predicting dystocia in combination with other variables such as width of the pelvic area.

At this time a satisfactory system for predicting dystocia has not been developed. However, the results of this study indicate the areas on which more effort should be concentrated. With continued study using larger numbers of primiparous females, it seems feasible that an accurate system may be developed to predict and thus prevent the occurrence of dystocia.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objectives of this study, made on 163 primiparous beef heifers were to: (1) identify the factors which are closely related to dystocia, (2) identify the degree of relationship between these factors, and (3) develop a practical system of predicting the occurrence of dystocia.

One hundred and sixty-three primiparous beef heifers of the Hereford or Angus breeds were studied at Ames Plantation, Alcoa, Knoxvill and Oak Ridge. Data were collected on these heifers during the first, second, and third trimester of gestation. Each heifer was observed and scored on the difficulty of her parturition. Measurements were taken on the calves at birth.

Regression analyses were conducted to determine the relationship of the various measurements to the occurrence of dystocia. Of the factors which could be measured or otherwise calculated prior to parturition, the width of the pelvic canal of the heifer was indicated to be the most influential. The sire of the heifer was found to be the next most significant factor in this analysis. Following closely behind the sire of the heifer in rank of importance were: height of the pelvic canal and the pelvic area per day of age.

Of the observations made postpartum, the length from hock to dew claws on the calf was the most closely correlated to dystocia.

Following in decreasing order or relationship were: length of the cannon bone, width of the shoulders, width of the hips, and circumference of the heart girth of the calf.

In evaluating the three data collection periods, it was observed that the data collected during the first trimester were able to account for a far greater percentage of the variability of dystocia than were either of the other collection periods. In this study, the data collected at breeding defined a maximum of 87 percent of the total variability compared to 76 percent at pregnancy determination and 75 percent immediately prior to the calving season.

With the limited number of observations available, it was not possible to designate one measurement which would predict dystocia to a satisfactory degree. Continued study on more heifers will be necessary. However, this study indicates that it may be possible to develop a technique which will enable cattlemen to accurately predict dystocia, at or before the time the heifer is bred.

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LITERATURE CITED

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