Incidence and cause of neonatal and postnatal bovine mortality and effects of peripartum complication on subsequent reproductive performance
by David James Patterson

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Animal Science
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Abstract:
Data collected at the Livestock and Range Research Station, Miles City, Montana for the years 1963 through 1977 were used to study: incidence and cause of neonatal and postnatal mortality to weaning in range cattle, effects of calf loss on subsequent reproductive performance of the dam, incidence of backward and breech presentation and effects of cesarean deliveries, retained placentae and prolapses on subsequent fertility. A total of 893 calves died during the 15 year period from 13,296 calvings for a mortality rate of 6.7%. Losses reported within dam age group were: first calf 2-year-olds, 10.9%; first calf 3-year-olds, 8.7%; second calf 3-year-olds, 4.1%; second calf 4-year-olds, 8.3%; third calf 4-year-olds, 4.8%, dams 5 years of age and older, 5.3% ($P < .01$). Losses to first calf heifers accounted for 41.0% of the 893 deaths. Within the first 24 hours postpartum (57.6%) of the losses were incurred, with 75% of the total occurring by day 7 postpartum. Male calves lost totaled 510 (57.1%) ($P < .01$) of the 893 calves. Of the 893 calves lost, 799 were subjectd to detailed postmortem examinations; 65.5% were found to have functional lungs.

Of calves autopsied, (77.6%) were antomically normal. Death due to dystocia was the single largest source of calf loss, accounting for 410 or 51.3% of the dead calves autopsied, and 374 (60.3%) of the 620 anatomically normal calves lost. Of the 178 abnormal calves, 60.8% died as a result of congenital malformation. Musculoskeletal and visceral anomalies accounted for 41.8% and 58.2% of the total defect incidence, respectively. Fall pregnancy rate of dams that lost calves was 72.4% compared to an overall herd pregnancy rate of 79.4% ($P \ll .01$).

A 1.6% incidence of backward and breech presentation was noted during the 15 year period. Backward presentation occurred more frequently than breech and was observed more often in primiparous dams ($P < .01$) and in births involving male calves ($P < .01$). Backward presentations occurred in 2.3, 5.6 and .8% of all calvings among first calf 2-year-old, first calf 3-year-old and multiparous dams, respectively. Survival rates of calves presented backward or breech were 70.7 and 32.9%, respectively. During the years studied, 121 cesareans were performed; 74.4% involved first calf 2-year-old dams, 4.0% of all 2-year-olds • calving. Pregnancy status of dams experiencing cesareans, exposed for breeding was 52.4%. Retained placentae occurred in 166 calvings,67 (57.8%) of which resulted from induced calving with adrenal steroids. Subsequent pregnancy rates of dams experiencing retained placentae were 82.2% and 50.7% for the non-induced and induced cows, respectively.

A total of 124 vaginal and 29 uterine prolapses were reported, with incidence among primiparous dams comprising 40.3% and 82.8% of that incidence, respectively. Pregnancy rates of cows having vaginal or uterine prolapses were 44.0% and 43.8%, respectively.

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INCIDENCE AND CAUSE OF NEONATAL AND POSTNATAL BOVINE MORTALITY
AND EFFECTS OF PERIPARTUM COMPLICATION ON
SUBSEQUENT REPRODUCTIVE PERFORMANCE

by

DAVID JAMES PATTERSON

A thesis submitted in partial fulfillment
of the requirements for the degree

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Approved:

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ABSTRACT

Data collected at the Livestock and Range Research Station, Miles City, Montana for the years 1963 through 1977 were used to study: incidence and cause of neonatal and postnatal mortality to weaning in range cattle, effects of calf loss on subsequent reproductive performance of the dam, incidence of backward and breech presentation and effects of cesarean deliveries, retained placentae and prolapses on subsequent fertility. A total of 893 calves died during the 15 year period from 13,296 calvings for a mortality rate of 6.7%. Losses reported within dam age group were: first calf 2-year-olds, 10.9%; first calf 3-year-olds, 8.7%; second calf 3-year-olds, 4.1%; second calf 4-year-olds, 8.3%; third calf 4-year-olds, 4.8%, dams 5 years of age and older, 5.3% ($P < .01$). Losses to first calf heifers accounted for 41.0% of the 893 deaths. Within the first 24 hours postpartum (57.6%) of the losses were incurred, with 75% of the total occurring by day 7 postpartum. Male calves lost totaled 510 (57.1%) ($P < .01$) of the 893 calves. Of the 893 calves lost, 799 were subjectd to detailed postmortem examinations; 65.5% were found to have functional lungs. Of calves autopsied, (77.6%) were antomically normal. Death due to dystocia was the single largest source of calf loss, accounting for 410 or 51.3% of the dead calves autopsied, and 374 (60.3%) of the 620 anatomically normal calves lost. Of the 178 abnormal calves, 60.8% died as a result of congenital malformation. Musculoskeletal and visceral anomalies accounted for 41.8% and 58.2% of the total defect incidence, respectively. Fall pregnancy rate of dams that lost calves was 72.4% compared to an overall herd pregnancy rate of 79.4% ($P < .01$). A 1.6% incidence of backward and breech presentation was noted during the 15 year period. Backward presentation occurred more frequently than breech and was observed more often in primiparous dams ($P < .01$) and in births involving male calves ($P < .01$). Backward presentations occurred in 2.3, 5.6 and .8% of all calvings among first calf 2-year-old, first calf 3-year-old and multiparous dams, respectively. Survival rates of calves presented backward or breech were 70.7 and 32.9%, respectively. During the years studied, 121 cesareans were performed; 74.4% involved first calf 2-year-old dams, 4.0% of all 2-year-olds calving. Pregnancy status of dams experiencing cesareans, exposed for breeding was 52.4%. Retained placentae occurred in 166 calvings, 67 (57.8%) of which resulted from induced calving with adrenal steroids. Subsequent pregnancy rates of dams experiencing retained placentae were 82.2% and 50.7% for the non-induced and induced cows, respectively. A total of 124 vaginal and 29 uterine prolapses were reported, with incidence among primiparous dams comprising 40.3% and 82.8% of that incidence, respectively. Pregnancy rates of cows having vaginal or uterine prolapses were 44.0% and 43.8%, respectively.

INTRODUCTION

Improved efficiency of production and optimum utilization of available resources, in light of current world population growth trends, warrant attention within the agricultural community. Development of new technology within the agricultural realm must keep pace with needs unique to the production segment; while research efforts must at the same time be directed toward identification and resolution of existing and possible future problem areas.

The interdependence of science upon industry highlights a need for exchange of information necessary for accomplishment of respective goals. The intent of this thesis, based upon consideration of these needs, will be to focus upon identification of specific problems encountered within animal agriculture, pertinent to the beef cattle industry.

Beef cattle production constitutes a major portion of our nation's total agricultural scope, with the sale of cattle and calves accounting for the largest single source of agricultural cash receipt. Problems unique to the beef cattle industry are, however, numerous and in many instances costly. Reproductive failure and resulting consequences are of noted importance, accounting for an estimated annual loss of 760 million dollars.

Calf loss accounts for a substantial portion of the reproductive inefficiency observed in beef cattle and exerts a profound impact upon associated economic ramifications stemming from such failure. Large scale review of cause and effect relationships regarding calf mortality (from time of birth to weaning), and effects upon subsequent fertility of involved females are notably deficient. Research efforts have in addition neglected to evaluate effects of peripartal complication on reproductive performance.

Producer need, regarding data of this nature, accompanied with the opportunity to pinpoint areas in need of further research were used as the major criteria upon which this investigation was based. The primary objectives of the study were to evaluate (1) incidence and cause of neonatal and postnatal mortality in range cattle, (2) incidence of backward or breech presentation, (3) subsequent reproductive performance of cows losing calves and (4) subsequent reproductive performance of cows experiencing cesarean section, retained placenta, or vaginal or uterine prolapse.

REVIEW OF LITERATURE

Reproductive failure in beef cattle results in substantial economic loss to producers. Three factors affecting reproductive performance, in order of importance, include: (1) number of cows in heat during the first 21 days of the breeding season (2) number of conceptions at first service and (3) number of calves dying at or near the time of parturition (Wiltbank et al., 1973). Studies by Wiltbank et al. (1961) and Dearborn et al. (1973) point to conception failure and early embryonic mortality as added causative factors. Economic loss associated with reproductive failure or calf mortality is incurred through forced culling or death of involved dams, production loss brought about via death of young calves and expenses incurred through veterinary services and drugs (McClure and Dowell, 1968).

Calf crop is generally expressed in percentage terms and is determined by comparing the number of calves weaned to the number of cows eligible for natural service or artificial insemination (National Academy of Sciences, 1968). Average percentage calf crop, under range conditions, may vary from 63-86% (Baker and Quesenberry, 1944; Burke, 1954; Wiltbank, 1973; Bailey et al., 1977; Kress et al., 1979). Work by Bellows (1972) and Wiltbank et al. (1961) imply that reductions in net calf crop may arise from (a) cows failing to become pregnant (b) calf losses during gestation (c) perinatal losses at or shortly after birth or (d) calves dying from birth to weaning.

Calf losses may vary for given time periods. Studies in dairy cattle by Hawk et al. (1955) indicate that 6.6% of all pregnancy loss (from early pregnancy diagnosis, 35-42 days post breeding) is attributable to death of the developing fetus up to day 150 of gestation. In cows carrying fetuses to term, Reynolds (1973) found that most death losses occur in calves during the first week of life following parturition. Previous death loss studies suggest that 6 to 18% of all conceptions result in nonviable abortions or full term stillbirths, while of all dairy calves alive at birth, 8 to 24% die before one year of age (Dickinson and Touchberry, 1961).

The term stillborn or stillbirth, defined by Dorland's Medical Dictionary (1974) refers to the delivery of a dead fetus, hence born dead. Further definition by Woodward and Clark (1959) classifies stillborn calves as those calves exhibiting no movement after birth, while Lindhe (1966) and Philipsson (1976a) associate the term with the occurrence of death at birth or within 24 hours after parturition. An expanded definition of perinatal mortality cites deaths occurring (a) prior to or during parturition (b) within a few hours after parturition or (c) following attended calvings (Donald, 1963).

Stillbirth incidence, as a function of total recorded death, varies. Comprehensive mortality studies allude to occurrence of highest calf death loss at time of parturition or within the first 24 hours of life (Rasbech, 1967; DeRouen et al., 1967; Koger et al., 1967; Pattulo, 1973; Young and Blair, 1974). Independent investigations cite stillbirth ranges from 2 to 11% (Wright, 1958; Woodward and Clark, 1959; Politiek, 1965; Arthur, 1966; Barriere, 1968; Gaillard, 1969; Auran, 1972; Dufty, 1972), stillbirths accounting for 56.4% of total deaths recorded (Withers, 1952). Neo- or perinatal mortality rates may range from 5 to 10% of all calves born (Hansen, 1965; Rice and Wiltbank, 1970b, 1972), with reported annual calf losses during the first 5 days of life varying from 8 to 25% (Bull et al., 1978a). The highest incidence of calf loss apparently occurs during the first 36 hours of life (Rice and Wiltbank, 1970b, 1972) and exceeds losses between 36 hours postpartum and weaning by 6% (Wiltbank et al., 1973).

Total calf loss percentages recorded for the period from conception to weaning differ. Lovell and Hill (1940) indicate one of every 20 calves born alive dies before the age of 6 months, with one in seven pregnancies failing to produce an adult animal. Prenatal death losses and postnatal losses up to 6 months of age range from 14.3 to 15.1 calves lost per hundred pregnancies (Withers, 1952). Preliminary research efforts of Baker and Quesenberry (1944) note calf death losses of 6% between spring calving date and December 31 of the same year, while more recent works point to overall mortality incidence of 8.6% (Laster and Gregory, 1973). Aggregate losses from birth to weaning effect a 4.1% reduction in net calf crop (Bellows, 1972; Bailey et al., 1977; Kress et al., 1979).

Calf Mortality Causes

Causative components of stillbirth and postnatal mortality are numerous and can best be expressed in factors attributable to the calf, the dam, the sire, pathological agents or climatic factors.

I. Dystocia

Dystocia, defined as delayed and difficult birth, ranks high among factors contributing to perinatal mortality. Calf mortality may be four to eight times higher in dystocia cases than in normal parturition (Wright, 1958; Arthur, 1966; Laster and Gregory, 1973; Smith et al., 1976; Laster, 1976) implicating its occurrence as the principle stillbirth cause (Politiek, 1965; Young 1968a). Dystocia victims number from 40 to 90% of total recorded deaths (Laster and Gregory, 1973; Young and Blair, 1974; Philipsson, 1976a), with the majority of casualties occurring within the first 24 hours of life (Anderson and Bellows, 1967; Pattulo, 1973; Laster, 1976). Reported incidence of dystocia in beef and dairy cattle varies from 2 to 7% of total births (Withers, 1953; Dreyer and Leiphitz, 1971; Joandet et al., 1973) resulting in an assisted birth rate of 6 to 14% (Hansen, 1965).

Means of measurement, regarding severity of dystocia or calving ease, are expressed in modified form. Type of parturition has been divided into discernible classifications of (1) no assistance rendered, (2) delivery assisted with hand pull, (3) required use of mechanical calf puller, (4) extreme traction with mechanical puller and/or surgical extraction via cesarean section or (5) abnormal presentation (Bellows, 1972; Laster and Gregory, 1973). The time interval from appearance of the allanto-chorion to fetal expulsion has been examined (O'Mary and Hillers, 1976) and suggests possible onset of dystocia within 2 hours following appearance of the allanto-chorion (Young, 1970).

Functional versus nonfunctional status of the lungs of the calf may be used to determine time of death relative to parturition. Available information indicates that lungs in 70 to 80% of the calves lost at birth were classified nonfunctional, while in 20 to 30% of the animals lung status was deemed functional (Anderson and Bellows, 1967; Laster and Gregory, 1973). Lungs that floated when placed in a container of water were classified as functional, those that did not float were classified as nonfunctional.

Visible lesions and post mortem findings indicative of dystocia include: subcutaneous edema of the head, protrusion and swelling of the tongue and presence of blood stained mucous in the nasal cavity and sinuses, larynx and trachea (Dufty, 1973). Petecheal hemorrhages of the thymus, thoracic pleura and pericardium, localized edema of the limbs and perineum, and contusions and/or bone fractures serve as additional evidence of dystocia (Anderson and Bellows, 1967; Young and Blair, 1974; Haughey, 1975; Gopal, 1977).

Contemplating the effects of dystocia on fetal survival, it is interesting to note that an estimated 70% of the identified variation in calving difficulty is due to factors existing or determined at the time of conception; principle effects exerted genetically via the calf's sire and dam (Bellows, 1976). Existence of identifiable variation therefore warrants discussion of individual components contributing to increased dystocia.

Birth weight. Birth weight of the calf has been implicated as one of the leading effectors of calving difficulty. Fetal oversize and/or extremes in birth weight account for the single largest dystocia source (Veterinary Clinical Observation Unit, 1963; Sloss *et al*., 1967; Bogner *et al*., 1970; Rice and Wiltbank, 1970a, 1970b; Bellows *et al*., 1971b; Nelson and Huber, 1971; Ward, 1973; Bellows, 1976; Foulley *et al*., 1976), with severity of dystocia dependent upon weight of the calf relative to that of its dam (Monteiro, 1969; Sagebiel *et al*., 1969). Linear increases in calving complication, corresponding to increasing birth weight of the calf, have been noted among and within breed groups (Smith *et al*., 1976), with increases in percent assisted birth of 2.3±0.21% for each kilogram increase in birth weight (Laster *et al*., 1973).

Paralleled increases in dystocia score and calf birth weight result in increased need of obstetrical assistance at time of birth (Nelson and Huber, 1971; Pattulo, 1973; Burfening, 1976; Laster, 1976; Kilkenny and Stollard, 1976), with reported increases in percent of cows requiring assistance at birth and calving ease score of 4.5% and 0.8 per kilogram increase in birth weight (Burfening et al., 1978a, 1978b). Consideration of the effects of birth weight on degree of calving difficulty make the highly significant correlation between birth weight and calving time logical (O'Mary and Coonrad, 1972; O'Mary and Hillers, 1976).

Effects of birth weight on calf survival are noteworthy. Calves with extremes in birth weight, light or heavy, have higher death rates than do those of intermediate weight (Regan et al., 1947; Koger et al., 1967; Pattulo, 1973). Birth weights of calves dying at parturition are generally heavier than averages for live calves (Politiek, 1965; Arthur, 1966; Kilkenny and Stollard, 1976), except in studies reported by Woodward and Clark (1959) and Anderson and Bellows (1967). Studies by Dickerson et al. (1974) note corresponding decreases in percent calf crop of 1% for each kilogram increase in birth weight.

Research efforts suggest that increased calf birth weight is primarily a function of increased soft tissue, not skeletal size (Laster, 1974). Little relationship has been found between calving difficulty and body length, chest depth, wither height and width of the shoulders and hips. Calf shape measurements, independent of birth weight do not relate significantly to dystocia score; however, correlations among body measurements and birth weight are significant (Boyd and Hafs, 1965).

Factors influencing birth weight indirectly affect calving performance (Philipsson, 1976c). Weight of the calf at birth is related to its genotype and sex, and the age, precalving weight, gestation length and gestation weight gain of the dam (Williams, 1968; Joandet et al., 1973; Bellows, 1976; Laster, 1976). Selection of cattle for faster growth rate results in corresponding increased birth weight of the calf, evidence manifest in the positive genetic correlation between weaning and yearling weights to those recorded at birth (Gregory et al., 1950; Foulley, 1976). A birth weight heritability estimate of .48 (Petty and Cartwright, 1966) indicates that selection for smaller birth weight via the sire is possible.

Correlated responses computed within sex by Pahnish et al. (1964) indicate that birth weight may have promise as an early selection criterion for weaning weight improvement unless emphasis on birth weight leads to dystocia. Selection for 18 month weight appears to be a good single criterion for selection for growth throughout life (Brinks et al., 1964). Recent studies suggest that anticipated increase in birth weight could be reduced an estimated 30% if selection emphasis was on postnatal growth rate rather than weaning or yearling weight (Koch et al., 1974). Selection for smaller birth weight and heavier yearling weight by use of a selection index has been predicted to result in shortened gestation lengths permitting rapid postnatal growth without increasing calving difficulty (Dickerson *et al.*, 1974).

Sex of calf. Sex of calf effects have been reported as one of the leading causes of variation associated with frequency of difficult calvings and subsequent calf mortality (Lindhe, 1966; Sellers *et al.*, 1968). Male calves elicit increased incidence of dystocia resulting in corresponding differences in percent assisted birth (Anderson and Bellows, 1967; Adler and Meding, 1968; Bellows *et al.*, 1971b; Dreyer and Leiphitz, 1971; Laster and Gregory, 1973; Laster *et al.*, 1973; Brinks *et al.*, 1973; Laster, 1974; Bellows, 1976; Philipsson, 1976b; Wilson and Willis, 1976). Estimates suggest that 70% of all dystocia cases (Bogner *et al.*, 1970) and 60 to 70% of all calvings warranting assistance involve birth of male calves (Young, 1968b; Nelson and Huber, 1971; Pattulo, 1973). Survival differences between sexes for births not requiring assistance are nonsignificant (Laster, 1976).

Available information indicates that nearly 70% of all abortions (Luktuke and Choudhury, 1965) and the majority of all stillbirths involve male fetuses (Woodward and Clark, 1959). Reports imply that one of every five male calves are associated with dystocia, while one in seven is stillborn or later dies (Veterinary Clinical Observation Unit, 1963). A higher incidence of male mortality has been reported (Withers, 1952; Dreyer and Leiphitz, 1971; Laster and Gregory, 1973); however, higher female calf mortality rates are cited by Lovell and Hill (1940) and Donald (1963).

Philipsson (1976d) found significantly larger body measurement in males with respect only to chest width. Most works indicate that increases in dystocia and stillbirth levels related to the male are primarily functions of higher mean birth weight and possible increased gestation length (Gregory et al., 1950; Burris and Blunn, 1952; Koch and Clark, 1955; Flower et al., 1963; Crowley, 1965; Franke et al., 1965; Milk Marketing Board, 1965; Philipsson, 1976b; Smith et al., 1976).

Gestation length. Stillbirth occurs more frequently following abnormally short or long gestation periods (Friedli, 1965). High birth weights resulting from extended gestation, may serve as partial explanation of such occurrence, when considering effects of birth weight on dystocia (Jafer et al., 1950; Davis et al., 1954; Dreyer and Smidt, 1966; Bellows et al., 1971b; Granola et al., 1972). Evidence from Laster (1976) and Burfening et al. (1978c) indicates that increases in birth weight of .25 kg/day for each additional day of gestation may be anticipated, accompanied with increases in percent assisted birth of .70% per day increase in gestation length. A highly significant correlation of .35 between length of gestation and birth weight has been reported (Bogner et al., 1970; Bellows et al., 1971b; Burfening et al., 1978c), while estimates of the heritability of gestation length are near 40% (Politiek, 1965). Consideration of these findings suggests that the influence of gestation length on calving ease is apparently expressed through effects on birth weight (Burfening et al., 1978c).

Genetic correlations and predicted correlated response to selection, reported by Burfening et al. (1978c), indicate that selection for calving ease would subsequently reduce the severity of calving difficulty and decrease gestation length with little affect on birth weight or 205-day weight. Direct selection against large birth weight was shown to be less effective in increasing calving ease with corresponding effects of shortened gestation length and decreased birth weight and 205-day weight.

Significant effects on gestation length for breed, sire, parity of the dam, type of birth (single or multiple) and sex of calf have been observed (Burris and Blunn, 1952; Everett and Magee, 1965; Boyd and Hafs, 1965; Crockett and Kidder, 1967; Koonce and Dillard, 1967; Bellows, 1976; Wilson and Willis, 1976). Data suggest male calves are carried an average 1.5 days longer than females, with the gestation length of a mature or multiparous dam averaging 1 to 1.6 days longer than that of a primiparous heifer (Anderson and Plum, 1965; Arthur, 1966; Philipsson, 1976b). Forced or restricted activity of the dam during pregnancy was shown to have little or no effect on gestation length or calf birth weight (Bellows, 1976).

Presentation, posture and position. Fetal presentation, posture and position are important considerations when discussing factors affecting dystocia. Presentation includes the relation of the spinal axis of the fetus to that of the dam (longitudinal or transverse) and the portion of the fetus that is approaching or entering the birth canal (anterior or posterior in the longitudinal presentation or dorsal or ventral in the transverse presentation; Roberts, 1971).

Position includes the relation of the dorsum of the fetus in longitudinal presentation, or the head in transverse presentation, to the quadrants of the maternal pelvis. These include the sacrum, the right ilium, the left ilium and the pubis (Roberts, 1971). Posture denotes the relation of the extremities or head, neck and limbs to the body of the fetus. Extremities may be flexed or extended or retained beneath, on the right or left side, or above the fetus (Roberts, 1971). Roberts (1971) defines normal presentation in the bovine as the anterior longitudinal presentation, dorso-sacral position with the head resting on the metacarpal bones and knees of the extended forelegs.

Observed frequencies of abnormal presentation range from 3.5 to 6% of total births; with two-thirds of the births experiencing abnormal presentation subsequently resulting in calving difficulty and one-third in stillborn calves (Philipsson, 1976a). Estimates indicate that 95% of all calves are born in an anterior presentation (Williams, 1948), while ranges from 3 to 12% have been noted for calves delivered backward or breech (Wiltbank, 1971; Smith et al., 1976). Fetal displacement has been shown to account for 34 to 50% of all difficult calvings (Sloss et al., 1967; Rice and Wiltbank, 1970b), with data from some researchers implicating abnormal presentation as the number one contributing factor to dystocia in beef cattle (Morten, 1968). Studies of calves assisted at birth observed 60% of those assisted presented normally, 21% in a posterior presentation and 19% with some other form of postural abnormality (Pattulo, 1973).

Death loss percentages generally rise with increased occurrence of malpresentation (Wright, 1958; Donald, 1963), with backward delivery being the presentation abnormality of highest incidence. Dystocia and stillbirth are anticipated to be four times as likely to occur if the calf is presented posteriorly (Arthur, 1966). An estimated two-thirds of all births experiencing difficulty are ones in which a normal anterior delivery was observed, while in one-third of the dystocias a posterior presentation was seen (Philipsson, 1976a). Studies report that up to 43% of total calf deaths may be attributable to posterior presentation (Sloss et al., 1967). Unassisted live births are known to occur less frequently in posteriorly presented calves (Woodward and Clark, 1959) due primarily to anoxia and lack of prompt fetal removal, necessary to prevent asphyxiation following pressure exerted on or rupture of the umbilical cord (Roberts, 1971).

Examinations of bovine pregnancy and parturition found the majority of all fetuses in a posterior presentation during months four, five and six of gestation (Arthur, 1966). By the end of the 6th month, half of the fetuses were in anterior position and half posterior. Observation one month later established that the majority of all calves were in normal anterior presentation. Arthur (1966) noted by palpation that beyond the 7th month of gestation one of every 17 fetuses was situated backward. Investigation by Rice and Wiltbank (1970b) found some calves in a dorsopubic position 2 to 5 hours before birth, yet these calves turned to the normal dorsosacral position and were unassisted at parturition.

Study indicates that presentation at birth is determined no later than the 7th month of gestation (Rice and Wilbank, 1972). Changes in presentation during the last month of gestation are unlikely, however changes in position and posture have been found to occur up to one day prepartum (Rice and Wiltbank, 1972). Fetal movement throughout gestation is believed to be due to intrauterine pressure exerted by myometrial contractions (Arthur, 1966). Postural changes by the fetus are said to occur frequently but do not appear to be related to changes in position of the fetus or parturition onset (Dufty, 1973).

Philipsson's data (1976a) indicate abnormal presentation relates to heavier fetal birth weight, which in turn results in less available movement space during late stages of pregnancy. A higher incidence of malpresentation generally occurs in first calf hiefers (Donald, 1963), with increased occurrence noted in one study in heifers with pelvic areas smaller than 230 sq. cm. (Wiltbank, 1971). Occurrence of backward delivery appears more frequently in cases of twin birth, possibly accounted for by lack of adequate uterine space (Arthur, 1966; Morten, 1968).

Type of birth. Significant differences in calf survival have been reported between twin and single births. Twinning results in a higher than average percentage of stillbirths (Woodward and Clark, 1959; Rasbech, 1967). Roughly one-fifth of all twins born die at birth or within the first 48 hours of life (Morten, 1968). Reduced dystocia frequency has been reported in cases of twin birth along with decreased gestation length (Philipsson, 1976a). Twinning rates appear to increase with advancing cow age. Dairy cows having twins before their fourth calving note increased incidence of infertility (Erb and Morrison, 1959).

Parity and age of dam. Evidence presented in the literature points to effects of parity and age of dam on dystocia and calf survival rate (Lindhe, 1966; Sellers et al., 1968). Significant effects on dystocia score are attributed to parity of the dam (Wilson and Willis, 1976), with the percent of total difficult calvings notably higher among primigravid heifers (Lefever and Wiltbank, 1961; Rasbech, 1967; Young, 1968b; Dreyer and Leiphitz, 1971; Dufty, 1972; Laster et al., 1973;

Hafez, 1974; Laster, 1976; Philipsson, 1976b; Tong et al., 1976; Bailey et al., 1977; Kress et al., 1979). Resulting higher incidence of perinatal mortality is reported (Woodward and Clark, 1959; Politiek, 1965; Arthur, 1966; Anderson and Bellows, 1967; Adler and Meding, 1968; Young, 1968b; Pattulo, 1973), with losses in some instances 50% higher in heifers than mature cows (Auran, 1972).

Study of the effects of parity on calving difficulty frequency notes decreases from 20% at first parity to 4% at second parity. Observed decreases have been attributed to enlargement of the birth canal and physiological condition change from first to second calvings (Monteiro, 1969). Early embryonic mortality and abortion rates are higher in first calf heifers (Withers, 1952; Withers, 1953, Donald, 1963; Luktuke and Choudhury, 1965), with reported frequency of stillbirth and abnormal presentation three times higher in first parity dams (Lindhe, 1966). Percentage differences in dystocia and loss due to stillbirth between male and female offspring are greater in primiparous dams (Politiek, 1965; Smith et al., 1976). Increases in dystocia, evidenced by the incidence of localized edema in calves born dead to primiparous dams, have also been noted (Young, 1974).

Uterine inertia, malposture and malposition occur more frequently in mature cows (Williams, 1968), with disproportion between fetal size and pelvic opening appearing more often in heifers. Maternal death loss at time of parturition is said to be highest in first calf heifers due to increased severity of calving complication (Wythes et al., 1976), with proportionately larger numbers of exposed heifers failing to wean their calves (Dearborn et al., 1973).

Age of dam and calf birth weight represent the two most important variables influencing calving difficulty (Laster, 1976), with up to 50% of the variation in calving score accounted for by birth weight of the calf (Ménissier, 1975). Sire and dam breed, calf sex and age of dam were shown to exert significant effects on dystocia score when holding birth weight constant or deleting it from the statistical model. Age of dam evoked the only significant effect on dystocia score when reconsidering birth weight in the analysis, with other variables expressing their effects indirectly via birth weight (Laster et al., 1973).

Reported calf losses are higher in 2-year-old dams not experiencing dystocia than in cows three and older; cow age however, fails to exert a significant influence on calf mortality in parturitions involving dystocia (Laster and Gregory, 1973). Despite these significant findings, conflicting reports regarding the influence of cow age on dystocia and neonatal survival exist (Politiek, 1965; Young, 1968a; Joandet et al., 1973).

Cows bred to calve first as 2-year-olds produce more calves and more total weaned calf weight, in their lifetime, than cows calving first as 3-year-olds and older (Donaldson, 1968). Studies record a higher incidence of calving difficulty and calf mortality in heifers calving first at 24 months of age versus those at 36 months, although early calving effects on growth rate, mature body weight and subsequent reproductive performance of the dam were not observed (Pittaluga _et al._, 1967).

Age of dam effects on birth weight, weaning weight and postweaning daily gain were shown to be highly significant (Koch and Clark, 1955; Flower _et al._, 1963; Petty and Cartwright, 1966; Kress and Burfening, 1972; Bogart _et al._, 1975). Cow production, regarding these factors, increased from 3 to 6 years of age with declining production noted in cows beyond 6 years. Contrasting results from prior research efforts indicate birth weight maximums will not be realized until dams reach 9 to 10 years of age (Burris and Blunn, 1952). More recent work suggests optimum productivity ranges from 5 to 10 years of age (Cunha and Warnick, 1973). Percent calf crop increases in cows aged 10 to 11 have been reported (Davenport _et al._, 1965; Bailey _et al._, Kress _et al._, 1979), with intermediate aged mature dams experiencing the least incidence of calving difficulty and perinatal loss (Philipsson, 1976b).

Cow weight and pelvic area. Positive effects of precalving body weight of the dam exert the most important influence on calf birth weight (Bellows _et al._, 1971a). Correlations of birth weight with cow weight are cited by Gregory _et al._ (1950) and O'Mary and Hillers (1976). Negative correlations were found to exist between body weight and height at the withers of the dam and level of calving difficulty (Cadle and Ruttle, 1976), with decreases in dystocia score of .68 for each 45.4 kg increase in dam weight (Singleton et al., 1973). These findings were in contrast to prior studies, which failed to note significant correlations of dam weight to calving difficulty and/or calf survival (Koger et al., 1967; Young, 1968a; Rice and Wiltbank, 1972).

Cow weight provides the largest source of variation associated with pelvic area (Bellows et al., 1971a; Laster, 1976). Larger cows have larger pelvic openings, in terms of height and width, as well as, greater hip width and rump length (Bellows et al., 1965; Ward, 1971; Laster, 1974). Pelvic size, independent of cow weight, affects calving difficulty (Foulley, 1976), with the highest relationship existing in first calf heifers (Rice and Wiltbank, 1970a, 1970b). Heifers of increased skeletal size have larger pelvic openings, but also tend to have larger calves (Bellows, 1976; Laster, 1976). Birth weights tend to increase when the size of the pelvic opening of the dam becomes larger (Menissier, 1975).

Differences in pelvic area are generally due to pelvic height, with discrepancies between the dam and fetus more likely to occur for pelvic height and depth of calf chest than for width measures (Singleton et al., 1973; Philipsson, 1976d). Bellows et al. (1971b) failed to elicit differences regarding pelvic height, but instead reported a negative effect on calving difficulty contributed via precalving total pelvic area. Pelvic areas in yearling heifers are influenced by breed of sire and dam (Laster, 1974), large increases in pelvic size occurring between ages two to three (Bellows et al., 1971a). Aside from cow weight and pelvic area considerations, subjective dam conditions scores and cow body measurements bear no significant relationship to calving difficulty (Nelson and Huber, 1971; Ward, 1973; Laster, 1974).

Nutrition. Level of nutrition during gestation has little effect on calving difficulty but may influence neonatal survival and subsequent reproduction of the dam (Joandet et al., 1973; Bellows, 1976). Prepartum feed level exerts a marked effect on postpartum reproduction with low feed levels being more detrimental to heifers than cows (Bellows et al., 1979). Increased amounts of energy or crude protein result in higher calf birth weights but do not affect the incidence or severity of dystocia, nor the percent of cows requiring calving assistance (Laster, 1974; Bellows et al., 1978).

Philipsson (1976d) warns that increased calving difficulty may be anticipated in extremely thin or fat heifers. Comparison of moderate conditioned dams to obese dams, by Arnett et al. (1971), noted fewer services per conception and reduced assistance at parturition among the moderate conditioned group, in addition to reduced losses at calving and increase in the proportion of calves weaned. Moderate short term obesity during pregnancy did not result in detrimental affects on mature dams. Reduced assistance at parturition was cited in cows considered thinner than average (Nelson and Huber, 1971), while increased losses at birth of 7% have been reported for calves born to cows fed on restricted energy levels (Corah et al., 1975).

Energy restriction during early and mid-gestation failed to reduce fetal size or calving difficulty (Laster, 1974), with higher recorded mortality rates in calves born to heifers fed at elevated energy levels (Wiltbank, 1971). Losses related to high energy levels were due in part to excess fat deposition in and around the pelvic opening of the dam, combined with a higher than normal incidence of backward presentation of the calves. Results of this study refute theories of corresponding increases in birth weight of the calf and dystocia caused by high gestation feed levels. Findings do suggest, however, that cows deprived of adequate energy subsequently give birth to lighter weight calves.

Hughes et al. (1978) summarized the long term effects of level of winter supplement on the productivity of range cows. Dams in the study were fed on low, moderate, high and very high levels of supplement. Very high level females weaned only 66.3% of their calves in calf crop one, while the other 33% were stillborn. Following the first calf crop, very high level dams weaned more kilograms of calf per cow exposed than the other three groups, however when weighted average calving percent data were calculated through nine calf crops, the low and very high groups ranked lowest of the four.

Breed and sire. Breed differences account for a portion of the variation observed in frequency of dystocia and resulting calf loss (Wiltbank et al., 1961; Lindhe, 1966; Koger et al., 1967; Young and Blair, 1974; Philipsson, 1976a). Breed group significantly affects calf mortality rate in births involving calving difficulty, but fails to exert an influence in unassisted parturitions (Laster and Gregory, 1973; Laster, 1976).

Evidence of survival difference between straight and crossbred calves appears frequently in the literature, with reported death loss in most instances highest in straightbreds (Gains et al., 1966; Laster and Gregory, 1973; Reynolds, 1973; Laster, 1976). Dystocia score comparisons between straight and crossbred calves fail to reveal significant differences between the two (Laster et al., 1973); however, reports of increased calving difficulty in crossbred heifer calves have been cited (Sagebiel et al., 1969). Crossbred calves tolerate higher levels of stress related to dystocia situations (Laster and Gregory, 1973), accompanied with percentage increases in the number of calves born, alive at 2 weeks postcalving and weaning (Gaines et al., 1966; Wiltbank et al., 1967).

Birth weights were higher in crossbreds than averages recorded for straightbreds (Laster et al., 1973). Breed of dam serves as one of the leading factors affecting variation in birth weight (Franke *et al.*, 1965), but fails to exert an influence on dystocia or calf mortality incidence (Milk Marketing Board, 1965). Findings contrary to these reports note increased frequency of dystocia in heavier dam breeds due to higher mean birth weights of their calves (Monteiro, 1969; Foulley *et al.*, 1976).

Breed of sire and individual sire within breed contribute to observed variation in calving difficulty incidence and severity (Donald, 1963; Lindhe, 1966; Sagebiel *et al.*, 1969; Dreyer and Leiphitz, 1971; Singleton *et al.*, 1973; Laster, 1974; Wilson and Willis, 1976; Burfening *et al.*, 1979). Significant sire effects on embryonic mortality, length of gestation, calving time, birth weight and stillbirth appear in the literature (Gregory *et al.*, 1950; Hawk *et al.*, 1955; Politiek, 1965; Crockett and Kidder, 1967, Adler and Meding, 1968; O'Mary and Coonrad, 1972; Laster, 1976, Philipsson, 1976a; O'Mary and Hiller, 1976), with influence of the dam on gestation length and birth weight outweighed by that of the sire (Everett and Magee, 1965).

Rising rates of dystocia augmented by increasing calf weights at birth are linked to the large European cattle breeds including: Charolais, Simmental, Limousin, South Devon, Maine Anjou, Chianina, Gelbveih, and Brown Swiss (Veterinary Clinic Observation Unit, 1963; Rowden, 1970; Laster *et al.*, 1973; Kilenny and Stollard, 1976; Laster, 1976; Smith *et al.*, 1976). This does not mean that sires of British or other breed origin are incapable of producing nor responsible for problems encountered at calving time.

Dystocia heritability estimates for sires within breeds of .18, accompanied with calculations independent of birth weight of .12 imply that breed and sire selection within breed can best be used to minimize calving difficulty (Laster, 1976). Selection of a paternal breed for use on heifers should enlist a sire capable of incorporating growth potential of the calf with calving ability of the cow (Menissier, 1975).

Miscellaneous. Year, season of the year, and location effect the nature of the parturition process and resulting calf survival (Wiltbank et al., 1961; Lindhe, 1966; Koger et al., 1967). Fewer cows experience calving difficulty and stillbirth problems during the spring and late summer months, with highest incidence occurring in winter (Withers, 1953; Politiek, 1965; Philipsson, 1976b; Wilson and Willis, 1976). Studies by Laster (1976) point to reduced occurrence of dystocia in the south when compared to reports from the western and midwestern United States.

Percentage increases in perinatal mortaility correspond to low temperature and high precipitation (DeRouen et al., 1967); with weights of calves at birth influenced to a degree by seasonal and yearly variation (Everett and Magee, 1965). Length of previous lactation and calving interval fail to exert a significant influence on the birth process (Dreyer and Smidt, 1966), while contradictory reports of