PERIPARTURIENT BEHAVIOR OF BEEF COWS AND CALVES

by

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ABSTRACT

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Crossbred and purebred gestating Angus and Hereford cows were monitored during the 1985 and 1986 spring calving seasons (number of calvings = 375). Cows were assigned randomly to one of two treatment groups that were balanced by breed-class, age and expected date of calving. The control group was fed corn silage at 0900 hours, and hay was available free choice. The treated group was fed the same diet but at 2100 hours, and time of access to the hay was restricted to between 2100 and 0900 hours. Each group was kept in a 3.2 ha paddock and observed continuously during the 1985 calving season. During 1986 similar treatments were used, but observations were not continuous. Data recorded were behavioral signs of parturition, times and locations of parturition and behaviors of cow-calf pairs observed continuously until 8 hours post-partum. Group diurnal activity patterns were recorded over 61 consecutive days in 1985. Post-partum behavior variables of the dam were time to first standing and grooming and total time spent standing, lying, grooming, browsing and eating. Calf variables were initial standing, teat seeking, mobility, suckling, total time spent on these activities and body weight at weaning. A significant ($P<.05$) shift in the diurnal activity patterns of the cows occurred when the feeding schedule was altered, but treatment did not affect ($P>.10$) the time of day when parturition occurred. The percentage of cows calving between 0600 and 1800 hours were 55 and 60 for the control and the treated groups, respectively. During the first 8 hours post-partum, differences in the time of onset and total time spent on some behaviors were determined to be related to breed of sire and dam, parity and sex of calf. Multiple regression of weaning weight on periparturient behavioral traits resulted in R^2 values of 54 and 24% for heifer and bull calves, respectively. It was concluded that night-time feeding does not result in a significant increase in day-time calvings, and there is at least a moderate relationship between cow-calf behavior in the first 8 hours after birth and the calf's weaning weight.

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I. INTRODUCTION

The ability to induce calving during daylight hours would provide several benefits to beef producers. Efficiency of management would be improved because of greater opportunity for assistance to cows in cases of dystocia, and this assistance should result in fewer cow and calf death losses at calving time.

Within the last 10 yr, there have been reports indicating that parturition in cows was successfully controlled by altering the time of feeding. The idea has been claimed to have originated with Gus Konefal, a Hereford breeder from Manitoba, Canada, in the mid-1970's. He believed that evening-feeding of late gestation cows resulted in more cows calving during daylight hours. Subsequently, researchers have tested this idea with ewes, gilts, and beef and dairy cattle utilizing different feedstuffs and feeding schedules.

The field studies reported to date of the influence of time of feeding on time of parturition of cattle have not been based on continuous observation. Instead, cows were checked in the morning and evening, and calves were categorized as either born during the night or during the day. Another method was the division of the 24-h period into time blocks, for example four 6-h blocks, in which parturition times were checked and reported accordingly.

The association between maternal-neonatal behavior and subsequent calf production performance through weaning has not been reported in beef cattle. Maternal behavior such as early grooming activity and calf early experiences such as time to first standing, teat seeking and suckling may be behavioral traits associated with the general fitness of the calf and could have a genetic component. An understanding of postpartum behavior and its relationship to later growth and performance could add new information about factors that result in the expression of greater vigor that is exhibited by crossbred individuals and referred to as heterosis. Similarly, a practical method of predicting subsequent performance of a calf based on periparturient behavior could benefit the beef producer in the selection of breeding stock or by altering management systems to maximize the attention to the more important traits.

The control of calving time and the optimal management of the cow and calf during calving requires a thorough understanding of periparturient behavior of both cow and calf. A series of experiments were conducted to evaluate the effectiveness of night-feeding in inducing daylight parturition. The diurnal patterns of cows were monitored, and the cows were observed continuously in order to record actual time of parturition. Periparturient behavior of beef cows and their calves were recorded immediately postpartum, and the relationship of these behaviors to the calves' performance through weaning was determined.

This dissertation is organised based on four general periparturient topics that were investigated in this study. A review of literature, Chapter 2, preceeds four chapters that each present research results on one topic. The final chapter is a general discussion about how all the topics are related.

II. REVIEW OF LITERATURE

Introduction

Factors that influence the time of parturition are numerous. From the time of conception until parturition, genetic and environmental factors play a role in determining the date and time that parturition will occur. In cattle factors that influence gestation length include the breed of the dam and sire, age of the dam, and sex of the calf, to mention some of the better known factors. Approximately 283 d after conception, parturition occurs.

The time that parturition occurs is largely determined by an interaction of factors "basic" to the dam and her fetus, especially their endocrine systems which play a major role in initiating parturition. The endocrine system, in turn, is influenced by neural mechanisms. Thus, external environmental factors such as weather, nutrition, and possibly even social behavior and general activity of a cow may play a role in determining the time of day that she will give birth.

This literature review does not deal directly with genetical, physiological, endocrinological or neural factors associated with parturition, but instead, the review concentrates on the environmental factors that influence the time of day that parturition occurs. Additionally, the review covers selected literature that deals with the periparturient behaviors of cows and calves.

This review has four major sections. The first section covers factors affecting time of parturition. The second section is a discussion of the diurnal activity patterns of beef cattle. The third section contains a review of the literature related to periparturient behavior of farm animals with special references to beef cows and calves. The final section covers the relationship between very early experiences and lifetime production performance in livestock.

Factors Affecting Time of Parturition

Natural diurnal patterns of time of calving. There are conflicting reports regarding the expected distribution of births in cattle over the 24 h of a day. While Arthur (1961) reported more frequent night calving, Ewbank (1963), George and Barger (1974) and Edwards (1979) found no evidence of a higher incidence of calving during the night. Yarney et al. (1979, 1982) observed relatively uniform distribution of births over the 24-h period.

The reports of greater night-time calving are not based on large numbers of observations. Arthur (1961) reported that two-thirds (of an unspecified number) of housed cows calved between 1800 and 0600 h.

Based on a small sample size, Ewbank (1963) reported that 16 of 25 tethered Ayrshire cows calved during the day.

George and Barger (1974) also found that 23 of 38 (60%) Hereford cows on pasture calved between 0600 and 1800 h. Records of 1151 beef cow births (Yarney et al., 1982) indicated that slightly more calves were born between 0700 and 1900 h (51.5%) than between 1900 and 0700 h when gestating cows were maintained in open-fronted pole-type sheds and fed corn silage plus hay. The corn silage was fed between 0830 and 0930 h with cows allowed free choice access to hay and water.

A summary of 422 calvings from dairy cows at Purdue University over two calving seasons indicated a slightly higher incidence of daylight calving (Albright and Pennington, 1984). Fifty-three percent of the births occurred between 0600 and 1800 h among the dairy cows fed total mixed rations in the morning.

Edwards (1979) reported that the time of parturition of 522 Freisian cows were evenly distributed throughout the 24-h period with no bias toward day or night calving. Using chi-square analysis, she concluded that the presence or absence of farm staff and daylight or darkness had no effect on calving time. However, she noted that a lower incidence of calving during the milking hours occurred in older cows (third and subsequent lactation) and speculated that either the activity or noise during milking or some rhythm internal to the cow created during the lactation period was regulating the calving pattern in older cows.

In the study by Yarney et al. (1982), time of parturition was influenced by the breed of maternal grandsire and maternal grandam. Cows with maternal Hereford and Angus grandams or grandsires were reported to be more likely to calve during the day while cows of grand-maternal Shorthorn breeding were more likely to calve during the night. Breed differences have also been reported in sheep (George, 1969).

Effect of time of feeding on time of parturition. Recently, researchers have attempted to control the onset of parturition by feeding late gestation cows at different times of the day. This phenomenon was first reported in beef cattle (Anonymous, 1984), but subsequent studies have involved other types of domesticated livestock.

Sharefeldin et al. (1971) observed that the lowest incidence of lambing in sheep occurred during the period of time that concentrate feed was available. They proposed that imminent parturitions were delayed as a result of increased adrenalin levels (because of feeding) which suppressed the action of oxytocin. Hancombe (1974) reported a higher incidence of lambing at the time when feed was made available to the animals than at any other times of the day. Lindahl (1964) recorded a higher incidence of lambing after the periods of feeding.

Hudgens et al. (1986) reported the results of four groups of gestating ewes (n=303) that were fed with two different types of feedstuffs consisting of either alfalfa hay or alfalfa haylage at either 1000 or 2200 h beginning 12 d prior to first lambing during the 1983 and 1984 winter-lambing seasons. Treatment did not significantly influence average time of day that lambing occurred. The peak periods for lambing were from 0300 to 0700 (22.1%) and from 1500 to 1900 h (22.1%). These two 4-h periods accounted for 44.6% of the total lambings.

Jilek et al. (1985) reported that feeding pregnant ewes (n=453) at 0900, 1630 and 2100 h did not significantly alter the time of parturition. However, more ewes lambed between 0600 and 1800 h for both the morning-fed and evening-fed groups (53 and 58%, respectively).

Gonyou and Cobb (1986) reported the results of three trials involving a total of 365 ewes. In trial 1, ewes were fed at either 0800, 1600 or 2400 h with feed restricted 8 h after the time of feeding in all feeding schedules. These researchers observed the frequency of lambings over a 24-h period were unevenly distributed with the majority of births occurring between 0400 and 0800. Peak periods of lambing for all feeding schedules occurred between 4 h prior to and 8 h after feeding. In trial 2, ewes were fed at either 0800, 1000 or 1200 h with access to feed limited to 4 h after time of feeding. They observed a similar trend as in trial 1 but with a slight, nonsignificant increase in day-time parturition, when ewes were fed late at 1200 h. In trial 3, the distribution of births were compared between ewes subjected to either 4 or 8 h of feed availability at either 0800 or 1200 h. They reported that treatment did not significantly influence the number of day-time parturitions.

Grandhi and Strains (1981) observed no increase in the number of farrowings (n=128) during the day-time when gilts were fed at 2000 h during the last 10 d of gestation. Significant decreases in piglet mortality during the first 24 h after birth were noted.

More success in inducing day-time parturition has been reported in beef cattle. Based on 104 cows allotted to two treatment groups, Yarney et al. (1979) reported that Hereford cows fed early in the morning and in mid-afternoon (0800 to 0900 and 1500 to 1600 h) calved significantly ($P<.01$) less between 0700 and 1900 h (34.4%). Hereford cows fed late in the morning and evening (1100 to 1200 and 2100 to 2200 h) calved significantly ($P<.01$) more during the day (0700 to 1900 h) with 79.6% of the parturitions recorded during this period and the rest during the night (1900 to 0700 h).

Similarly, when beef cows (n=535) were fed daily at 1615 h during nine seasons studied, Brackelsberg (1985) recorded a higher incidence of day-time parturitions. Sixty-nine percent of the 535 cows calved between 0600 and 1800 h. Extending the calving hours, 82 and 92% of the calves were born between 0600 and 2200 h and 0500 to 2300 h, respectively. Lowman et al. (1981) recorded 79 and 57% of 128 and 36 beef cows calved between 0600 and 2200 h when fed at 2200 and 0900 h, respectively.

Albright and Pennington (1984) observed a higher incidence of daylight calving among dairy cows both in treated (night-fed) and control groups regardless of feeding time. In their studies, 58 control Holstein cows were fed at 2000 h with feed available free choice, while 53 treated cows were fed at 2000 h with no feed available after 0800 h. These researchers speculated that the feeding of a total mixed ration once daily to the dry cows during 1982 and 1983 and prior to the study may have influenced the calving patterns. Subsequently, Pennington and Albright (1985) added data to their original study and concluded that there were no significant effects due to feeding schedules on time of parturition. They summarized the occurrence of births among Holstein cows from May to November for 2 yr. From 0600 to 1800 h, 62.5% (40 of 64) of the control cows and 67.6% (44 of 64) of the night-fed cows calved. When the working hours of herdsmen were extended (0500 to 2100 h), there was an increase in the number of parturitions in both groups during the time herdsmen were present.

Based on data from dairy cows fed ad libitum, Edwards (1979) reported that the distribution of calvings (n=522) appeared to be independent of feeding time. Similar results in beef cows (n=170) were presented by Tucker et al. (1985).

Time of parturition was not significant when data were compared between early morning feeding (0830 h) and late afternoon (1600 h) or night feeding (2100 h). Prior to the birth of the first calf, cows were subjected to the different feeding regimens 30 d for year 1 and 60 d for years 2 and 3. Significantly more calves were born during the day (0600 to 1800 h) regardless of feeding time. Based on data pooled over the three years, cows fed in the morning had shorter intervals between feeding and calving (11.1 h) compared to the pm-fed cows (13.4 h).

However a much higher day-time calving was reported by Clark et al. (1983) when Holstein cows (n=40 per treatment group) were offered a complete ration (at either 0800 or 1730 h) 2 wk prior to the expected parturition date. Fifty-five percent of the cows fed at 0800 h calved between 0600 and 1800 h, while 72% of the cows fed at 1730 h calved during the same time period. Multiple regression of feeding time, sex of calf, age of dam(mo), month of calving, photoperiod length (min), min of light 12 h post-feeding, minimum and maximum temperature for the day of parturition, gestation length (days), and weight of calf explained only 15% of the variation in time of parturition. These researchers concluded that a shift in the expected calving pattern was obtained by feeding dry cows once daily at 1730 h; however the influence of the variables included in their analysis was low.

Data from the Pennsylvania State University dairy herd and two commercial dairy herds (n=800 total) indicated that feeding dry cows once daily (1600 h) may cause 10% fewer night calvings than feeding cows twice daily (0800 and 1600 h). Fifty-six percent of the cows calved between 0600 and 1800 h when dry cows were fed once daily (Muller and Moon, 1983).

Arave et al. (1984) suggested that feeding per se might not influence calving time. Other management factors such as noise and the presence of attendants in conjunction with feeding may affect the distribution of time of parturition. Naakgeboren (1979) speculated that environmental factors can influence the onset of labor. He cited anxiety and fright as factors that can prolong the onset of parturition. The temperature on the day of calving and change in body weight of the dam from initial timed feeding until after calving might also contribute to factors that influence the time of parturition (Pennington and Albright, 1985).

Effect of lighting on time of parturition. The effects of photoperiod on the onset of parturition have not been described in cattle and sheep. However, there is some evidence in rats that the onset of parturition can be altered by photoperiod (Lincoln and Porter, 1979). These researchers speculated that the maternal hypothalamus was involved in mediating the photoperiod influence, although the mechanisms involved were not clear. In some species of animals, photoperiod determines the precise time at which birth occurs on the last day of pregnancy, possibly through interaction with circadian rhythms of the animals. Arthur (1961) speculated that night-time births may have evolved in some species as a means of avoiding predation.

The effect of short and long days on the time of parturition in rats exposed to 2, 14 and 22 h of daily light was investigated by Mitchell and Yochim (1970). More rats gave birth during the hours of light (14 h of daily light illumination) than would have been expected had the time of parturition not been related to the lighting regimen. Eighty-seven percent of the parturitions in this group occurred during the period of light. Boer et al. (1975) observed that the majority of parturitions in rats on day 22 of gestation occurred between 1200 and 1800 h and a smaller number during the early hours of day 23. With the approach of dark at 2000 h on day 22, the gestating rats became active and ceased to show any impending signs of parturition.

Lincoln and Porter (1979) suggested that it was not the light per se that inhibited labor. Rats which were continuously exposed to darkness on day 22 of gestation, after having been kept throughout pregnancy under a controlled photoperiod, had similar median times of parturition on day 22 as rats of the control group. The researchers suggested that the relationship between photoperiod and the timing of parturition was more closely related to circadian rhythms of rats than to any short-term cue resulting from altering the light-dark cycle.

Bosc and Nicolle (1985) concluded that the time of parturition in rats may be regulated by photoperiod, time of feeding and the interaction between these two factors.

Effect of exercise-activity on time on parturition. No evidence in cattle has been presented as to whether the onset of parturition is affected when pregnant cows are subjected to a daily routine of exercise for a short period at night during the latter part of gestation. However, exercise-activity may be related to delaying onset of parturition. Naaktgeboren (1979) observed that ewes which were about to lamb remained completely quiescent when they tried to record the uterine activity. Similarly, sows which started nest-building and had developed normal uterine activity remained quiescent for 2 h when they were removed to another cage.

Diurnal Feeding Activity Patterns

Time of parturition could be indirectly influenced by other exercise related behaviors such as time of eating. The periodicity of some behaviors of free ranging cattle, including eating, are highly repeatable with the majority of the activity associated with natural events such as time of sunrise and sunset (Wagnon, 1963; Gonzalez, 1964; Ruckebusch and Bueno, 1978; Gonyou and Stricklin, 1984).

Bond et al. (1978) observed that the most intensive eating period (1500 to 1800 h) in confined cattle, coincided with the time just prior to sunset and immediately following the time when feed was added. The peak times of feeding shift as the seasons (day length) change (Wilson and Flynn, 1979; Gonyou and Stricklin, 1984).

Stricklin and Swanson (1985) noted that eating activity peaked at 0700, 1600 and 2300 h each day, when housed bulls in Maryland were fed with a complete finishing diet free choice. Attempts to change these patterns and stimulate night activity by providing supplemental light, sound stimuli or both between 2300 and 0200 h failed to increase the amount of night eating activity.

Periparturient Behavior

The principle events at parturition in domestic farm animals have been reviewed by Fraser (1968). The critical period postpartum during which a cow will form a bond with her calf is relatively short. During this period the maternal behavior of the dam is under hormonal control. Beyond this time the calf has to provide cues in order to stimulate the dam to continue maternal behavior. The descriptive behavioral events of a periparturient cow are presented in table II-1.

Maternal-filial behaviors in farm animals have been generally well documented. Recently, Arnold (1985a and 1985b) reviewed the periparturient behavior of farm animals, and references to beef cattle were included. An early descriptive report of calf behavior was that of three calves during the first 4 d postpartum (Walker, 1950). Edwards and Broom (1982) presented a detailed study involving 82 Freisian cows and their newborn calves with each cow-calf pair individually penned. Kiley-Worthington (1983) observed cows during spring-calving (32 to 38 cows) and autumn-calving (120 to 150 cows) herds over a 2-yr period. Included in her discussions were descriptions of the periparturient behavior, social organization, ecology and the genetic basis of social behavior of cattle.

Standing by cow and calf. Dairy cows were generally recumbent during parturition unless assisted by humans (Edwards and Broom, 1982), and the initial time a cow stood up was influenced by parity. The delay between birth and standing decreased as parity increased. Hermann and Stenum (1982) reported that six of eight beef-dairy cows completed parturition in a lying position.

Selman et al. (1970a) reported that cows showed

TABLE II-1. BEHAVIORAL EVENTS OF PERIPARTURIENT COWS

Stages	Behavioral Events
Late gestation	Ingestive behavior may increase, slower gait.
Pre-partum	May separate from the herd and seek screened location (1 d). Anorexia develops. Restlessness begins several hours prior to parturition.
Parturition	Vocalizes. Pain and discomfort expres sed in very restless behavior (alternate lying and rising). Usually lies but may stand during expulsion of the fetus. Period relatively short (4 h).
Postpartum period	Usually eats fetal membranes; sometime before uterine separation is complete. Maternal behavior expressed to a degree and for a duration dependent on the quantity of association between the dam and her calf.

After Fraser (1968)

spontaneous maternal behavior with the dam getting up almost immediately after parturition and starting to lick (groom) her calf. Differences in maternal behavior between dairy and beef-dairy breeds were insignificant with the dairy cow slightly slower to rise up after parturition than crossbred cows (Hermann and Stenum, 1982).

Edwards and Broom (1982) observed that the time spent standing by a cow decreased with time after parturition. Heifers, however, spent less time standing during the first hour before reaching a peak in standing time during the second hour with decreasing time spent standing thereafter. The time spent standing by a calf increased from the first to the third hours and then decreased. Calves from dams which had more than three calvings, remained active until the end of the 6-h observation periods. Median times spent standing were 104.8, 131.0, 131.8 and 129.7 min, for calves out of dams with 1, 2, 3 and 4 or more calvings, respectively. The correlation between the total time a calf spent standing and the total amount of licking it received from its dam was not significant.

Selman et al. (1970a) concluded that there were differences in the maternal behavior between dairy and beef cows. Beef cows carried out their grooming activity much longer and more intensely compared to dairy cows. Similar findings were documented between multiparous and primiparous dams (Hermann and Stenum, 1982).

Less total standing time has been recorded in primiparous dams. This was attributed to lack of maternal experiences in cows (Hermann and Stenum, 1982) and lambing difficulty in ewes (Alexander, 1960; Sharafeldin, 1971; Arnold and Morgan, 1975). Lack of maternal influences were associated with delayed early grooming activity. Edwards and Broom (1982) attributed the lack of necessity to stand in order to reach her calf as the cause of lower total standing time in dairy cows early postpartum. In their study standard husbandry practice was to move the calf to the head of the cow to ensure licking. Delayed standing in ewes was more frequently observed in those experiencing long labor (Shelly, 1970). Hermann and Stenum (1982) indicated that heifers experiencing difficult parturition remained recumbent for 63 to 318 min. At the same time, the ability of their calves to stand upright was significantly delayed. The intervals from calving to standing were 39.8, 50.9 and 84.3 min, respectively, for calves from unassisted, easy pull and hard pull dams (Odde et al., 1986).

LeNeindre (1982) reported that Salers and Freisian calves attempted to stand 9.4 min (mean) after birth and succeeded 41.7 min (mean) later. Similar findings were observed in Hereford and crossbred calves with the time from parturition to first standing averaging 58 min (Lewandrowski and Hurnik, 1982).

The occasions when a cow remained lying while her calf was active were infrequent, occupying a mean of 5.4% of the total observation time (Edwards and Broom, 1982). There appeared to be a relationship between standing and lying activities of a cow to that of her calf with the degree of synchronization decreasing with parity. The higher level of synchronization in younger cows was attributed to the greater reactivity of the heifer towards her calf (Edwards and Broom, 1982) and the reluctance of the heifer to remain lying while her calf was active (Selman et al., 1970a).

Grooming. Grooming of the neonate is common to all domestic farm animals. Grooming behavior plays an important role in the survival prospects of the neonate (Edwards and Broom, 1982). Some suggested functions of initial grooming or licking are:

a. removal of the fetal membrane (Edwards and Broom, 1982),
b. drying of the coat (Edwards and Broom, 1982),
c. stimulation of breathing and activity in newborn (Edwards and Broom, 1982),
d. stimulation of circulation (Moore, 1968),
e. stimulation of urination and defecation (Hediger, 1955; Hafez and Lineweaver, 1968; Metz and Metz, 1986),

f. ensuring calf recognition by its dam (LeNeindre, 1982; Edwards and Broom, 1982), and

g. improvement of body surface hygiene; minimizing infection and predation (Sambraus, 1973 and Townsend and Bailey, 1975).

Edwards and Broom (1982) reported that dairy cows spent 30 to 50% of the first hour postpartum licking their newborn calves. The intensity of licking decreased markedly with time after parturition. They attributed this decline to the progressive de-saturation of the neonatal coat as had been shown by Hudson (1977), who demonstrated that licking of an older calf can be induced by wetting its haircoat with amniotic fluid from the parturient dam.

Hudson and Mullard (1977) and Klopfer et al. (1964) reported that ungulates prevented from licking their newborn offspring normally showed a higher rate of subsequently rejecting their own offspring. A short period of neonatal licking was adequate to establish a long lasting maternal-filial relationship capable of surviving subsequent separat-ion.

In cattle, the failure to lick the calf was reported only in heifers (Selman et al., 1970a; Edwards and Broom, 1982). Frequency of licking averaged 43 min during the first 4 h after parturition, and this activity persisted until weaning (LeNeindre, 1982). The dam licked and faced the calf less often after the calf was able to stand (Selman et al., 1970a).

Teat seeking. Teat seeking by the newborn calf has been described as a trial and error learning process (Hafez and Lineweaver, 1968). Contact with the udder may have stimulus value for the neonate (Hermann and Stenum, 1982). Greater time is spent at the hind-quarters than the front and mid-section of the cow. Edwards and Broom (1982) found that calves from dams which had given birth to more than three calves had the greatest difficulty locating teats because of poor conformation of these cows. The calf's ability to locate the teats is reinforced by successful suckling (Fraser, 1976). If separated from the dam for more than 6 d, a calf may show a loss in ability to locate the teats (Finger and Brumner, 1969).

Alexander and Williams (1966) suggested that the initial peak in teat seeking activity was not solely due to hunger, because this activity was not completely suppressed when lambs were each given 600 ml of milk during the first 6 h after lambing.

Suckling. The rate of suckling and the amount of milk consumed by a calf is related to the size of the calf, breed, methods of suckling, ease of milk let-down by the dam and the persistance of the calf during suckling (Hafez and

Bouissou, 1975). The total time spent suckling during the first 6 h postpartum was reported to decrease with cow parity, principally because of a greater latency to first suckling and a higher incidence of failure to suckle within the time observed in older cows (Edwards and Broom, 1979). It was common for a calf to suckle the front teats (Selman et al., 1970b; Edwards and Broom, 1982). However, as time progressed, calves from heifer dams usually distributed the suckling activity equally over all quarters with frequent changing of teats within a suckling bout. Calves from older cows seldom suckled from more than two teats which could reflect differences in milk supply or teat accessibility. More frequent interruption of suckling activity during the first hours after parturition was observed among calves with primiparous dams (Edwards and Broom, 1982). Heifers had more sensitive udders and were reluctant to allow their calves near the abdominal region. The frequency of butting of the dam's udder by her calf was an indication of the restricted milk supply and less ready let-down in primiparous dams.

LeNeindre (1982) reported that Salers and Freisian calves averaged 72.6 min to start suckling (range 41 to 132 min after birth). Calves spent an average of 25.7 min suckling within the 4-h period observed in his study. In Hereford and crossbred calves, Lewandrowski and Hurnik (1892) recorded a mean time of 131 min from birth to initial onset of suckling. The frequency of daily suckling bouts was greater in Hereford (13.7) than in crossbred (7.0) calves. Approximately 61% of the suckling activity occurred between 0600 to 1800 h. Somerville and Lowman (1979) found that the number of suckling bouts were approximately equal during the day and night when the suckling activity in 21 beef cows was assessed.

During suckling activity, the calf stands in an opposite position to the dam (Hermann and Stenum, 1982), and this facilitates licking, especially, the ano-genital region which stimulates defecation and urination, and reinforces pair bonding development between the dam and her calf.

A reduction in suckling frequency as calf age increased has been observed by Ewbank (1969). However, Walker (1962), Somerville and Lowman (1979) and Odde et al. (1985) observed no relationship between these two variables. The number of suckling bouts was inversely related to the weight of the calf and high milk production in the dam (Odde et al., 1985).

The nursing behavior of calves from cows of different levels of milk production was observed for 2 d on alternate days at approximately 52, 104 and 167 d following parturition (Day et al., 1984). It was concluded that calves of high milk producing dams suckled less often but for a longer period during each suckling event than calves of low milk-producing dams. Total minutes nursed per 24 h were not affected by milk production level, and all calves suckled less as lactation progressed but the duration of each nursing event remained constant. Distinct differences in nursing behavior of cows with different levels of milk production existed.

Spacing. Several authors have described the postpartum spacing in cattle (Edwards and Broom, 1982; Hermann and Stenum, 1982). Typically a cow spends more time lying, orients less towards her calf and the distance between the cow and calf progressively increases as the intense interest initially shown to the newborn decreases. Dams were reported to maintain a defended area for themselves and their offspring (LeNeindre, 1982), and spent more time walking as the result of close proximity to their calves during the first 2 d postpartum (Lewandrowski and Hurnik, 1982).

Interaction with offspring of herdmates. Some cows groomed alien calves but often ended the activity by butting the calves. Similarly, some calves tried unsuccessfully to lick alien cows (LeNeindre, 1982).

In sheep, Bareham (1976) indicated that a newborn lamb which approached or contacted other ewes was butted unless those ewes were in labor or were themselves mothers of very young lambs. Mismothering, adoptions and desertions were common in lambs reared under confined conditions (Alexander, 1960; Alexander and Peterson, 1961). A high proportion of separation usually occurred when ewes left the birth site (Alexander et al., 1983) and occurred more frequently in multiple lambings than in single lambings, 8.1 and 2.9%, respectively (Gonyou, 1985).

General eating activity. Onset of eating hay by cows following parturition was influenced by parity (Edwards and Broom, 1982) with older cows spending more time eating during the first 6 h postpartum. Time spent eating hay also increased progressively during this period. Beyond the first day of parturition, Lewandrowski and Hurnik (1982) recorded a significant increase in resting and feeding time. Shelly (1970) reported that ewes would leave the birth site to graze, but frequently returned to their lambs.

Maternal-offspring bonding. Numerous studies of maternal-filial relationships have been conducted with sheep, as indicated by the number of literature citations on sheep compared to cattle in a review of the behavior related to maternal-offspring bonding (Curtis and Houpt, 1983). It is postulated that the initial recognition of the lamb by its mother is based on olfactory cues (Baldwin and Shillito, 1974). However, the formation and maintenance of the mechanisms involved are yet to be established. Attempts to mask the lambs specific odor (Alexander and Stevens, 1982a) have failed, and there are reasons to believe that this specific odor originates from the lambs rather than the ewes (Alexander and Stevens, 1982b). In cattle, Curtis (1983) indicated that a cow and her calf recognized each other by smell, sight and sound. Cows appeared to use mainly olfactory cues; and the calves, vocal cues.

LeNeindre (1982) reported that a calf passed in front of its dam only 29% of the suckling periods before or during suckling, which suggested that other factors might also be important in maternal-offspring recognition especially in beef cattle. Edwards and Broom (1982) associated the period of maximum licking of the newborn calf by its dams as corresponding to the time at which the formation of the dam-calf bond was occurring.

In sheep, bond formation between an ewe and her offspring was dependent on the combined process of association with its mother and rejection by other ewes (Smith et al., 1966). Maternal recognition of a lamb by its ewe several days postpartum had been associated with sight, sound and smell (Morgan et al., 1975; Alexander and Shillito, 1977a and 1977b). Among the various body regions, evidence suggests that the lamb's head may be the most important physical cue in maternal recognition. When a lamb was artificially dyed, Alexander and Shillito (1978) demonstrated that an ewe would tend to approach an alien lamb having the same color as her own.

Multiple fostering of alien calves on to dam immediately following parturition resulted in the formation of a strong bond while fostering after a dam had physical contact with her own calf was less successful (Hudson, 1977). This technique has been assessed in Australia and New Zealand as a potential management approach in dairy-beef production (Kaiser, 1975; Kaiser and O'Neill, 1975; Hudson, 1977; Moss, 1977, Rayner et al., 1977; Peel et al., 1979).

Based on 2684 parturitions over an 11-yr period, Buddenberg et al. (1986) rated the postpartum maternal behavior of beef cows on a scale from 1 to 11, where 1 indicated extreme aggressiveness and 11 indicated no maternal attentiveness. This score was based on the dam's attentiveness to her calf and aggressiveness towards the caretaker at the time a calf was weighed, tattooed and ear-tagged simultaneously within 24 h after birth. Respective breed means for Hereford, Angus, Charolais and Red Polled for maternal behavior rating were 6.2, 5.3, 6.0 and 5.7. The genetic correlations between maternal rating and birth weight and condition score (fattest to thinnest) were low. These researchers concluded that differences in aggressiveness of cows at parturition were due primarily to nongenetic influence.

Periparturient Behavior and Subsequent Calf Performance

Although there are numerous studies on periparturient behavior of domestic animals, no known effort has been made to relate these observations to subsequent performances. Little direct information is currently available concerning heritability or breed differences on time of birth to initial standing, initial suckling and other measures of periparturient calf vigor (Stricklin and Kautz-Scanavy, 1984). However, significant weight advantage of crossbred beef calves over their straightbred counterparts has been well established (Cundiff, 1970; Warnick and Legates, 1979). Similarly, subsequent reproductive performance and calf weaning weight were reduced in dams with dystocia (Laster et al., 1973; Brinks et al., 1973). Cue and Hays (1985) reported a genetic correlation of -.80 in both dairy heifers and cows for direct effects between calving ease and calf survival; whereas the phenotypic correlations for the same two traits were -.32 and -.20 in heifers and cows, respectively. Stephens (1982) emphasized that the vigor and speed with which a calf became active after parturition depended on the ease of parturition and subsequent establishment of the bond between the dam and her newborn. Increased calving difficulty was associated with decreases in vigor and lower serum immunoglobulin concentration in calves (Odde et al, 1986). Calves from difficult births had poorer mothering scores and were more susceptible to diseases.

Waddington (1957) compared the development of a particular part of an individual towards an adult structure to a ball rolling down a succession of developmental pathways from the top of a hill. The different valleys represented alternative courses of development, and the selection of a particular pathway depended upon several factors, but most importantly upon the control of epigenetic landscape by the underlying genes, genes products and their various interactions. If this is true, then much of the advantages observed in crossbred calves could possibly be the result of vigor expressed early in calf life, possibly during the first few hours after parturition since this would influence the particular valley selected by the ball as it rolls down the hill as depicted in Waddington`s Theory.

High calf mortality in Denmark (15 to 16%) has been attributed partly to the separation of the calf from its dam immediately after parturition thereby denying it the opportunity to get essential colostrum by suckling naturally (Hermann and Stenum, 1982). Calves deprived from colostrum gained poorly and suffered severe long scour and high mortality (Nocek et al., 1984).

Calves which were bucket-fed had lower immunoglobulin concentrations when compared to those that were directly suckling their own mother (Selman et al., 1971). In management of beef cattle, calves that were rejected by their dams due to delayed development of pair-bond relationship or difficult parturition could be assumed to have a lower serum immunoglobulin than their conspecifics. Calves isolated from dams were less active than those kept together with dams (LeNeindre, 1982). Similarly, colostrum intake was less for Salers calves that were bottle-fed when compared to calves that were suckling directly their dam. It has been shown in humans (Jelliffe and Jelliffe, 1978) that specific antibodies are produced locally by the reticula-endothelial tissue of the breast of a woman and are discharged into the milk within 8 h of immunological stimulation. If similar mechanisms occur in bovine, the newborn calf will be provided with the immunological protection specific for each dam offspring pair. Through early suckling immediately after parturition, the antigen from the calf and its environment could stimulate rapid development of antibodies in the dam and be transferred to the calf within the 12 h period after birth. Thus the calf is able to get the additional antibodies appropriate for the environment apart from the dam's immune system (Stephens, 1982).

From a production standpoint, periparturient behavior, especially the pair bonding relationship, is far more important in beef than in dairy breeds in determining subsequent performance. Selection for reduced social activities and relatively easy acceptance of isolation in calves have been practiced in the dairy but not in the beef industry.

Summary

Recent reports, especially popular articles, have stated that day-time parturition frequency in ruminants can be increased by night-time feeding. However, evidence from different refereed publications suggest that conclusive evidence is still lacking. Current knowledge of the underlying factors influencing parturition in beef cattle has generally failed to include diurnal activity patterns, especially during the few weeks prior to birth, yet in other species there is evidence that these patterns are related to time of parturition.

To date, there have been no large systematic studies on postpartum maternal behavior and early neonate experiences in beef cattle, although significant contributions have been documented in sheep and dairy cattle. Similarly, no known studies have attempted to predict subsequent or lifetime performance of calves based on behavior of cows and calves during and after the first few hours postparturition.

III. FACTORS INFLUENCING TIME OF PARTURITION AND LOCATION OF CALVING SITE AMONG BEEF COWS

ABSTRACT

Periparturient behavior of purebred and crossbred gestating beef cows (375 births) of Angus and Hereford breeding was monitored during two spring-calving seasons (1985 and 1986). Assignment of cows to one of two treatment groups (control and night-fed) was balanced by breed-class, age and expected date of calving. The control group was fed corn silage at 0900 h, and hay was available free choice. The night-fed group was fed the same diet but at 2100 h, and time of access to hay was restricted to 2100 to 0900 h. Each group was kept in a 3.2 ha paddock and observed continuously in 1985. During 1986, similar feeding schedule treatments were used, but observation of cows between sunset and sunrise was intermittent. Cows were on the feeding schedules for an average of 20.6$\pm$.7 d prior to parturition, and the range was 1 to 50 d. Time of parturition was coded four ways; time from sunrise, night vs day (sunset to sunrise and sunrise to sunset; respectively), night vs day (1800 to 0600 h and 0600 to 1800, respectively) and period of day (2400 to 0600, 0600 to 1200, 1200 to 1800, and 1800 to 2400 h). Time of Feeding did not influence time of parturition for any of the four methods of classifying time of birth. There was a tendency for more cows to calve

during daylight (0600 to 1800) hours (P>.25) for both control and night-fed groups; 55 and 60%, respectively. The number of births for the four 6-h periods of the day (1985 data) were 48, 49, 77, and 41, respectively. With the exclusion of wet areas and steeply sloped areas in the observation paddocks, calving sites in 1985 were generally uniformly distributed over the paddocks. Heifers had a tendency to calve near perimeter fences and stream banks. Among both first-calf heifers and older cows, some females chose calving sites near the stream bank endangering the survival chances of the calves. It was concluded that night feeding corn silage and hay to beef cows was not an effective way of increasing the frequency of daylight calvings, and cows do not have the ability to choose calving sites that are safe for calves in all environments.

Introduction

Close observation and attention of cows at calving time reduces cow and calf death losses, but even periodic checking of the cow herd during late gestation requires extra labor input by the beef producer and continuous observation is infeasible. Thus, development of a practical method of inducing parturition during daylight hours would save labor and possibly reduce cow and calf death losses.

The influence of feeding schedule on the time of parturition in livestock has received some recent research attention. Studies of night-time feeding in swine and sheep have failed to show a consistent increase in day-time parturition. The reported results on beef and dairy cows are not consistent, but some reports state that a higher percentage of day-time calving can be obtained by feeding gestating beef and dairy cows at night. Some reports speculated that the number of days that cows were on the feeding schedule was an important factor in determining whether or not night-time feeding resulted in day-time calvings.

The primary objective of this study was to determine the effects of time of feeding on time of parturition, especially as influenced by number of days on the feeding schedule. The Sykesville Beef Farm over a 5-yr period had lost approximately 10 calves that drowned because their dams calved on the bank adjacent to a stream. Therefore, a secondary objective was to determine if the location of calving site was random among cows and heifers calving in small paddocks.

Materials and Methods

During the 1985 and 1986 spring-calving seasons, purebred and crossbred gestating Angus and Hereford cows at the University of Maryland Beef Research Farm, Sykesville, Maryland, were stratified according to breed-class, age and expected date of parturition then randomly allotted into two treatment groups. Parturition data were collected during February through April during each calving season. Two-hundred and fifteen and 160 calvings were recorded during 1985 and 1986, respectively.

Two feeding schedules were used; designated the control and night-fed treatments. The control group was fed a diet of corn silage at 0900 h, and hay was continuously available free choice. The night-fed group was given the same diet at 2100 h, and time of access to hay was restricted to 2100 to 0900 h. Cows had continuous access to the feed bunks in both groups.

Observation paddocks. Each observation paddock measured approximately 3.2 ha, and essentially no forage was available for grazing. Water from a stream and salt and mineral stations were located in each field. An observation booth with a view of both paddocks was positioned on an elevated site outside and adjacent to the two paddocks, and the majority of observations were recorded from this location. Some low visibility conditions required observers to move into paddocks to collect data. Cows below the stream bank were not visible from the observation booth.

1985 Trial. Before the start of the 1985 calving season, 216 cows were placed on a corn silage ration fed at 0900 h. Each week cows due to calve within the next 2 to 3 wk (based on artificial insemination records and rectal palpation at approximately 100 d after breeding) were separated from this herd and placed in either the control or night-fed group (table A-1; letters indicate material is in Appendix). Each cow was given a unique paint marking (number or code) on both sides of the upper rib area. The experimental groups were maintained in one of two adjacent paddocks, separated by a public, gravel road that had a low volume of traffic. Each week cows that had calved and their calves were removed from the observation paddocks and new cows were added.

Behavioral data collection. Prior to placing a cow in an observation paddock in 1985, her bodyweight and chute score were recorded. Chute score was determined using a subjective scoring system of 1 to 4 (table A-2) based her on activity between the time she entered and left the head gate. A score of 1 indicated a docile cow, and a 4 was assigned to the less tractable cows. The number of days each cow was on the feeding schedule prior to calving was computed for cows in both the night-fed and control groups.

Between February 20 and April 15, 1985, cows were observed continuously for periparturient activities. For each cow, traits were recorded in minutes based on the interval between the time the activity or event was observed until the time of parturition. Time of parturition was defined as the time the fetus was completely expelled by the cow, either assisted or unassisted.

Six observers recorded all the behavioral activities of the cows and calves. Three observers were responsible during the weekdays and three during the weekends. During each 24-h period, an observer was responsible for a total of 8 h of observation consisting of two separate 4-h periods of data collection. All data were recorded on a prepared data form. Binoculars and a night viewing-light gathering device (Javelin model 221 NVD) were used to aid in data collection. All cows were observed for behavioral and physical signs of parturition including; isolation seeking, heaving of the tail and rupture of the fetal membranes as described by Schilling and Hartwig (1984).

When parturition was imminent, cows were observed for calving difficulty. If assistance was necessary, the observer notified the herdsman. Each birth was given an ease of calving score of 1 to 4 (Table A-3). During the 1985 calving season, the location of the calving site for each cow and heifer was recorded on a sheet containing a map of the observation-calving paddocks.

Birth weight was recorded within 24 h after the calf was born and the calf was ear-tagged. Vitamins A and D were administered im, and each calf was vaccinated against scours via a second injection. At the time these procedures were administered by the herdsman, each calf was assessed a subjective score for vigor (Table A-4) based on the difficulty of restraint as determined by the herdsman. All calf vigor scores were assigned by the same herdsman throughout the 1985 calving season.

1986 Trial. In 1986 parturition data were collected on 170 cows from the Sykesville herd. Relative to the 1985 trial, the cows were of similar breeding, type and condition. The management procedure used in 1986 was slightly modified from that of 1985, and the same calving paddocks were not used. In 1986 all cows in both groups were placed in their respective paddocks 2 wk prior to the beginning of the calving season. The night-fed and the control cows received the same time of feeding schedule as in 1985. Chute scores of cows and cow bodyweights were not recorded.

In 1986, cows were not observed continuously through the night. When a birth was not observed, the time of parturition to the nearest hour was estimated by the herdsman when the cows were checked in the morning subsequent to a birth.

Statistical analysis. Parturition for each cow was coded four different ways:

1. the time interval in hours from sunrise (on the day the calf was born) to parturition,

2. coded as either 1 or 2, with the former corresponding to day-time calving and the latter corresponding to night-time calving. All calvings from 0600 to 1800 h were classified as daylight and 1800 to 0600 h as night-time,

3. coded as 1 or 2 (as above) but was based on the time of sunrise and sunset, and

4. categorized into four 6-h periods of the day; periods 1, 2, 3 and 4 corresponded to births occurring from 2400 to 0600, 0600 to 1200, 1200 to 1800, and 1800 to 2400 h, respectively.

The parturition data were analyzed using parametric (Analysis of Variance) analyses to test the following null hypothesis:

$$H_o : u_{night\text{-}fed(parturition)} = u_{day\text{-}fed(parturition)}$$

where: u = number (or time) of parturitions for the respective treatments.

Additionally, the number of day-time and night-time parturitions of the night-fed and the control groups were further stratified according to the number of days that the cows were on trial. A non-parametric analysis (Chi-square) was performed to determine if differences existed between the two groups based on the number of days on treatment.

Results

Means and standard errors of traits associated with parturition are presented in table III-1. The mean bodyweight of cows recorded at the time they entered the observation paddocks was 527 kg. The mean number of days on the feeding schedule for the cows receiving night-feeding was 19.6 and 22.7 d, respectively, for 1985 and 1986 calving seasons. The distribution of parturitions by hour of day over a 24-h period by number of days cows were in the observation paddock prior to calving are presented in figures III-1 and III-2 for the control and night-fed groups, respectively. These plots indicate that calvings are fairly evenly distributed over night and day with the possible exception of some tendency for more night-fed cows to calve during the day for cows that have been on the feeding schedule for more than approximately 30 d.

The time of sunrise varied from 0501 to 0659 h during the days represented by two calving seasons with a mean of 0612 h for all parturitions. Mean interval from sunrise to parturition was 12.2 h.

The majority of parturitions were unassisted, with only 11% of the cows over the two seasons requiring assistance during calving. Of those recorded as difficult births, 62% were by heifers. The number of unassisted parturitions in which a calf was expelled while the dam was standing was only five of 108 cases (4.8%).

TABLE III-1. LEAST-SQUARE MEANS AND STANDARD ERRORS OF TRAITS ASSOCIATED WITH PARTURITION.

Variables	N	Mean	SE
Angus breeding, %	375	51.4	2.07
Age of dam, yr	375	4.6	.13
Dam weight, kg	210	527.0	4.41
Days on trial	375	20.6	.77
Time of parturition, h	375	1106	32
Time of sunrise, h	375	06.2	.02
Interval to parturition;			
time of sunrise, h	375	12.2	.36
isolation seeking, min	94	88.3	6.79
heaving up tail, min	99	76.4	6.43
rupture of the fetal membrane, min	111	47.6	4.82
Chute score[a]	210	1.8	.05
Calving score[b]	373	1.2	.03
Birth weight, kg	375	37.9	.25
Calf vigor score[c]	358	2.2	.02

[a]1=docile to 4=very aggressive.

[b]1=no assistance to 4=very hard pull.

[c]1=weak calf to 3=very vigorous.

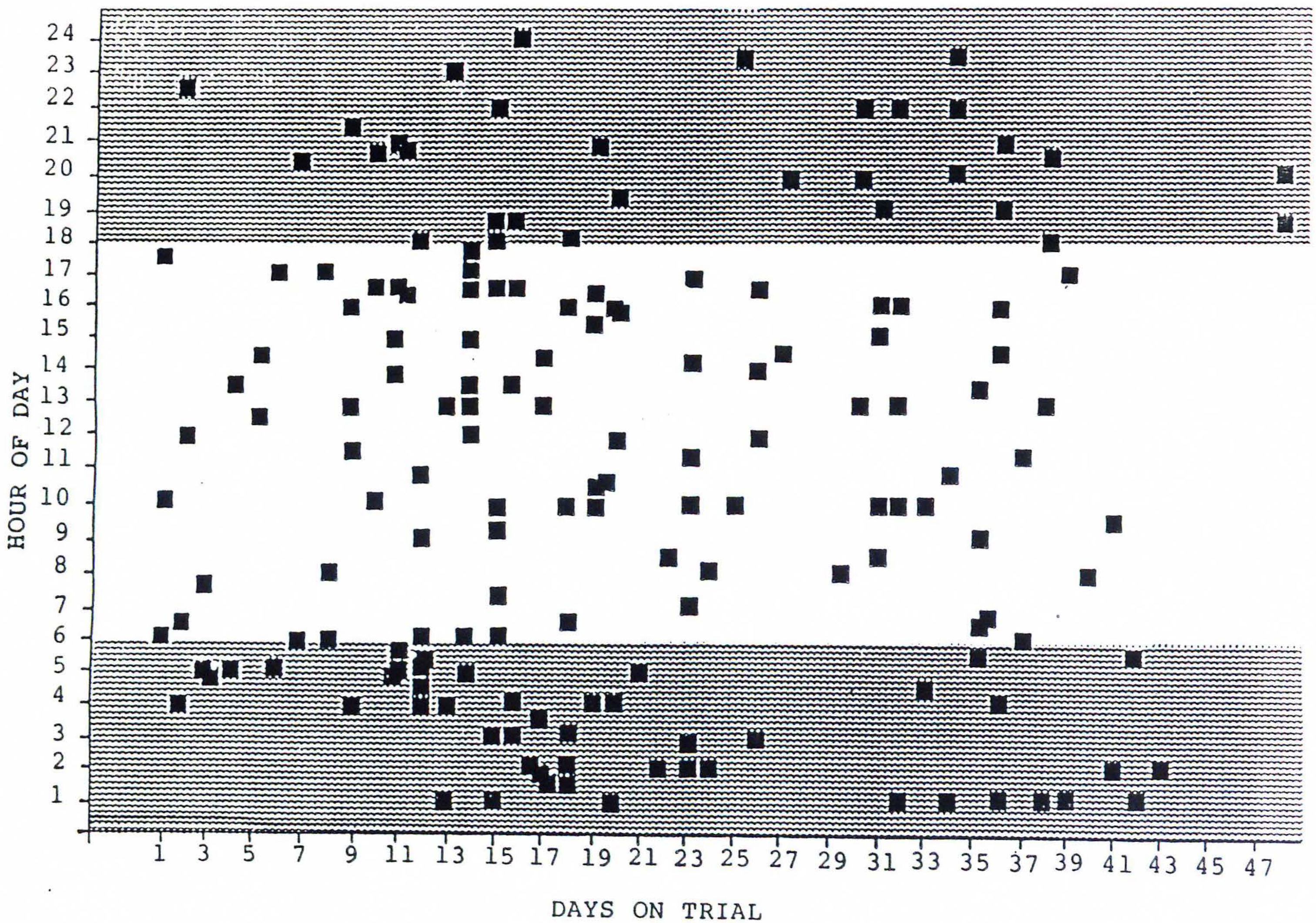

Figure III-1. The distribution of calvings (■) for control group cows by the number of days in the observation paddock prior to calving.

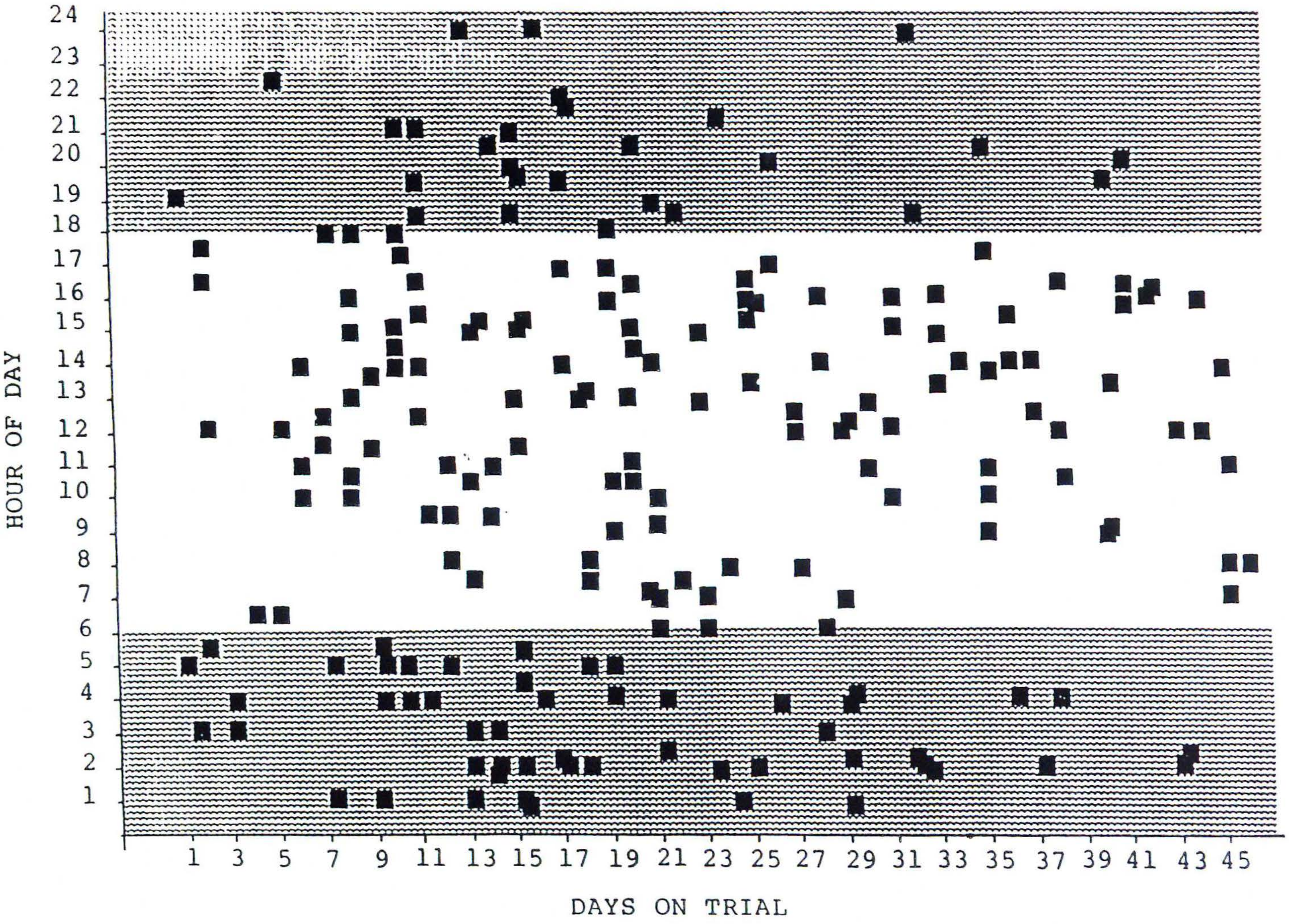

Figure III-2. The distribution of calvings (■) for night-fed cows by the number of days in the observation paddock prior to calving.

<u>Effect of time of feeding on time of birth</u>. Time of feeding (treatment) was not significant (table III-2) for any of the four ways of coding the time of parturition. In the analysis with the time of birth recorded as the length of time from sunrise to parturition, none of the variables included in the analysis were significant. When time of parturition was coded as either occurring during the daylight or night-time, only breed of sire ($P<.10$), breed of dam ($P<.05$), and chute score ($P<.01$) were significant. Year effect ($P<.01$) and calving score ($P<.10$) were significant when the time of birth was categorized according to the four 6-h periods of the day.

Treatment was not significant ($P>.10$) when data were analyzed (table III-3) according to nonparametric analysis (Chi-square). Although there were more day-time calvings recorded in the night-fed group compared to the control group, the difference was not significant ($P>.10$). The frequency of day-time vs night-time calvings in the night-fed groups tended to increase for cows that were on the feeding schedule for more than 21 d. However, this trend was not significant. The overall number of daylight vs night-time calvings (pooled across treatment) did not differ ($P>.10$) even though overall there were approximately 10 to 15% more daylight calvings.

Correlation coefficients between time interval from sunrise to parturition and other traits are presented in

TABLE III-2. ANALYSIS OF VARIANCE FOR TIME OF CALVING CODED FOUR DIFFERENT WAYS.

		Mean square			
Item	df	Time from sunrise	Night vs day[a]	Sunrise to sunset[b]	Period[c]
Treatment	1	75.4	.18	.22	.28
Year	1	86.4	.02	.22	16.29**
Breed of sire	1	22.7	.28	.56+	.73
Breed of dam	5	63.4	.61*	.48	.69
Parity[d]	1	4.6	.06	.57	.15
Sex[e]	1	8.6	.13	.34	1.41
Angus breeding[ef],%	1	127.4	.03	.06	2.32
Age of dam[f], yr	1	30.5	.03	.25	1.41
Birth weight[ef], kg	1	.7	.05	.04	.47
Days on trial[f]	1	114.2	.01	.16	.47
Calving score[g]	3	40.5	.19	.21	2.69+
Remainder	352	50.1	.24	.24	1.03
Variables from 1985					
Dam weight[f], kg	1	18.4	.01	.01	.87
Chute score[g]	3	79.5	.50	.65*	.83
Remainder	172	39.8	.25	.24	1.08

[a]Coded 1=day (0600 to 1800 hr) and 2=night (1800 to 0600 hr).
[b]Coded 1=day and 2=night based on time of sunrise and sunset for the respective days that calves were born.
[c]Day divided into four periods; 2400 to 0600, 0600 to 1200, 1200 to 1800 and 1800 to 2400 hr and coded 1 to 4, respectively.
[d]Coded 1=heifer and 2=cow.
[e]Calf traits.
[f]Linear variables.
[g]See text for description of scores.
+P<.10.
*P<.05.
**P<.01.

TABLE III-3. DAY VS NIGHT CALVINGS BY NUMBER OF DAYS ON TRIAL FOR NIGHT-FED AND DAY-FED BEEF COWS[a].

Number of days on trial	N	Night-fed (calvings) Day (%)	Night-fed (calvings) Night (%)	N	Day-fed (calvings) Day (%)	Day-fed (calvings) Night (%)
Day = 0600 to 1800 h						
0 to 7	21	52.3	57.7	18	61.1	38.9
8 to 14	49	57.1	42.9	43	62.8	37.2
15 to 21	51	52.9	47.1	42	47.6	52.4
22 to 28	26	69.2	30.8	18	66.7	33.3
29 to 35	28	64.3	35.7	26	57.7	42.3
36 to 42	19	73.7	26.3	15	53.3	46.7
43 to 50	11	72.7	27.3	8	12.5	87.5
Total	205	60.5	39.5	170	55.3	44.7
Day = sunrise to sunset						
0 to 7	21	52.3	57.3	18	44.4	55.6
8 to 14	49	57.1	42.9	43	55.8	44.2
15 to 21	51	51.0	49.0	42	47.6	52.4
22 to 28	26	61.5	38.5	18	66.7	33.3
29 to 35	28	64.3	35.7	26	57.7	42.3
36 to 42	19	73.7	26.3	15	53.3	46.7
43 to 50	11	72.7	27.3	8	12.5	87.5
Total	205	59.0	41.0	170	52.3	47.7

[a]Chi-square value = 14.6; (df=18, NS) for frequency of parturition (day coded 0600 to 1800 h).

table III-4. Behavioral traits significantly correlated (P<.01) with the time of parturition were interval subsequent to parturition and isolation seeking (r=.77), heaving of tail (r=.89), and rupture of fetal membranes (r=.26).

Distribution of parturitions by hour of day. Parturition data were pooled over years by treatment, and the percentage of total parturitions by treatment for each hour of the day were plotted (figure III-3). More cows calved between 0600 and 1800 h in both the night-fed (60.5%) and the control (55.3%) groups. Slightly more cows in the treated group calved within this period when compared to the control group. For cows subjected to both feeding schedules, there appeared to be a low incidence of parturitions between 1700 and 0100 h. This 8-h period accounted for only 16.8% of the parturitions and the peak parturition period for the treated group was 1200 to 1700 h, with 33% of parturitions (68/205) occurring within this 5-h period. The trend resulting from graphing the data combined across treatment groups and calving seasons (figure III-4) suggests a lower frequency of parturitions between 1700 and 0100 h and indicated a fairly even distribution over the other hours of the day with the possible exception of a small spike in activity at approximately 1600 h. However, when calving data for 1985 and 1986 were plotted by year (figure III-5), the pattern of frequency of calving during the night differed. Since times of

TABLE III-4. CORRELATION COEFFICIENTS[a] AMONG TRAITS RELATED TO TIME OF PARTURITION IN BEEF COWS.

Variables	2	3	4	5	6	7	8	9	10	11	12
1) Angus breeding,%	.05	-.02	.16*	-.15**	.07	-.02	-.18**	-.03	.10	.01	-.05
2) Dam age, yr		.56**	-.28**	.10	.05	-.15**	.10*	.10*	-.21**	-.06	-.07
3) Dam weight, kg			-.33**	.16*	-.01	.27**	.31**	.15*	-.20	-.15	-.21**
4) Chute score[b]				-.08	-.15*	.13	-.14*	-.06	.20	.20*	.11
5) Days on trial					-.04	.07	.10*	.03	.07	.07	.00
6) Interval from sunrise[c]						-.11*	-.04	-.06	.10	.18	.26**
7) Calving difficulty score[b]							.09	-.15**	.55**	.54**	.60**
8) Birth weight, kg								.13*	-.04	-.05	-.04
9) Calf vigor score[b]									-.20	-.22*	-.11
10)Isolation seeking[c]										.95**	.77**
11)Heaving tail[c]											.89**
12)Rupture of fetal membranes[c]											1.00

[a]Adjusted for number of observations.

[b]See text for description.

[c]Time interval (h) between variable and time of parturition.

*P<.05.

**P<.01.

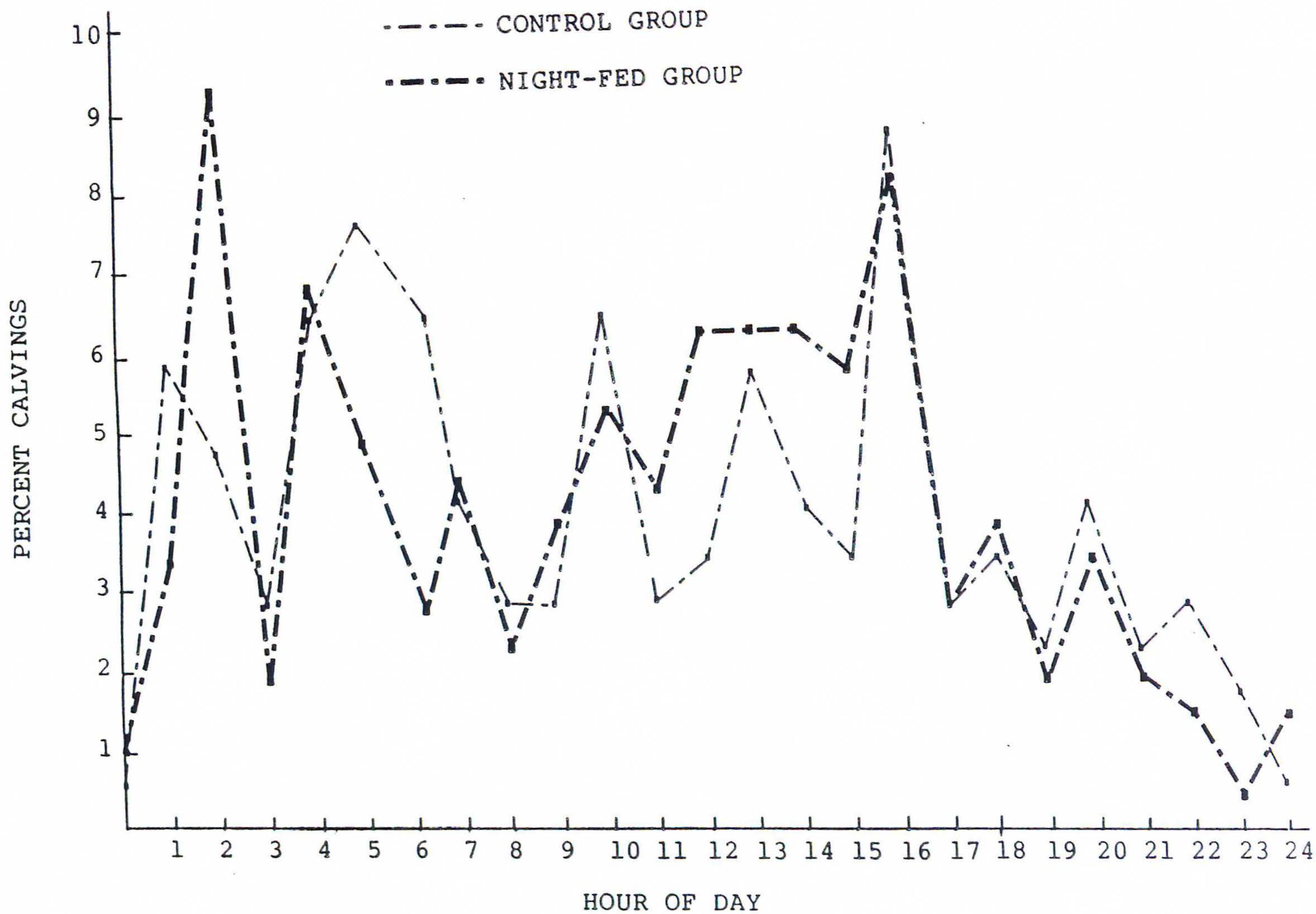

Figure III-3. The distribution of hour of calving, by treatment, for combined data from 1985 and 1986 calving seasons.

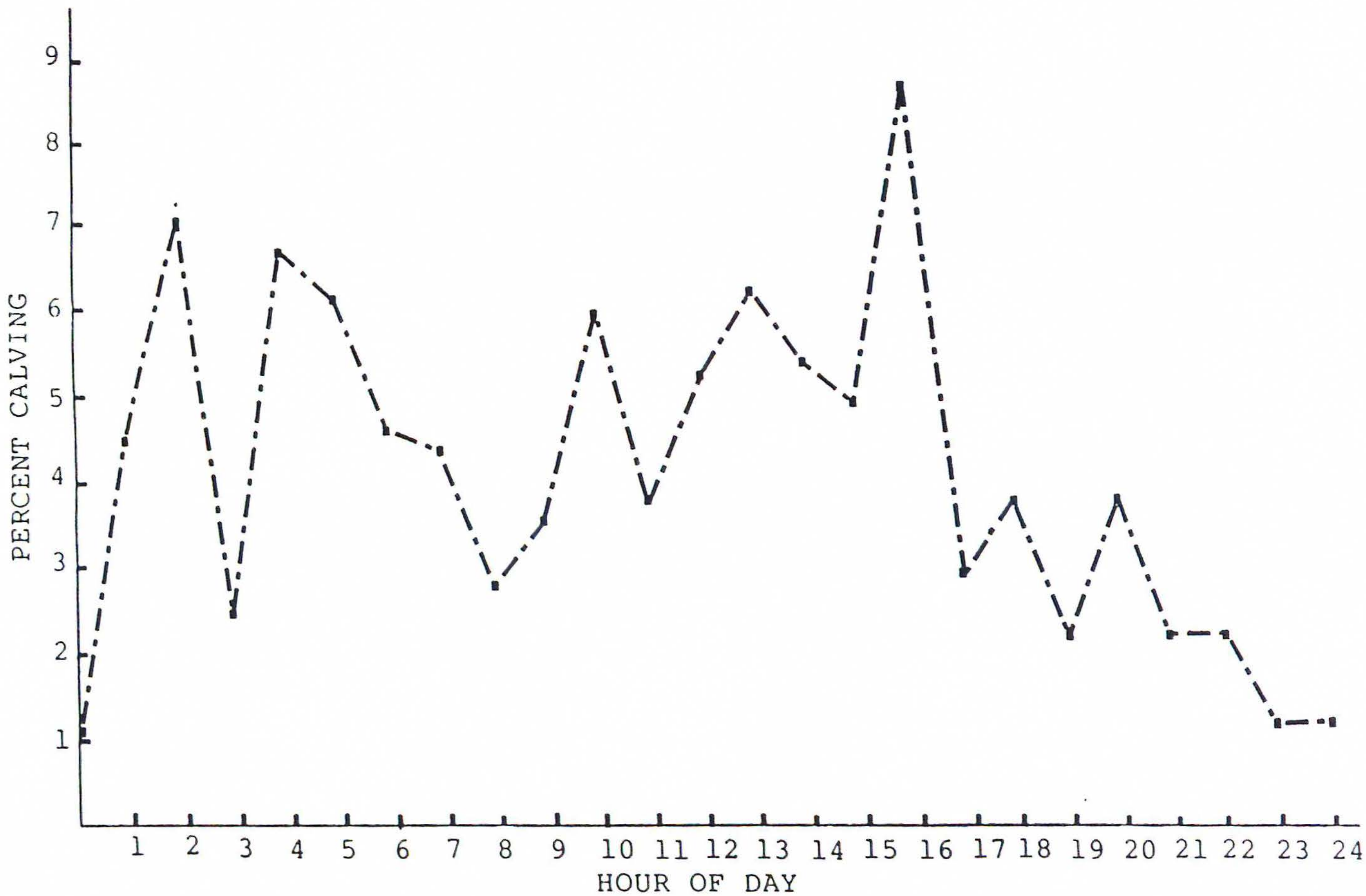

Figure III-4. The distribution of calvings by hour of day for the pooled data from the 1985 and 1986 calving seasons.

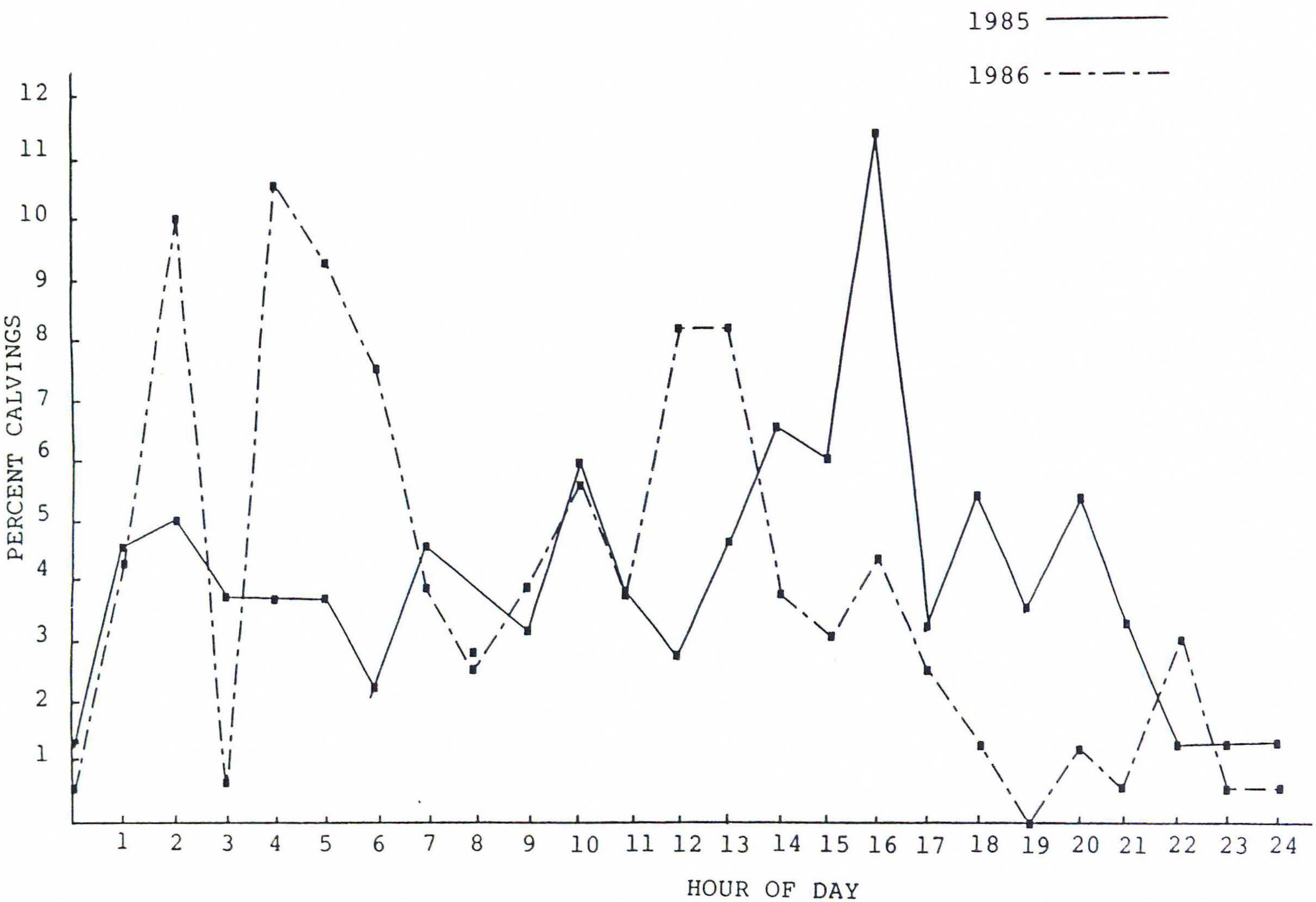

Figure III-5. The distribution of calvings by hour of day during the 1985 and 1986 calving seasons.

calving in the 1986 data for night calvings were estimates and not observed times, it was concluded that the 1985 data were more representative of true diurnal calving patterns.

When the 1985 parturition data were classified according to four equal periods of the day, the number of parturition were 48, 49, 77 and 41 for the periods from 2400 to 0600, 0600 to 1200, 1200 to 1800 and 1800 to 2400 h, respectively (figure III-6). There was a tendency for the frequency of calving to decline from approximately 1600 to 2400 h, and the frequency was generally uniform over the other hours of the day.

Location of calving sites. The location of calving sites during 1985 for cows in both 3.2 ha paddocks are presented in figures III-7 and III-8. When steeply sloped areas, wet ground, and areas closer to the public road were excluded, the distribution of calving sites appeared to be randomly distributed throughout the two observation paddocks.

Discussion

Time of calving results in this study were consistent with those of Tucker et al.(1985) and Pennington and Albright (1985) who did not observe a significant shift in the time of parturition when cows were fed at different times of the day. In this study both parametric and nonparametric analyses were performed to determine the effect

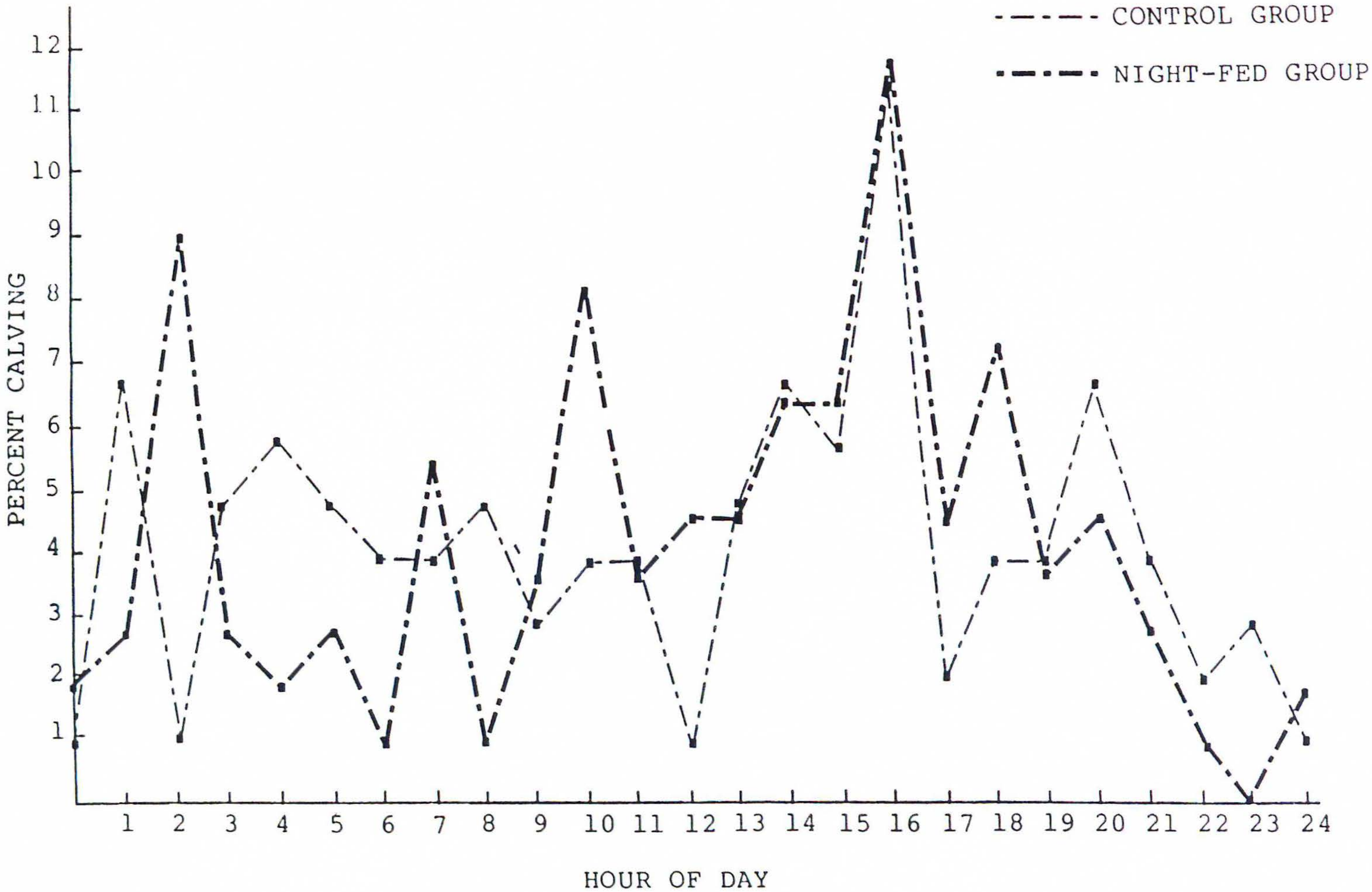

Figure III-6. The distribution of calvings by hour of day during the 1985 spring-calving season (night-fed and control cows).

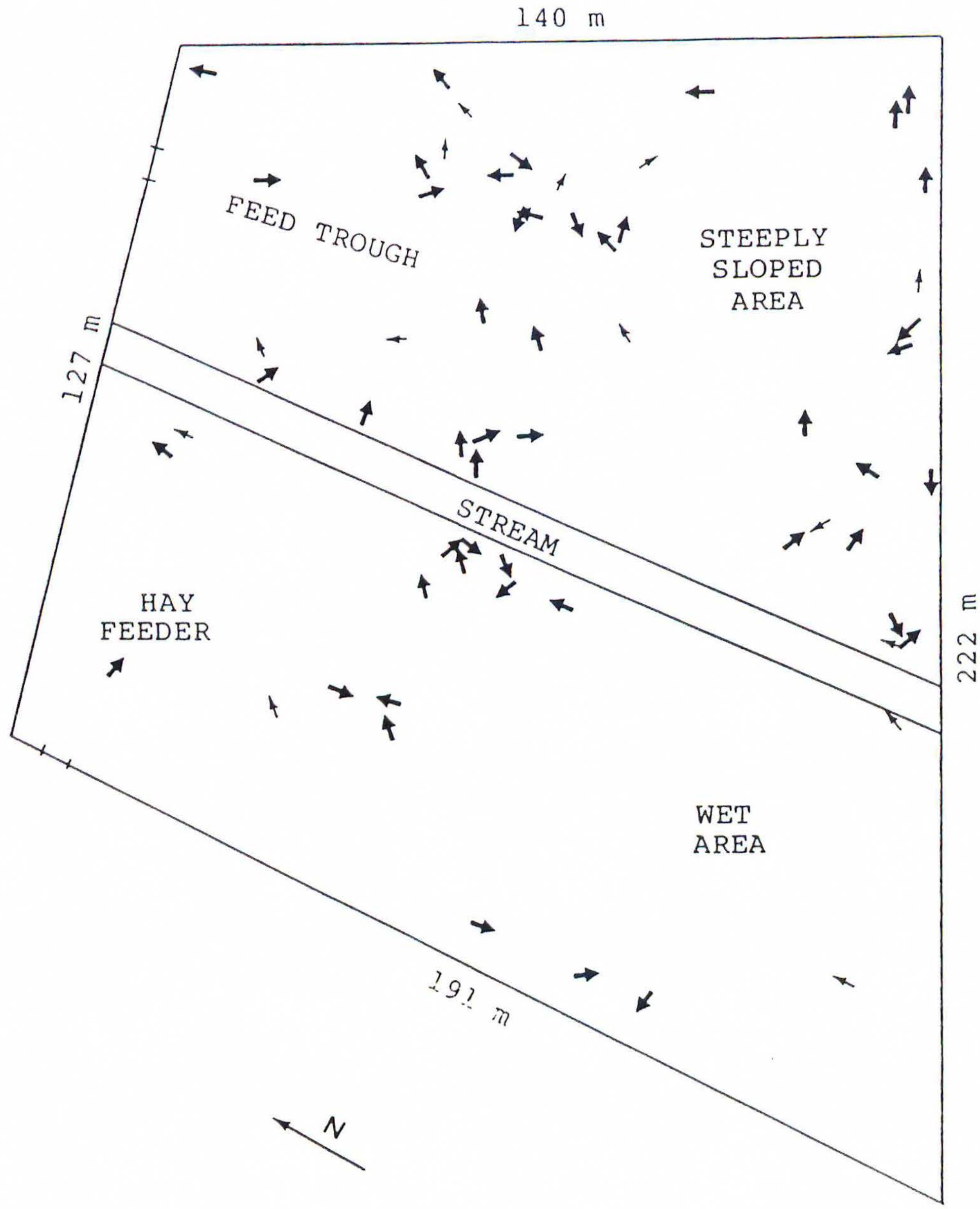

Figure III-7. Location of calving sites of control cows, indicated by large arrows (➔), and heifers, indicated by small arrows (→), recorded during the 1985 calving season.

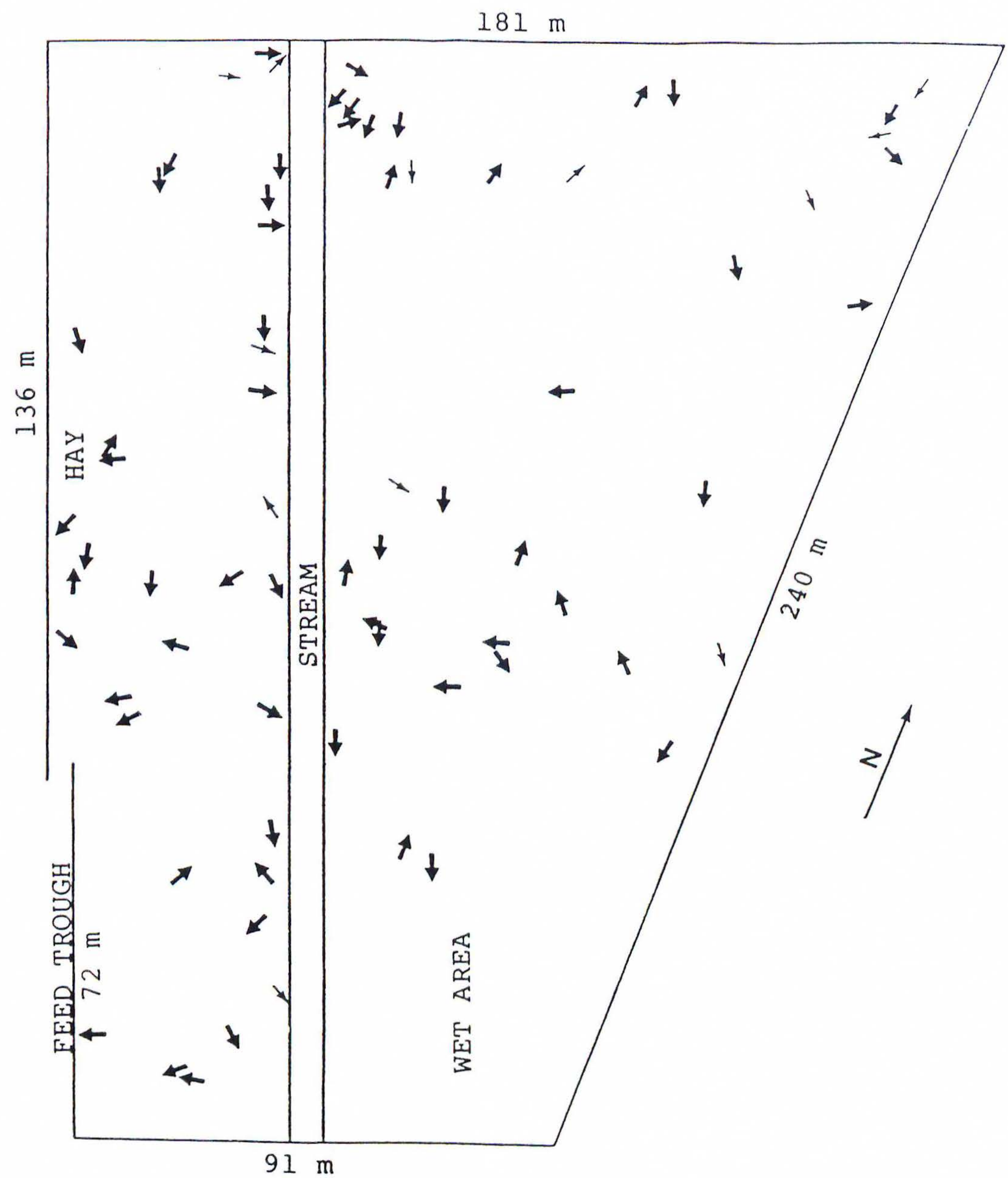

Figure III-8. Location of calving sites of night-fed cows, indicated by large arrows (➜), and heifers, indicated by small arrows (→), recorded during the 1985 calving season.

of feeding times on time of calving. Treatment was not significant in any analysis, and the number of days on trial did not influence the frequency of daylight calvings. Thus, the null hypothesis of this study could not be rejected. On this basis, it was concluded that night feeding of corn silage and hay did not significantly increase the frequency of day-time calvings.

The significant influences of cow chute score (table III-2) indicates that general temperament may influence or at least be related to calving activity. In addition to cow temperament, calf vigor when included in the analysis of variance for time of parturition subsequent to sunrise was significant ($P<.10$)

Mean intervals from sunrise to parturition for cows with calves that received vigor scores of 1, 2 and 3 were 16.2, 11.4 and 10.0 h, respectively. These data are evidence that calves born during the day are more vigorous, and calves born during the night tended to be weaker. It is possible that calves born at night received less grooming and had more difficult suckling which could have resulted in their being less vigorous.

Chute score was significant ($P<.05$) in the analysis of variance test (table III-2) when the dependent variable was day-time vs night-time calvings (based on time of sunrise and sunset). The tendency was for cows that were more aggressive in the chute to calve during the day. For chute scores 1, 2, 3 and 4, the mean times from sunrise to parturition (the number of cows in parenthesis) were 12.6 (67), 11.1 (94), 9.0 (29) and 11.7 h (5), respectively. The number of cows in the most aggressive category (score of 4) tended to also calve at night, but the number of observations was small.

Cows with a higher percentage of Angus breeding tended to score higher in chute score. Chute score and percent Angus breeding were significantly correlated ($P<.05$ and $r=.16$). Similarly, a negative relationship existed between cow age and chute score indicating that older cows were less aggressive when restrained than were younger cows. If tractability is in fact related to daylight calving, this may indicate that domestication (increased tractability) has resulted in artificial selection for increased night-time calving. Further investigation is warranted to determine if there is a physiological, but genetically based, effect that influences time of parturition of cows differing in tractability.

The significant influence of breed of dam on time of parturition (based on 0600 to 1800 h coded as daylight) determined in this study agrees with an investigation by Yarney et al. (1979). Their results indicated that breed influence was one source of variation affecting time of parturition in beef cattle.

When births were classified according to the four 6-h periods of day, year differences were determined to be significant which is probably due to the manner in which parturition data were recorded. While cows were observed continuously in 1985, the observations in 1986 were intermittent between sunset and sunrise, and the time of unobserved parturitions were estimated. Estimates were biased in that some hours were selected by the herdsman in greater frequency over other hours. These data indicate that estimating time of birth is not a reliable method of establishing time of birth.

In addition to the variables investigated in the current study, meteorological factors have been reported to affect time of calving. Dvorak (1978) reported that a decline in the 1900-h reading of barometric pressure between day 3 and day 1 pre-partum, followed by a rise in pressure was the pattern that preceded onset of labor. It was suggested that changing pressure may have stressed the cows and stimulated corticoid secretion to a level that triggered the initiation of parturition.

Sommer (1965), as reported by Dvorak (1978), determined that the greatest proportion of calvings occurred after the passage of fronts. Pennington and Albright (1985) noted that low temperature on the day of calving significantly ($P<.10$) affected calving. In a study unrelated to parturition, Malechek and Smith (1976) found that the mean daily temperature and change in barometric pressure significantly affected the grazing behavior of range cows during winter. These results suggest that weather may influence the general activity levels of cows which may in turn influence the initiation of labor.

More calves at Sykesville tended to be born during the day, and this trend was also reported by previous researchers (Pennnigton and Albright, 1985) regardless of feeding time. Brackelsberg (1985) observed a low frequency of parturition in cows between 1200 and 1600 h which he speculated was the result of morning feeding (0800 to 1200 h), but results from the current study do not support this observation. The frequency of parturitions of the control group, although variable, remained high between 1000 and 1600 h. Reduced incidence of parturitions immediately following feeding tended to occur in the treated group, but a similar trend at this time of night also occurred in the control group between 2100 and 0100 h.

Continuous observation during the 1985 calving season (figures III-5 and III-6) further indicated a tendency for the cows to give birth less frequently between approximately 1600 and 2400 h irrespective of treatments. This trend was consistent with Pennington and Albright (1985) who observed a lower incidence of calvings between 2000 and 0200 h in both the control and the night-fed groups. Results from this study did not agree with Brackelsberg (1985) who speculated that the decline in the number of parturitions between 2300 to 0300 h was the result of low "biological" activity in cows during this period. Night-fed cows in the present study were fed at 2100 h, and their eating activity persisted until 2400 h (Chapter IV). The peak period (1600 to 1700 h) of parturitions for the night-fed group correspo-nded to the period when corn silage was not available in the feed bunks and access to hay was restricted.

Cows were observed to generally seek isolation from the herd prior to parturition. Kiley-Worthington and Plain (1983) suggested that purposeful separation from the herd was rare among cows. They speculated that isolation was rather the result of pre-parturient cows not being able to synchronize their activity with the rest of the herd, resulting in their being left behind as the herd grazed and moved on. In the present study, cows tended to avoid wet areas, steeply sloped areas and perimeter fencing adjacent to the public road as sites of calving. When these locati-ons were excluded, cows generally did not show strong preferences for specific calving sites. However, heifers tended to select areas closer to the perimeter fencing and stream as their calving sites. During the 1985 spring-calving season, two calves from primiparous dams had to be rescued from drowning as the result of their dam calving on the edge of the stream. One newborn calf from a heifer dam was found dead in the stream presumably from drowning. The heifer had positioned herself on a sand bar below the stream bank and calved between 0300 and 0400 h.

The major conclusion from this experiment is that feeding cows at night does not result in a significant increase of day-time parturitions. Additionally, cows and heifers do not have the ability to safely choose calving sites and should be managed accordingly.

IV. DIURNAL ACTIVITY PATTERNS OF NIGHT-FED AND DAY-FED PERIPARTURIENT COWS

ABSTRACT

Diurnal activity patterns of periparturient beef cows were determined for a group of cows fed at 0900 h and a similar group of cows fed at 2100 h. Continuous observations and automatic recording devices were used during the 1985 spring-calving season to determine standing, lying and eating patterns of activity. The study involved 216 cows, but group size averaged 37 cows per observation (range 16 to 54 cows) because cows were added and removed from the calving paddocks based on their date of calving. Group diurnal activity patterns (percentage of cows eating hay, silage, browsing, overall eating, lying and standing) were recorded at hourly intervals over 61 consecutive days (February 13 to April 14). Hour of day effects were highly significant ($P<.01$) for all activities as expected. Treatment (time of feeding) differences were significant for time spent browsing ($P<.01$), eating hay ($P<.01$) and combined eating activity ($P<.05$). Night-fed cows were not given free choice access to hay which resulted in less total eating hay and probably led to more browsing and more total time spent eating. Hour and treatment interactions were significant ($P<.01$) for all activities, except browsing, and this relationship was expected as the cows were fed at different

times of the day. Date (linear and quadratic) tended to be significant probably because of daylength increases and changes in temperature. Major periods of eating activity of cows in the control group were associated with the period immediately following feeding (0900 h) and the time of sunset. Peak periods of eating activity in the night-fed group coincided with the times of sunrise and sunset and immediately following night feeding (2100 h). A similar trend in the resting patterns was observed between the two groups except between 2100 to 0100 and 0900 to 1200 h. This study indicated that a major shift in the diurnal patterns of late gestating cows could be accomplished by changing the daily feeding schedule of cows and feeding the cows at night.

Introduction

Knowledge of normal activity patterns of cattle could lead to the design of management systems that control animal activity or exploit natural behavioral patterns. An example would be controlling time of calving by altering time of feeding, which in practice does not appear to be effective, but there may be other behaviors that could be exploited.

The periodicity of grazing activity associated with natural events such as the times of sunrise and sunset has been well established (Hancock 1953, Stricklin et al., 1976). Similarly, a peak in eating activity among drylot and feedlot cattle has been observed when fresh feed is first made available (Bond et al., 1978). However, diurnal activity patterns among gestating cows during the final weeks prior to parturition has not been investigated. Reports of night-time feeding as related to time of calving have been published, but these studies have not included reports of the activity patterns of the cows. Vibracorders have been used to monitor grazing activity of sheep (Stobbs, 1970) and cows on pasture and cows eating silage (Stricklin et al., 1976). Diurnal patterns of eating activity of cows prior to and at the time of calving have not been assessed using recording devices such as vibracorders. An understanding of individual cow activity patterns, as well as group feeding behavior patterns, should be helpful in explaining factors associated with the onset of parturition.

The objective of this study was to quantify the diurnal patterns of individual cows and groups of cows in late gestation. Behaviors of primary interest were eating and resting activity recorded on groups by direct observation and general movement activity of individual cows recorded by vibracorder devices.

Materials and Methods

The management of beef cows and feeding treatments at the Sykesville Research Farm during the 1985 spring-calving season was described in Chapter III. During the spring of 1985, activity of cows in both the night-fed and the control feeding groups was observed and recorded for 61 consecutive days, at hourly intervals from February 13 until April 14, 1985, except during periods when an observer was recording the post-partum behavior of cow-calf pairs or when a cow had to be assisted because of calving difficulty. During each observation period, the number of cows browsing, eating silage, eating hay, standing and lying was recorded. The term browsing, rather than grazing was used in this study because essentially no pasture-forages were available in either of the two observation paddocks during the study.

To supplement direct observations, 40 cows were selected randomly from the control and the night-fed groups, and "head-down" activity was measured by an automatic motion monitoring device (vibracorder) mounted on each cow. The vibracorders were reset weekly until the cow calved, after which the recorder was mounted on another cow. The selection of cows was made from those that were predicted to calve within the subsequent week based on insemination dates and rectal palpations taken at approximately 100 d.

The vibracorder, when mounted on a cow, transmitted movement via a stylus attached to a freely oscillating pendulum to a waxed chart which rotated once every 24 h thus providing up to 8 d of head-down movement information. This device was mounted on a zinc "neckband" similar to an inverted U in shape (Schmitdman and Valla, 1982). The edges and the inner surface of the zinc neckband were cushioned by a layer of rubber to reduce abrasions. The vibracorder was protected by an outer rubber cover and the neck assembly secured on a cow via adjustable canvas belting at the base of the neck.

By properly positioning the vibracorder, it was possible to determine movement by the cow especially movement when the cow's head was down and moving which was primarily the time spent browsing or eating. With the aid of visual records of time of parturition, changes in the diurnal activity pattern of cows prior to and after parturition could be studied. Since hourly recordings included all cows in each observation field, matching these data to the vibracorder charts provided information on individual variation in diurnal patterns of periparturient cows.

Statistical analysis. Hourly data were analyzed using an analysis of variance procedure (SAS, 1985) to determine the significance of diurnal patterns (interaction between hour of day and treatment). The percentage of the total number of animals lying, standing, eating silage, hay, browsing and overall eating (hay, silage and browsing) was analyzed for treatment effects (T), hourly interval (H), date (D), two-way and three-way interactions of these effects and date quadratic. Date was treated as a continuous variable and calculated in number of days from January 1 to the day the group diurnal activities were recorded.

Results

The effect of treatment, hour of day and other variables on diurnal activities of periparturient cows are presented in table IV-1. Differences between time of day were highly significant (P<.01) in all activities. Treatment differences were observed in browsing (P<.01), eating hay (P<.01) and combined eating activity (P<.05) but not in other group activities. Effects of date (linear) were significant (P<.01) for standing, browsing eating hay and combined eating activity. Similarly two-way and three-way interactions and date as a quadratic effect tended to be significant.

The mean proportion of cows recorded as browsing (table IV-2) was greater for night-fed vs control cows; 10.5 and 7.7, respectively. Night-fed cows were allowed access to hay only during the 2100 to 0900-h period of each day. The day-fed cows had free choice access to hay 24 h/d, and this probably resulted in the greater browsing and thus greater overall time spent in eating type activities (table IV-2).

In figure IV-1 is presented the distribution of lying activity of the two groups of cows plotted by hour of day. Lying activity of the night-fed group increased sharply after sunset and decreased sharply when the cows were fed at 2100 h. Lying activity for the control group increased sharply after sunset and remained high until a sharp decrease occurred at sunrise (approximately 1900 to 0500 h),

TABLE IV-1. MEAN SQUARES FOR DIURNAL ACTIVITIES OF BEEF COWS.

Item	df	Lying	Standing	Eating			
				Browsing	Hay	Silage	Combined
Treatment (T)	1	434.7	806.9	3181.4**	1093.2**	671.6	2426.0*
Hour of day (H)	23	7008.6**	1735.8**	604.5**	434.3**	3982.6**	4140.7**
Date (D; linear)	1	65.0	8702.0**	3564.9**	1068.4**	80.2	10271.0**
T X H	23	1244.1**	1099.2**	310.7	679.5**	2390.5**	2925.0**
T X D	1	120.6	843.3	2156.3**	832.6**	503.5	1601.6*
H X D	23	4549.8**	939.6**	845.4**	436.7**	2818.4**	3089.0**
D X D (quadratic)	1	176.4	9485.0**	5928.9**	689.6**	55.0	12248.7**
D X T X H	23	507.0	749.9**	263.4	441.3**	1126.2*	1087.8**
Remainder	1866	470.5	408.7	209.1	98.0	298.4	410.8

*P<.05.
**P<.01.

TABLE IV-2. MEAN (±SE) PROPORTION OF COWS ENGAGED IN BEHAVIORAL ACTIVITIES BY FEEDING TREATMENT.

Item	Control	Night-fed	Significance
Lying	41.7±1.1	38.8±1.1	NS
Standing	25.7± .8	25.2± .7	NS
Browsing	7.7± .5	10.5± .6	**
Eating hay	6.3± .4	5.4± .4	**
Eating silage	18.6± .8	20.2± .8	NS
Combined eating	32.6±1.0	36.1±1.0	*

*$P<.05$.
**$P<.01$.

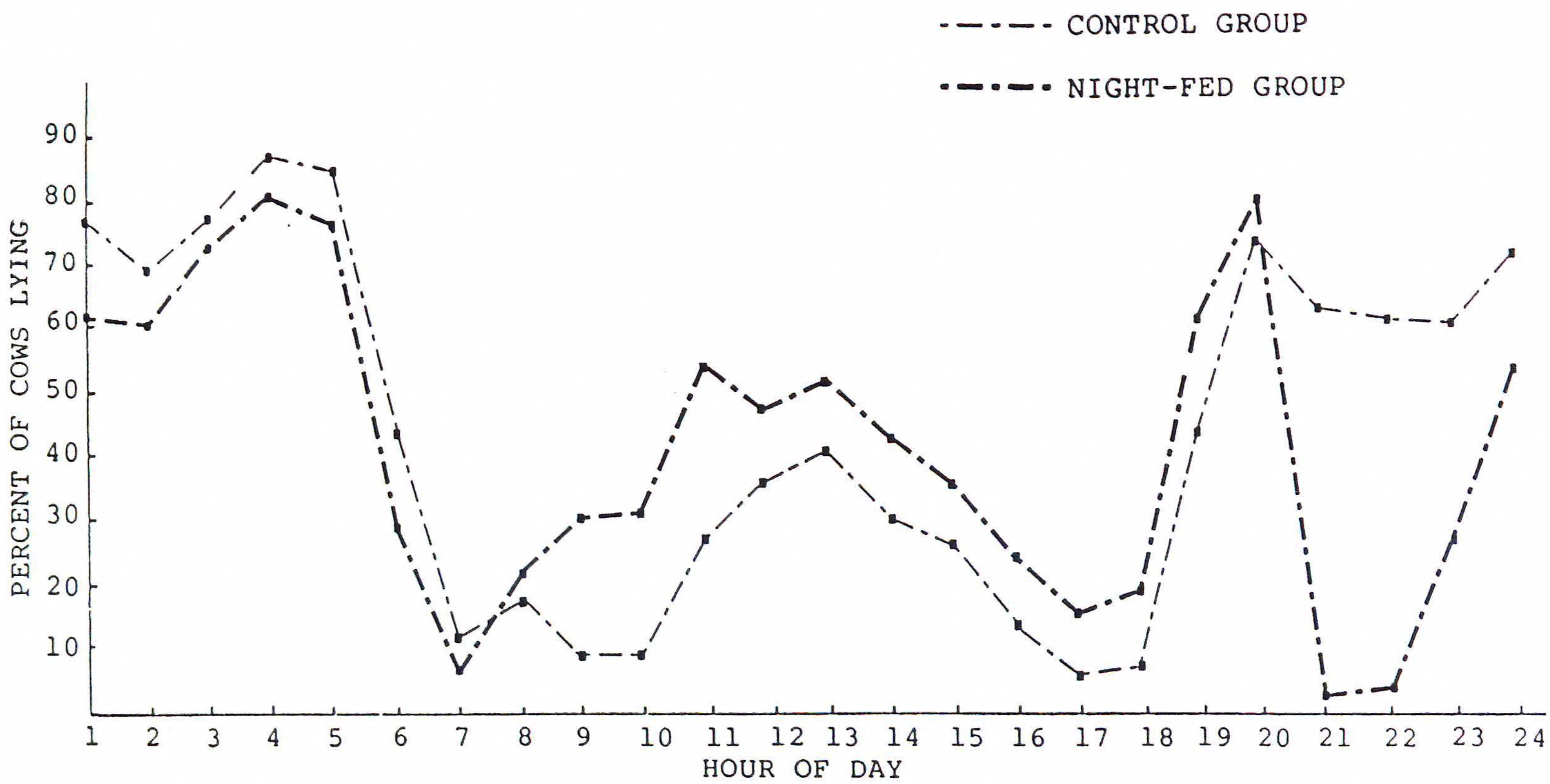

Figure IV-1. Diurnal lying activity patterns of gorups of periparturient beef cows fed at either 2100 or 0900 h.

and a small peak occurred in mid-afternoon (1300 h). Both groups exhibited similar resting patterns from 0100 to 0800 and 1800 to 2000 h. During the day (0900 to 1800 h), more cows in the night-fed group were observed lying. However, both groups exhibited a decrease in the lying activity from mid-afternoon (1300 h) to 1700 h. The greatest difference between the two groups was noted during the intervals of 2100 and 2200 h when less than 3% of the cows in the treated group were lying as opposed to more than 60% in the control group.

The percentage of cows eating hay between 0100 and 0900 h was generally similar in both groups (figure IV-2). Cows in the treated group had no access to hay between 0900 and 2100 h, and the peak period of eating hay in the treated group corresponded with the time at night when hay was first made available. In the control group, the greatest period of hay eating activity corresponded with the time of sunset. The mean percentage of night-fed cows that ate hay at 2100 h was approximately 35%, and the proportion decreased sharply until 0100 h with minor proportions of cows recorded eating silage through 0900 h.

Major periods of silage eating (figure IV-3) in the control group were observed immediately following feeding (0900 to 1000 h) and sunset (1700 h). In the night-fed group, these periods corresponded with the time of sunrise

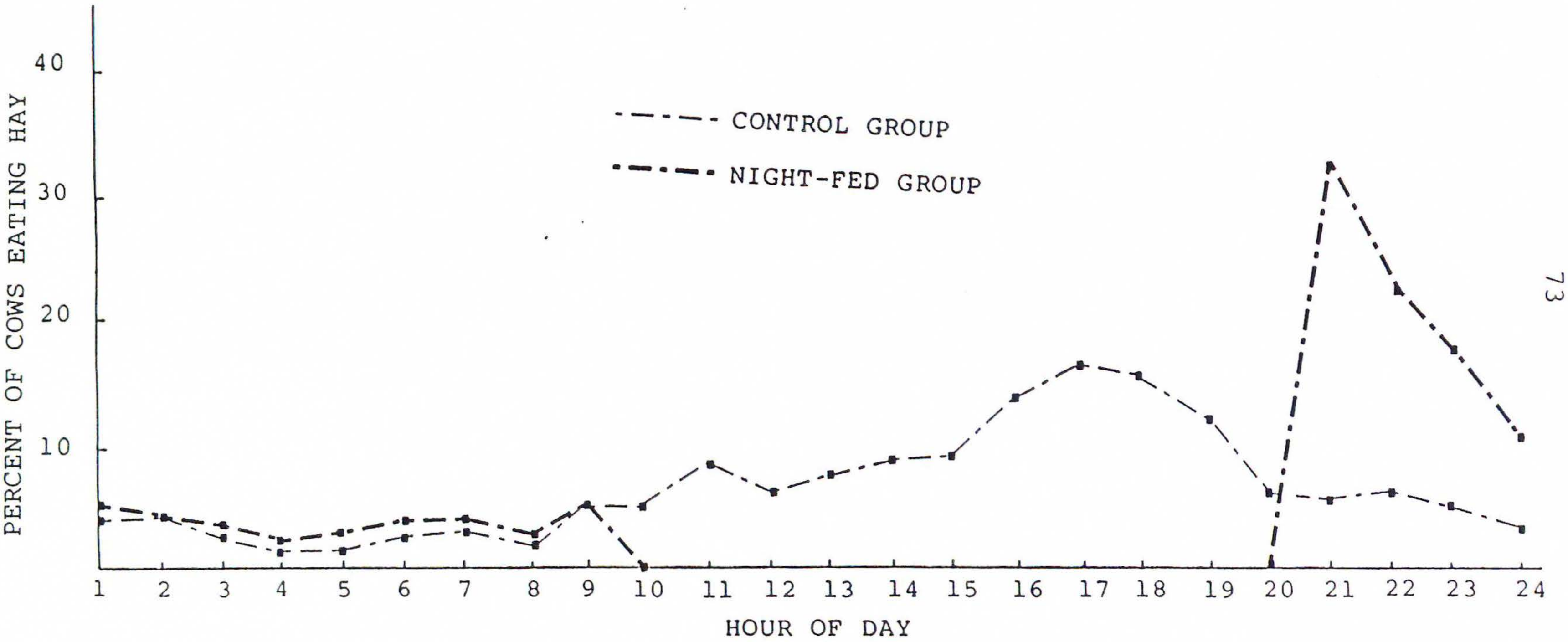

Figure IV-2. Diurnal pattern of eating (hay) of groups of periparturient beef cows fed at either 2100 or 0900 h.

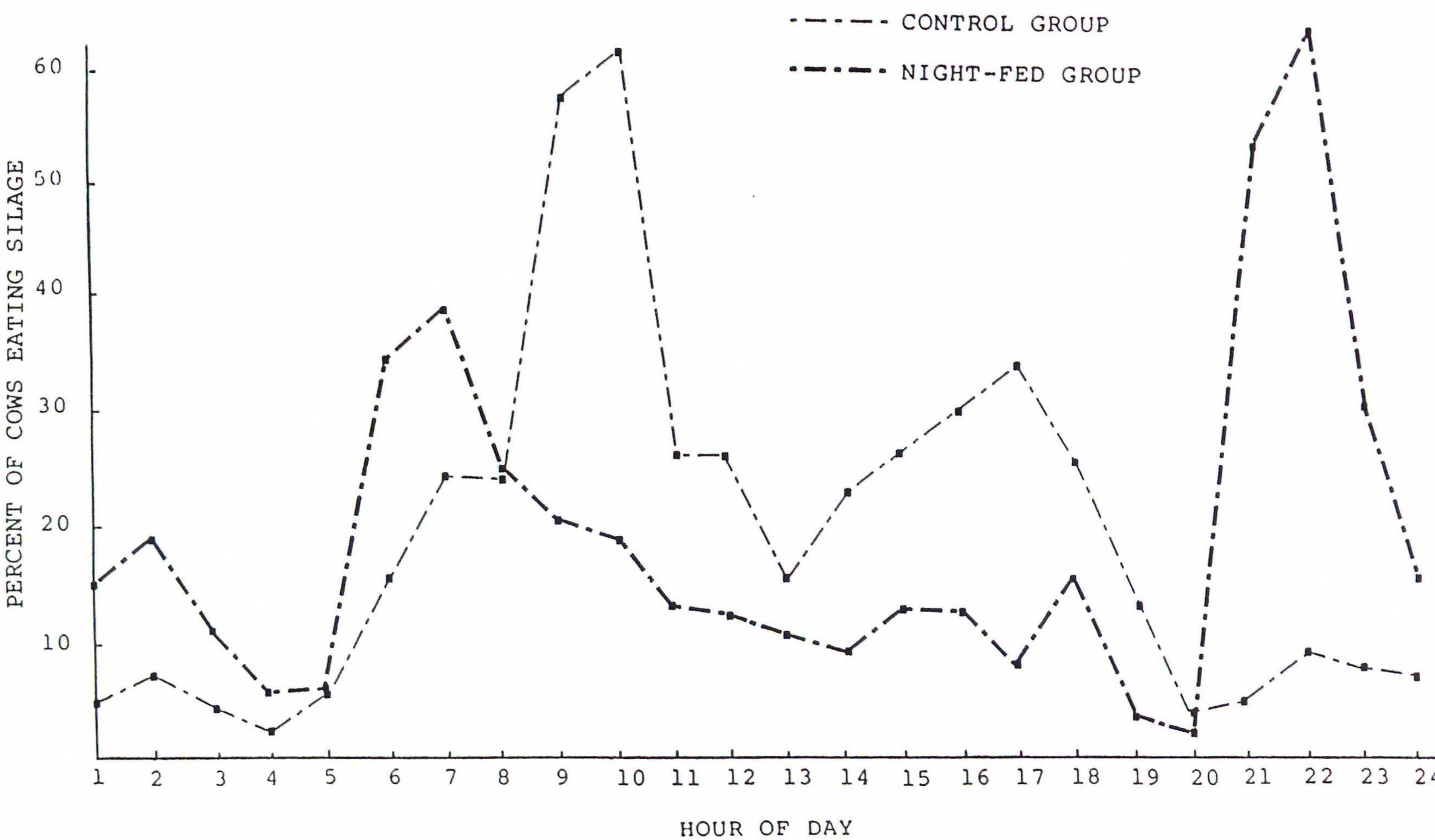

Figure IV-3. Diurnal pattern of eating (silage) of groups of periparturient beef cows fed at either 2100 or 0900 h.

silage was added (2100 to 2300 h).

The highest frequency of browsing activity (figure IV-4 in both groups was during the daylight hours, with a major spike at 1700 h (36.7%) for the night-fed group and at 1800 h (21.33%) for the control group. These peak periods coincided with the time of sunset. Overall, more cows in the treated group spent time browsing during the daylight hours. At night, less than 6% of the cows in both groups browsed during each hourly interval between 2000 to 0500 h. Slightly more cows from the control group browsed at 2200 h.

The activity of eating hay, silage and browsing was pooled to determine combined eating activity (figure IV-5). Two major spikes were observed in the control group which were associated with the time of daily feeding and sunset. Conversely, three major spikes were observed in the night-fed group coinciding with the time of sunrise, sunset and the night feeding itself. Major differences in the mean percentages of cows eating between the two groups were noted at 2100 and 2200 h intervals. After sunset, a period of rest was observed in both groups until commencement of the next feeding schedule.

Vibracorder charts (figures IV-6,7,8 and 9) indicate that considerable variation exists among individual cow activity patterns. Some cows showed strong tendencies to eat at 2100 h in the night-fed group, and others apparently ate at 2100 h on some nights and not during other nights

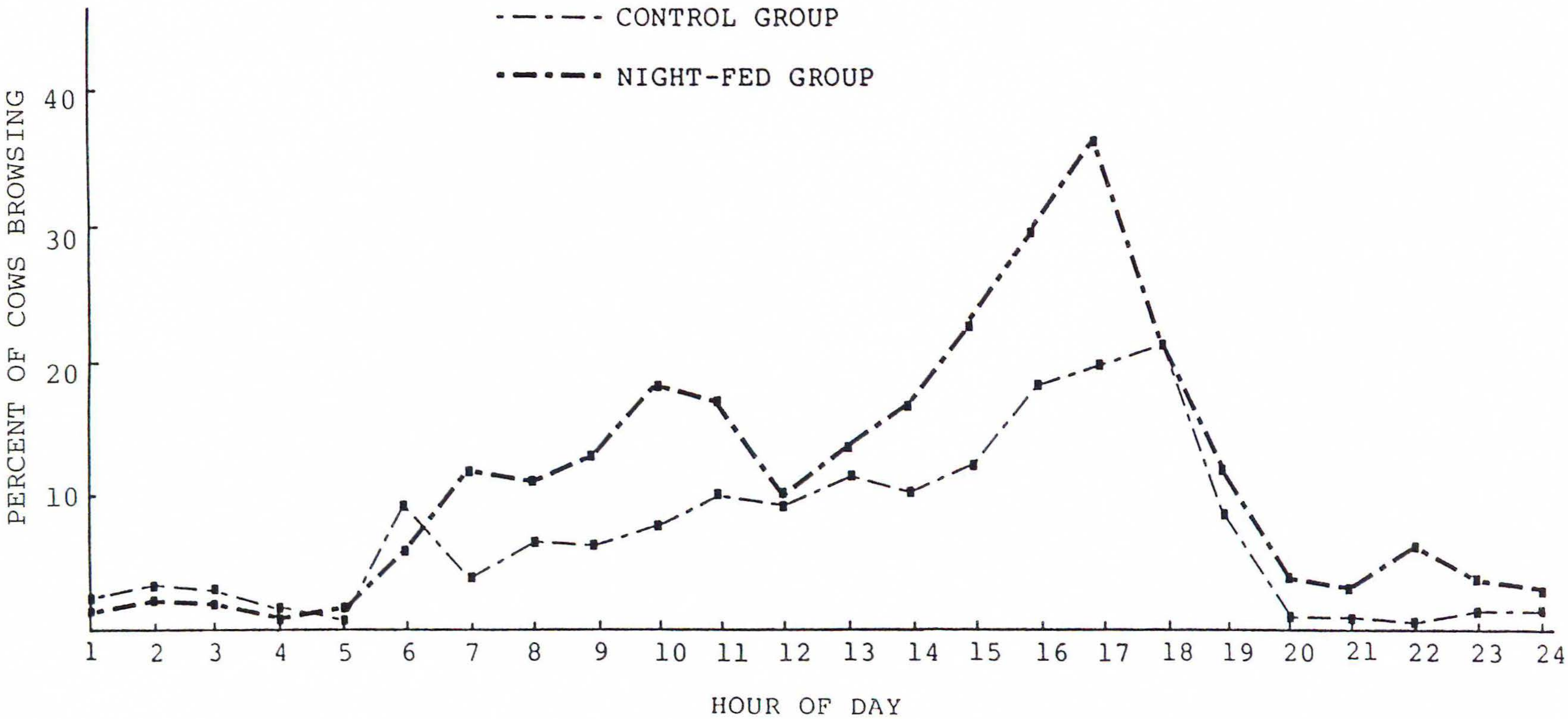

Figure IV-4. Diurnal pattern of browsing of groups of periparturient beef cows fed at either 2100 or 0900 h.

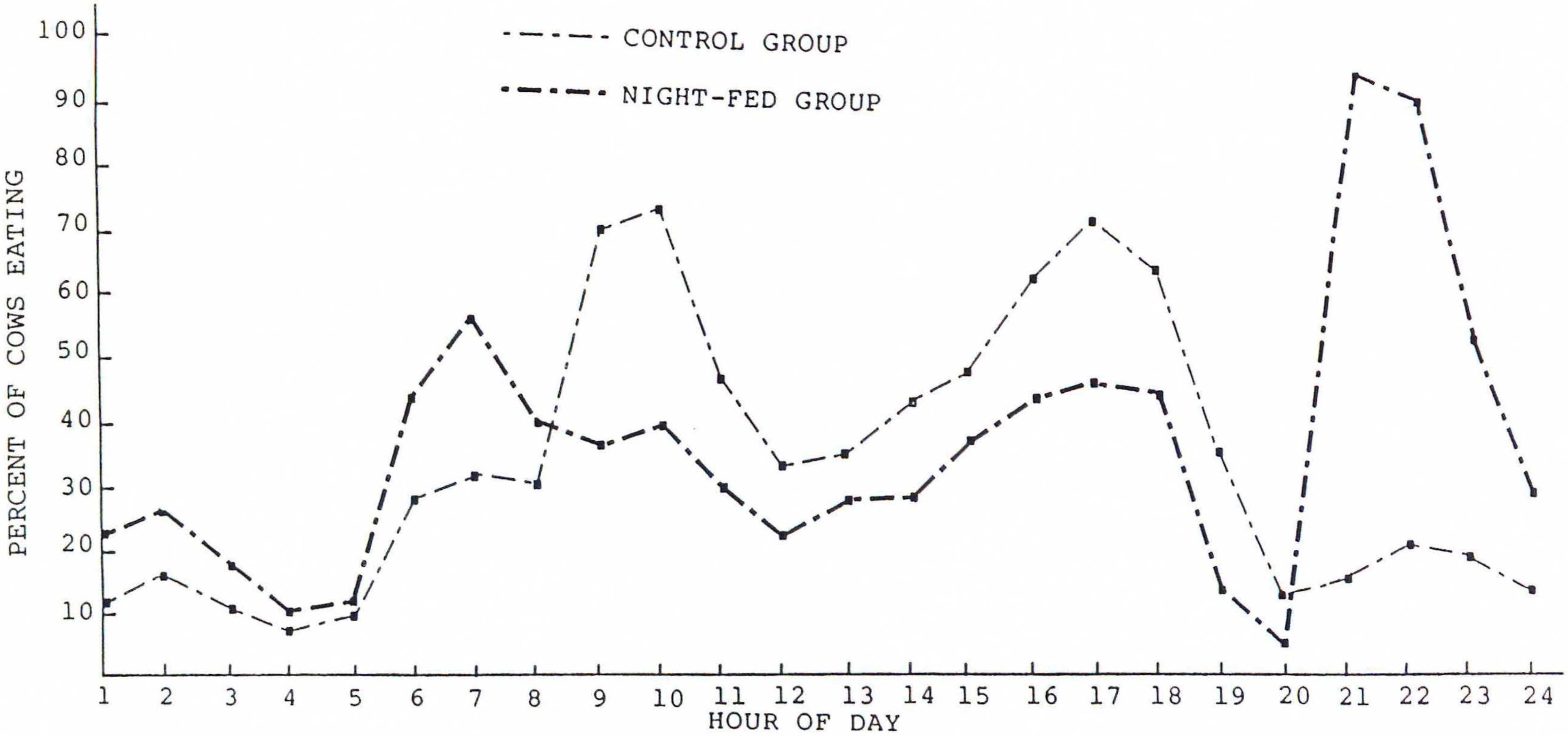

Figure IV-5. Diurnal pattern of eating (combined hay, silage and browsing) of periparturient beef cows fed at 2100 or 0900 h.

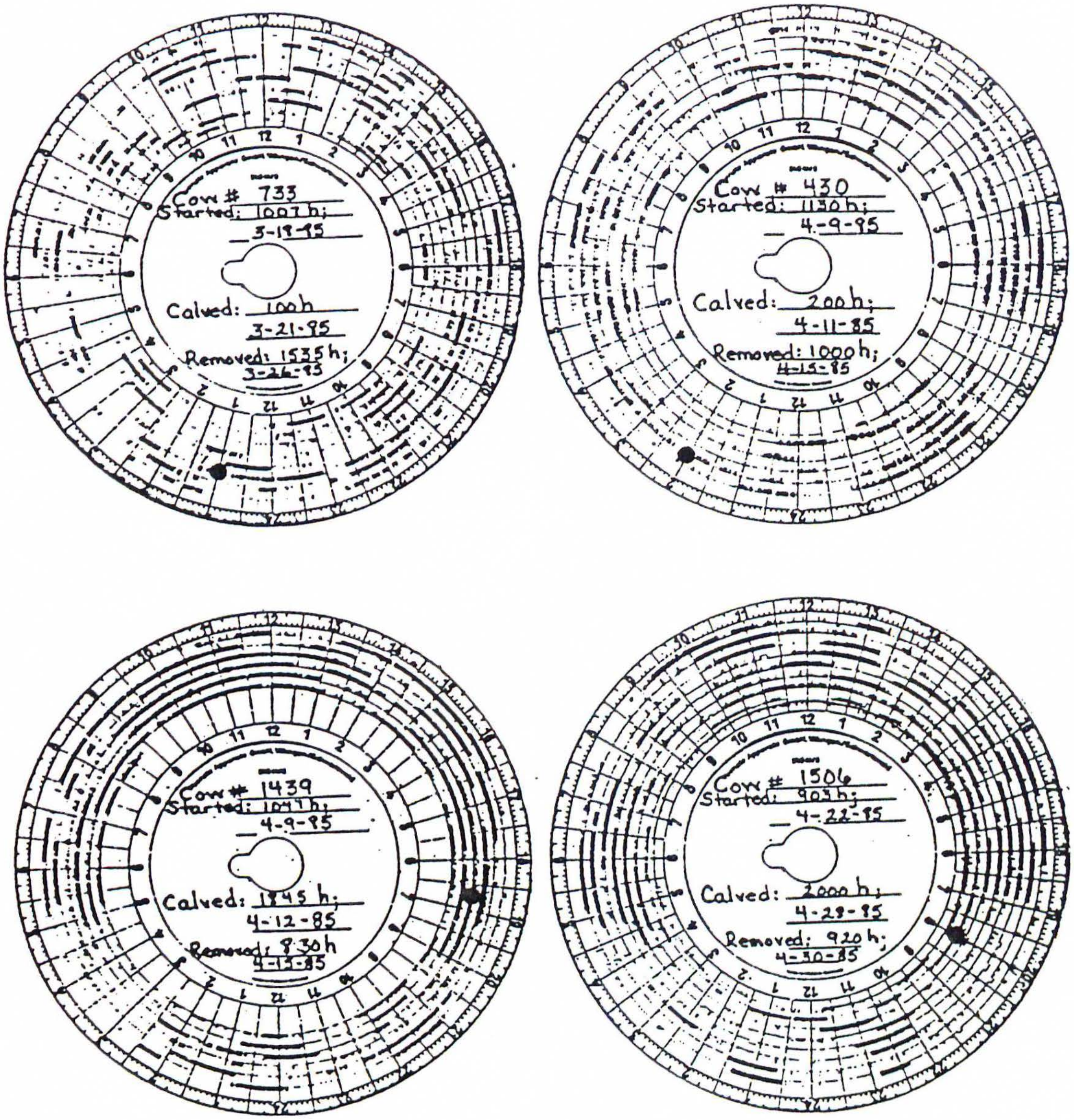

Figure IV-6. Activity charts of four beef cows that were night-fed (2100 h). These cows calved (●) during the night (1800 to 0600 h).

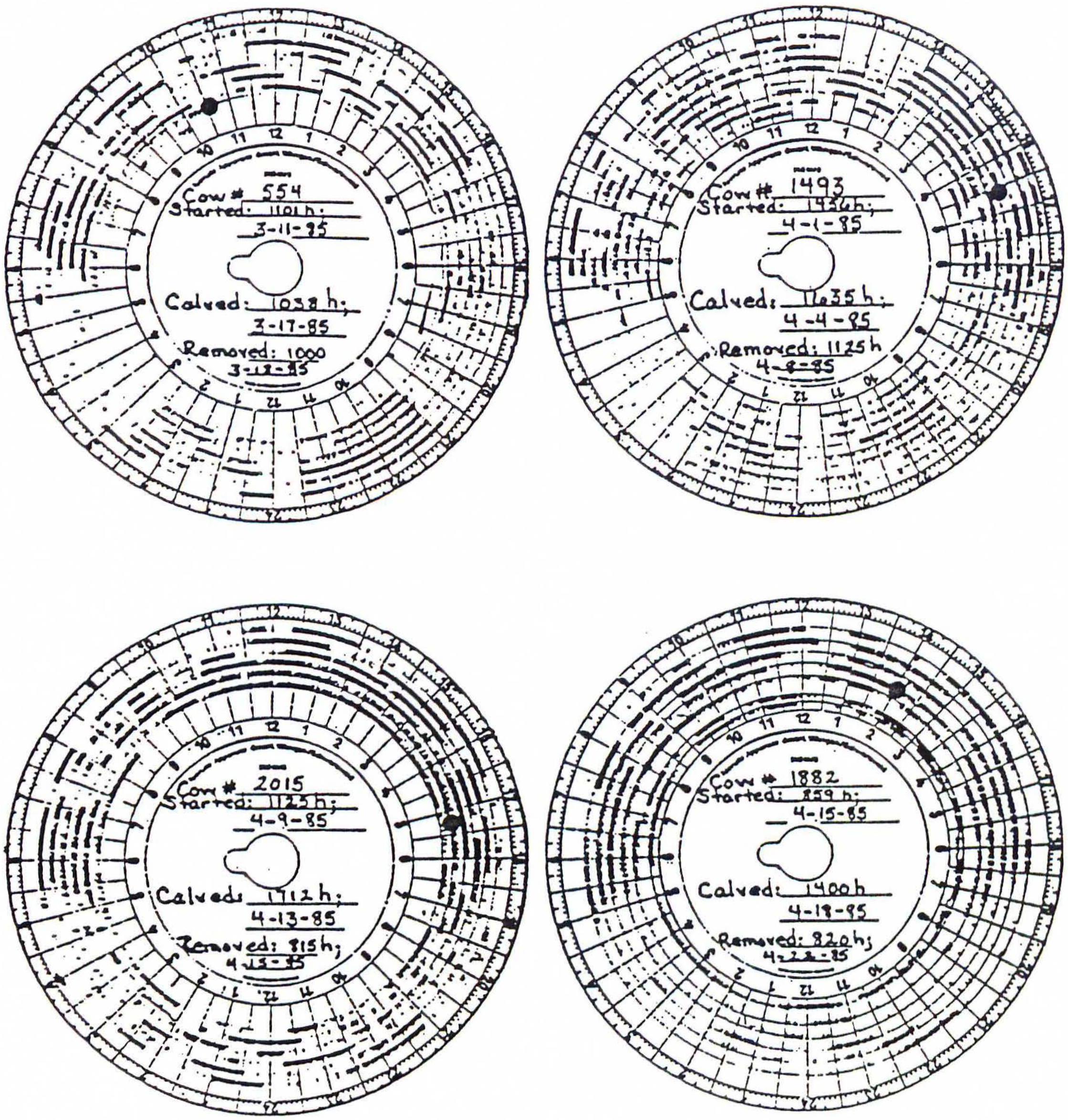

Figure IV-7. Activity charts of four beef cows that were night-fed (2100 h). These cows calved (●) during the day (0600 to 1800 h).

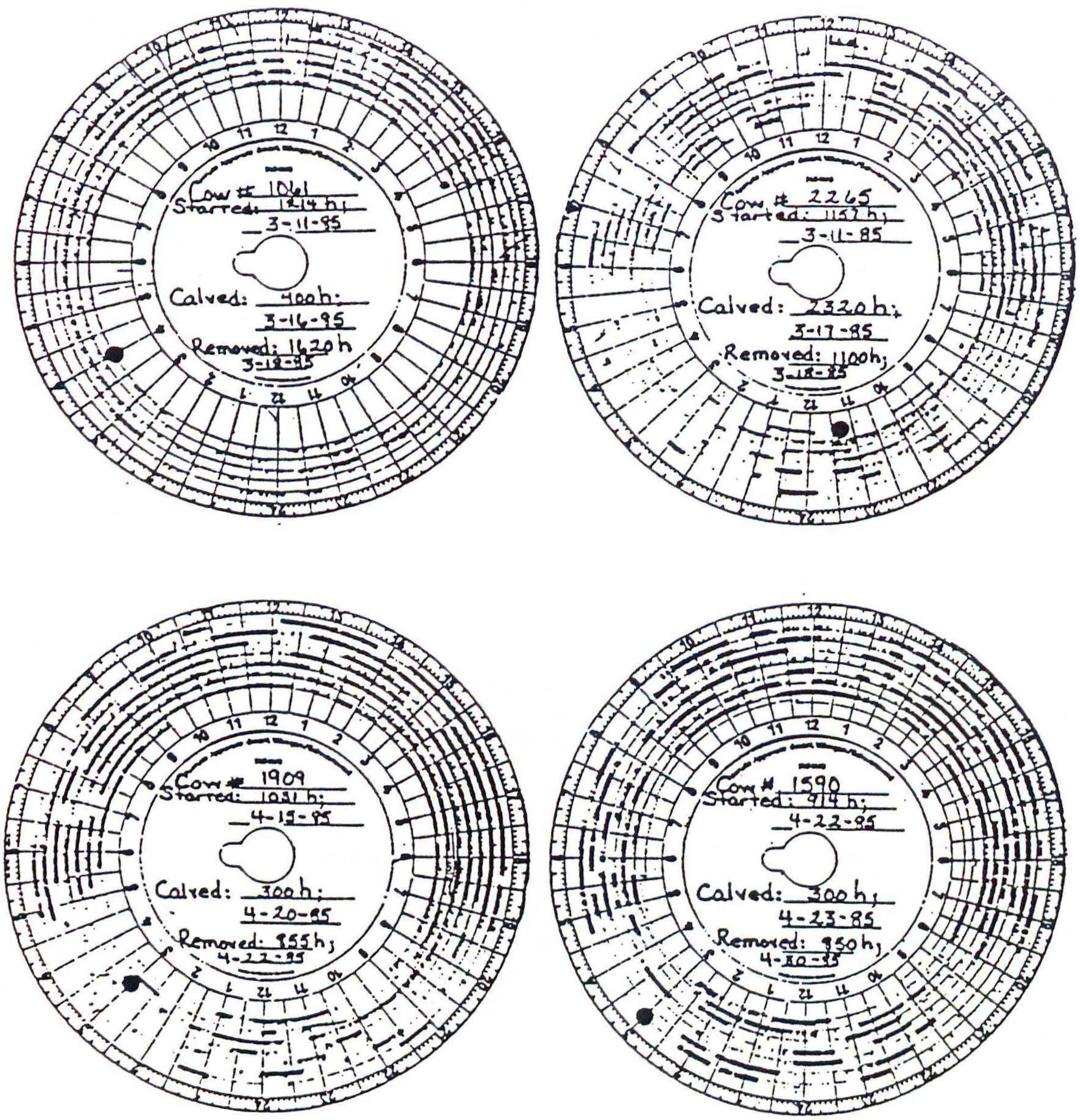

Figure IV-8. Activity charts of four beef cows that were day-fed (0900 h). These cows calved (●) during the night (1800 to 0600 h).

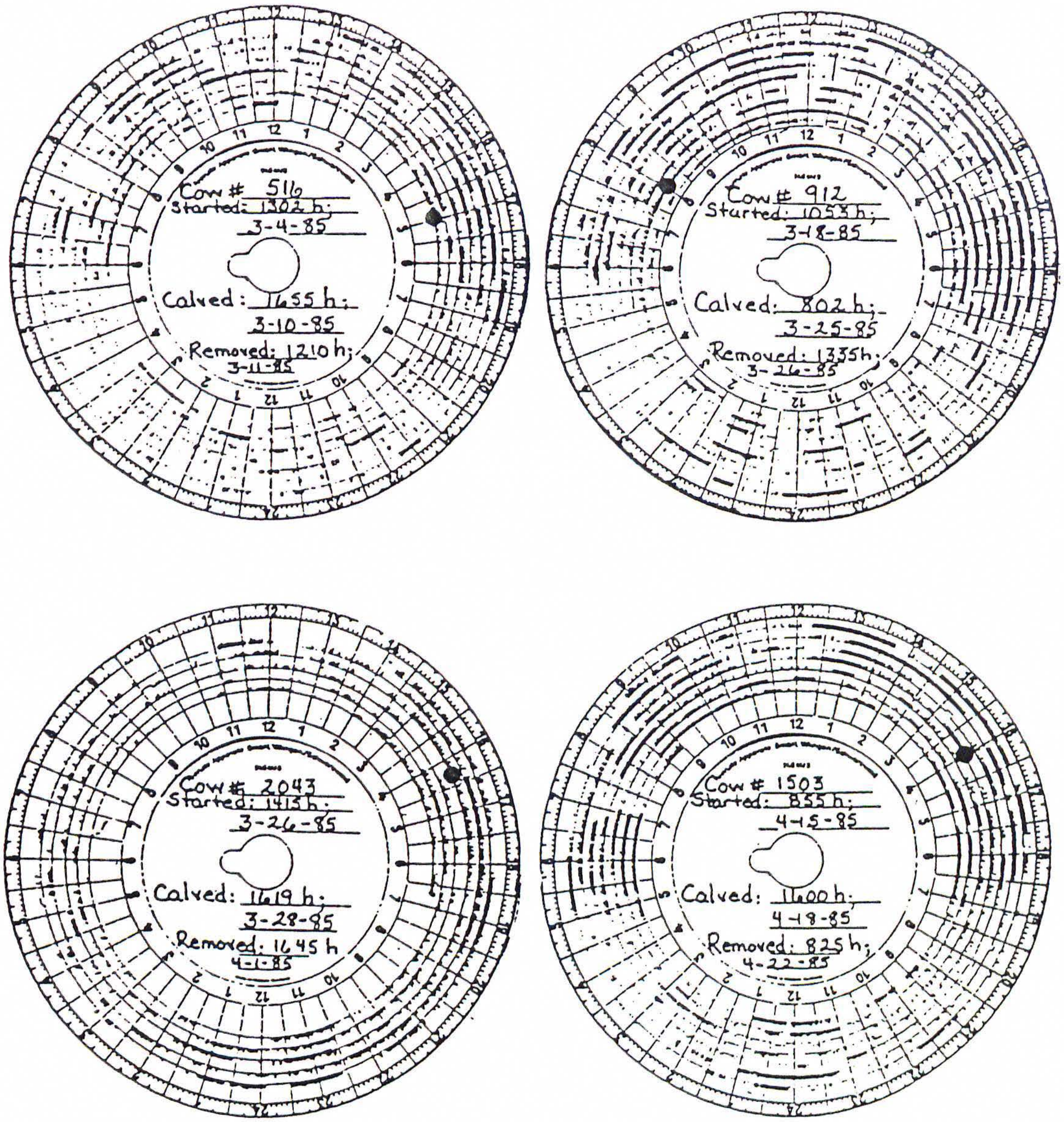

Figure IV-9. Activity charts of four beef cows that were day-fed (0900 h). These cows calved (●) during the day (0600 to 1800 h).

(figures IV-6 and 7). Some cows tended to have inactive periods prior to calving and possibly missed the "meal" or feeding period just prior to calving, and other cows apparently ate a meal shortly before calving. No obvious resting-activity patterns could be detected from the vibracorder charts in relation to calving. The grooming activity by the cow could be detected on the majority of the charts.

Discussion

The overall pattern of eating activity observed in this study followed similar trends as those reviewed in the literature (Hafez and Bouissou, 1975; and Gonyou and Stricklin, 1984) which corresponded with the periods of sunrise and sunset. Similarly, intensive eating periods were also related to the time of feeding. This observation was in agreement with Bond et al. (1978).

Data from this study indicated that a shift in the feeding schedule altered the eating patterns of late gestating cows. A major shift in the eating activity was observed at 2100 and 2200 h with more than 80% of the cows in the night-fed group consuming silage and hay. Likewise, less than 15% of the cows in the control group were observed eating during these time intervals even though hay was available at all times.

Generally, the corn silage in both paddocks was consumed within approximately 10 h after being added to the feed bunks. However, the cows in the treated group still frequented the feed bunk after 0900 h to pick up what was left and sort through any overflow scattered on the ground. More cows in the treated group browsed during the day (0900 to 2100 h), probably to compensate for the lack of silage and restricted access to hay between this time interval.

Despite the differences in the time of day that the cows were fed, the resting pattern of cows during the daylight hours (figure IV-1) followed a similar pattern with periods of rest and activity occurring at about the same time for both groups. This suggests that optimal periods of eating activity are intrinsic to the animals, possibly genetically based or influenced, and highly related to the time of sunrise and sunset. If this is true, then altering the feeding patterns (time when meals are provided, meal length or time between meals) may exert some deviation from normal (or established) biological rhythm especially during the periparturition period.

Cows tended to cease their eating activity following sunset. This was indicated by the decline in the mean percentage of group eating activity and a sharp increase in the number of animals resting (lying) up to the time when feed was again made available. The pattern of this activity tends to agree with Stricklin et al. (1976) who observed that grazing cows usually rest for 2 h or more after each grazing activity. In this study most of the browsing activity occurred during the period around sunset. The sound of the tractor bringing silage to the night-fed group did not result in an increase of the percentage of animals eating or appreciable decrease in the number of animals lying in the control group at 2100 h.

The effect of date of data collection were significant in all eating activities except in group silage eating activity. This was expected because corn silage was consistently placed in the feed bunks for the two treatment groups at their designated feeding schedules. However, other eating activities could be influenced by the time of sunrise and sunset and the progressive increase in daylight hours as the observations continued into April.

In summary, data from this study confirm previous findings that eating activity of cows are highly associated with the times of sunrise, sunset and the period immediately following feeding.

V. POSTPARTUM BEHAVIOR OF BEEF COWS AND CALVES

ABSTRACT

Postpartum behavior of 134 cow-calf pairs (with Angus (A) and Hereford (H) as breed of sire and A, AH, H, and HA as the maternal breed-classes) were recorded during the 1985 spring-calving season. Each cow-calf pair was observed continuously for 1 to 8 h postpartum. Maternal traits included were the onset and total time spent standing, grooming and eating. Neonatal behavioral traits recorded were the time to onset of standing, mobility, teat seeking and suckling and total time spent in each of these activities. Postpartum data (99 cows with 8-h observation periods) were pooled by hour into eight 1-h periods by behavioral activity and analyzed to determine the effects of time (hour) postpartum, breed of sire and dam, parity and sex of calf. Differences between each hour were significant ($P<.01$) for all behavioral traits. With the exception of lying and eating, all cow activities decreased with increasing hours postpartum. Movement related activities of the calf tended to peak during the second hour of the calf's life. Breed of sire of the calf significantly affected grooming ($P<.10$). Maternal breed-class affected standing time of the dam ($P<.01$), grooming ($P<.10$) and time to onset of teat-seeking ($P<.10$). Sex of calf influenced ($P<.10$) maternal behavior

(grooming) and the calf's behavior (mobility). Parity significantly influenced lying ($P<.10$) and mobility of the calf ($P<.05$). When purebred calves were compared to crossbreds, Angus tended to be more active and Herefords were less active. Crossbred calves tended to be intermediate in activity. Data from this study indicate that there are significant differences in maternal and neonatal behaviors of beef cattle that are due to breed, parity and the sex of the calf.

Introduction

The study of animal behavior as a means of designing more efficient production systems has recently received some research attention in animal science. The maternal behavior of beef cows and its relationship to early calf behavior has been researched in beef cattle, but the effect of crossbreeding on early behavior has not been thoroughly investigated. However, results from such a study could be beneficial to the beef industry because this information would complement current knowledge on animal breeding.

An understanding of neonatal and maternal behaviors during the initial hours of the calf's life could help explain the development of heterosis observed in crossbred calves. The superiority of a crossbred calf's slightly greater growth and performance could result from early vigorous behavior of the calf that results in earlier time to first suckle, which in turn could be due to crossbred calves being more alert and active during the first hours of life eliciting more attention by the dam.

In this study, specific postpartum behaviors of cows and their calves during the first 8 h postpartum were quantified. Total time engaged in different activities and time interval between parturition and onset of cow and calf behaviors were determined.

Material and Methods

A series of data sets were collected at the Sykesville Beef Research Station during the 1985 spring-calving season. One data set was collected to investigate the postparturient behavior of beef cows and calves. Details of the experimental procedures have been discussed in chapter III.

Postparturient behavior of 134 cow-calf pairs were observed continuously for up to 8 h after parturition. Data were recorded using prepared scoring sheets. Each score sheet (Appendix table A-5) contained 1 h of cow-calf behavioral activity recorded to the nearest minute. The duration of each cow-calf observation was dependent on the weather condition and the number of cow-calf pairs being recorded at a given time. An observation was discontinued when the visibility at night was poor due to heavy rain or fogginess or when multiple recordings were being made and the distance of a cow-calf pair from the observer became too great to adequately observe all activities of both pairs.

Behavioral traits associated with the dams were the time interval from parturition to first standing and grooming (licking) of the calf, degree of initial grooming (Appendix table A-6), the onset and termination of each standing, lying, grooming and eating bouts categorized into browsing, eating hay and silage.

Behavioral traits associated with the calf were the time intervals from parturition to the time of initial attempt to stand up, successfully standing for the first time for a period exceeding 1 min or more, initial mobility, teat seeking and suckling. The beginning and ending of each standing, lying, mobility, teat seeking and suckling bout were also noted for each calf. Two activities of a cow or calf were recorded concurrently if they occurred at the same time.

The onset and duration of the various behavioral activities were recorded to the nearest minute. The cow was recorded either as standing or lying. Thus the standing activity of a cow, but not of a calf, was inclusive of the time when the animal was ambulating-moving.

The behavioral terms used in this trial were defined as follows:

1. initial attempt to stand. A calf attempting to stand, characterized by hind legs thrust forward and

upward with some parts of the calf's body raised from the ground.

2. successful standing. When a calf first stood for 1 min or more.
3. initial mobility. When a calf moved approximately 1 m away from its original standing position.
4. mobility. When a calf performed a motor activity such as walking, running or jumping for a duration exceeding 1 min and more.
5. teat seeking. When a calf exhibited a tendency to search for the teats prior to first suckle.
6. suckling. A calf drawing the teats of its dam into its mouth and by action of the lips and the tongue.
7. grooming. The cleaning of the calf's body surface by its dam through licking.

Statistical Analysis. The postpartum activity data of a cow and her calf were summarized into eight 1-h periods after parturition. The first period corresponded with the total time spent on each activity during the first hour of observation. Subsequent periods represented hourly activities of the same cow-calf pair thereafter.

Postpartum data were analyzed using the analysis of variance procedure (SAS, 1985) for differences due to period (hour), breed of sire and dam, parity (primiparous or multiparous dam) and sex of calf effects. Subsequently, breed of sire and dam breed-classes were reclassified according to the breed of calf (purebred Angus, purebred Hereford and crossbred calves), and the same analyses were performed.

Correlation coefficients, least-square means and standard errors for these variables were calculated.

Results

Means and standard errors of traits associated with postpartum behavior of the cows and calves and the average length of the respective behavioral bouts of the cows and calves are given in tables V-1 and V-2, respectively. Cows stood up almost immediately and started licking their calves following parturition. Cows stood an average of 55.4% of the total 8-h period postpartum. Mean number of standing bouts during this period was 7.3, and bouts averaged 36.1 min. Cows spent 76.9 min grooming their calves. The average number of bouts recorded/cow was 10.9, and bouts lasted an average of 7.1 min.

Calves spent 70.3% of the 8-h period lying. Of the time recorded not lying, 31.6 and 41.0% was spent in suckling and ambulating-moving, respectively. The mean number of suckling bouts recorded per calf was 5.7, and each suckling bout lasted an average of 7.8 min.

TABLE V-1. LEAST-SQUARE MEANS AND STANDARD ERRORS FOR VARIOUS TRAITS ASSOCIATED WITH POSTPARTUM BEHAVIOR OF BEEF COWS AND CALVES.

Variables	N	Means	SE
Calf traits.			
Time from parturition (min) subsequent to:			
Attempt to stand	134	16.8	2.00
Successful standing for 1 min or more	134	34.8	2.48
Initial mobility	134	40.9	2.73
Initial teat seeking	130	47.9	3.56
Initial suckling	130	62.8	3.77
Total standing[a]	99	140.8	4.78
Total lying[a]	99	333.2	5.69
Total mobility[a]	99	57.8	3.58
Total suckling[a]	99	44.5	2.06
Cow traits.			
Time to initial grooming, min	131	1.4	.43
Degree of initial grooming[b]	104	2.1	.05
Total grooming[a], min	99	76.9	3.25

[a]Total time (min) engaged in activity is based on cow-calf pairs with 8 complete h of observation.

[b]Scored 1 to 3 for increasing intensity of grooming attention.

TABLE V-2. ACTIVITY BOUTS OF BEEF COWS-CALF PAIRS DURING THE FIRST 8 H POSTPARTUM[a]

Item	No. of bouts observed	Bout length ($\bar{x}\pm SE$) (min)	Range in bout length (min)
Dam activity			
Standing	724	36.1±1.4	1 to 250
Lying	704	29.8±1.3	1 to 279
Grooming calf	1078	7.1± .3	1 to 94
Eating silage	17	10.6±1.5	2 to 25
Eating hay	5	17.6±5.9	4 to 36
Calf activity			
Standing	723	19.3± .7	1 to 138
Lying	819	49.5±1.5	1 to 310
Ambulating-moving	806	7.3± .3	1 to 76
Teat seeking	177	4.4± .3	1 to 21
Suckling	569	7.8± .3	1 to 47

[a]Based on 99 cow-calf pairs observed for 8 h each.

The calves stood for the first time 34.8 min after parturition and initiated mobility, teat seeking and suckling 6.1, 13.1 and 28.0 min after first standing, respectively. Each calf initiated an average of 1.8 teat seeking bouts prior to first suckling, and each bout lasted an average of 4.4 min.

Analysis of variance. Factors influencing early postpartum behaviors of a cow and her calf are presented in tables V-3, 4 and 5. Hour differences in the activities of cows and calves were significant (P<.01). During the first hour, dams spent an average of 54.4 min standing and 33.9 min grooming their calves (figure V-1). Standing activity became less frequent towards the last hour of observation with each cow spending an average of 23.1 min standing and 36.9 min lying. The major eating activity was browsing, which gradually increased as the time after birth progressed until the sixth hour (figure V-2). Browsing activity decreased during the seventh hour before reaching peak activity during the eighth hour. Cows spent an average of 5.4 min browsing during the last hour of observation. Cows did not consume hay or silage until 3 and 6 h after parturition, respectively, and these activities were infrequent as indicated by the number of total bouts given.

Behavioral traits associated with the calf peaked during the second hour (figure V-3). Standing and suckling activities gradually declined after the second through the

TABLE V-3. FACTORS INFLUENCING POSTPARTUM BEHAVIOR OF BEEF CALVES.

		Mean square				
Source	df	Successfully standing (1)	Initial mobility (2)	Initial teat seeking(3)	Initial suckling (4)	Initial grooming by dams(5)
Parity[a]	1	1834.4	1597.3	1383.3	.1	.2
Breed of sire[b]	1	131.6	575.4	1170.0	1873.5	11.7
Breed of dam[c]	5	1405.9	1458.2	3012.4+	2437.4	9.8
Sex of calf	1	68.0	648.2	1012.1	1773.4	35.7
Remainder	--[d]	801.1	959.0	1532.1	1773.4	25.1
Breed of calf coded as Angus, Hereford and Crossbred						
Breed of calf	2	1567.3	2984.2*	7713.3**	6007.7*	46.1
Remainder	--[e]	813.9	975.1	1566.6	1813.2	24.2

+P<.10.
*P<.05.
**P<.01.
[a]Primiparous and multiparous dams.
[b]Angus (A) and Hereford (H).
[c]Angus, AH, Hereford and HA.
[d]df=125, 125, 121, 121 and 122 for activities 1, 2, 3, 4 and 5, respectively.
[e]df=129, 129, 125, 125 and 122 for activities 1, 2, 3, 4 and 5, respectively.

TABLE V-4. FACTORS INFLUENCING BEHAVIORAL ACTIVITIES OF BEEF COWS BETWEEN BIRTH AND 8 HOURS POSTPARTUM.

		Mean square		
Source	df	Standing	Grooming	Browsing
Hour	7	10157.2**	12658.3**	235.5**
Parity[a]	1	.5	161.3	153.7+
Breed of sire[b]	1	259.9	197.3+	253.5*
Breed of dam[c]	5	760.5**	156.6+	139.1*
Sex of calf	1	435.4	192.7+	102.3
Remainder	768	310.7	70.8	51.0
Breed of calf coded as Angus, Hereford and Crossbred				
Breed of calf	2	650.0	516.7**	152.7
Remainder	771	315.4	70.9	51.4

+P<.10.

*P<.05.

**P<.01.

[a]Primiparous and multiparous dams.

[b]Angus (A) and Hereford (H).

[c]Angus, AH, Hereford, and HA.

TABLE V-5. FACTORS INFLUENCING BEHAVIORAL ACTIVITIES OF BEEF CALVES FROM BIRTH TO EIGHT HOURS POSTPARTUM.

Source	df	Mean square			
		Standing	Lying	Mobility	Suckling
Postpartum, h	7	1815.0**	4315.6**	549.6**	1398.8**
Parity[a]	1	24.6	673.4*	433.4*	138.1
Breed of sire[b]	1	25.0	2.5	18.3	96.4
Breed of dam[c]	5	37.9	182.5	90.8	79.6
Sex of calf	1	.8	245.0	227.9+	26.2
Remainder	768	122.1	218.9	82.7	59.9
Breed of calf coded as Angus, Hereford and Crossbred					
Breed of calf	2	6.8	315.1	267.5*	65.8
Remainder	771	121.8	218.0	81.8	60.0

+P<.10.

*P<.05.

**P<.01.

[a]Primiparous and multiparous dams.

[b]Angus (A) and Hereford (H).

[c]Angus, AH, Hereford and HA.

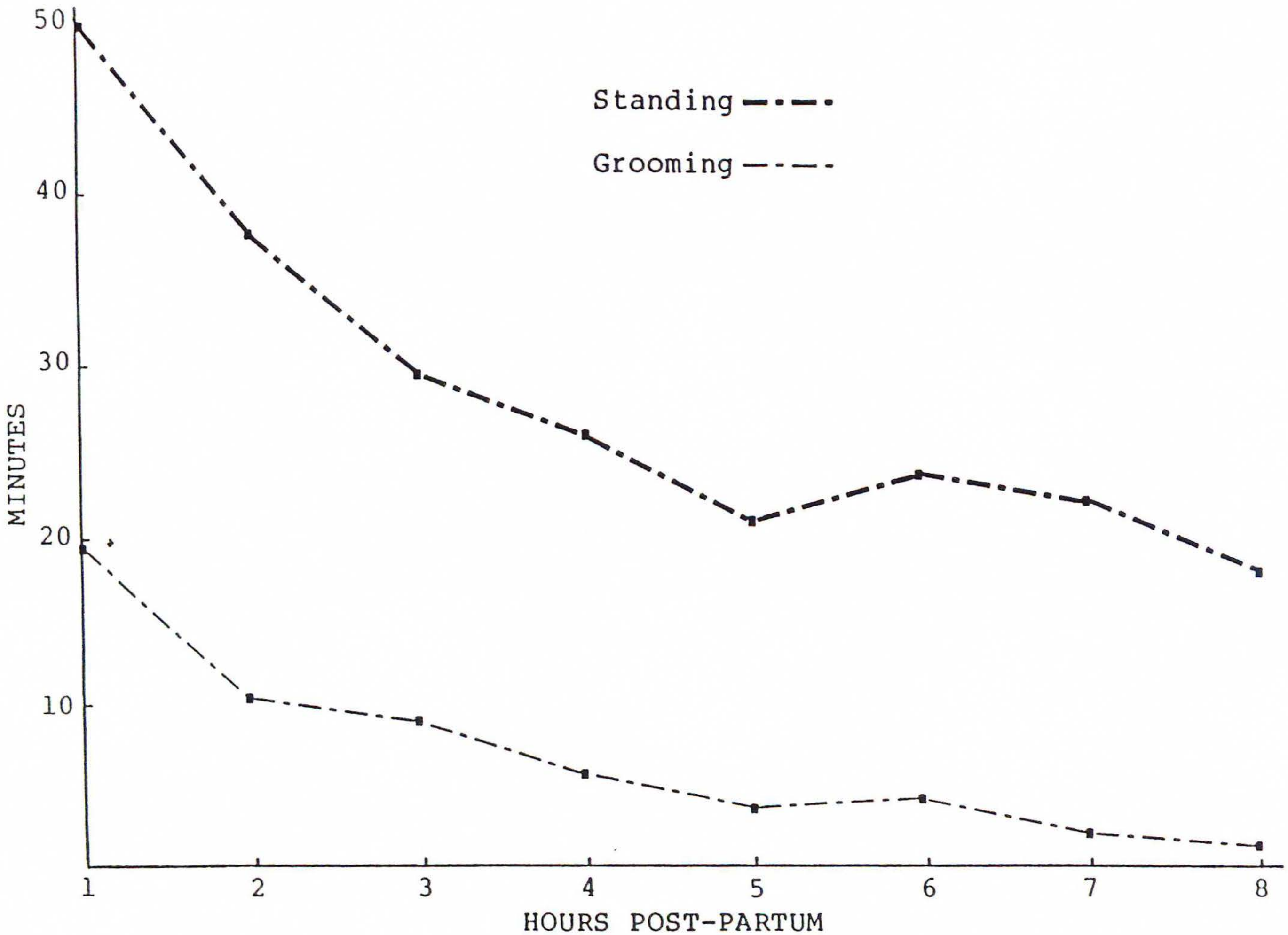

Figure V-1. Standing and grooming activities of beef dams during the first 8 h post-partum.

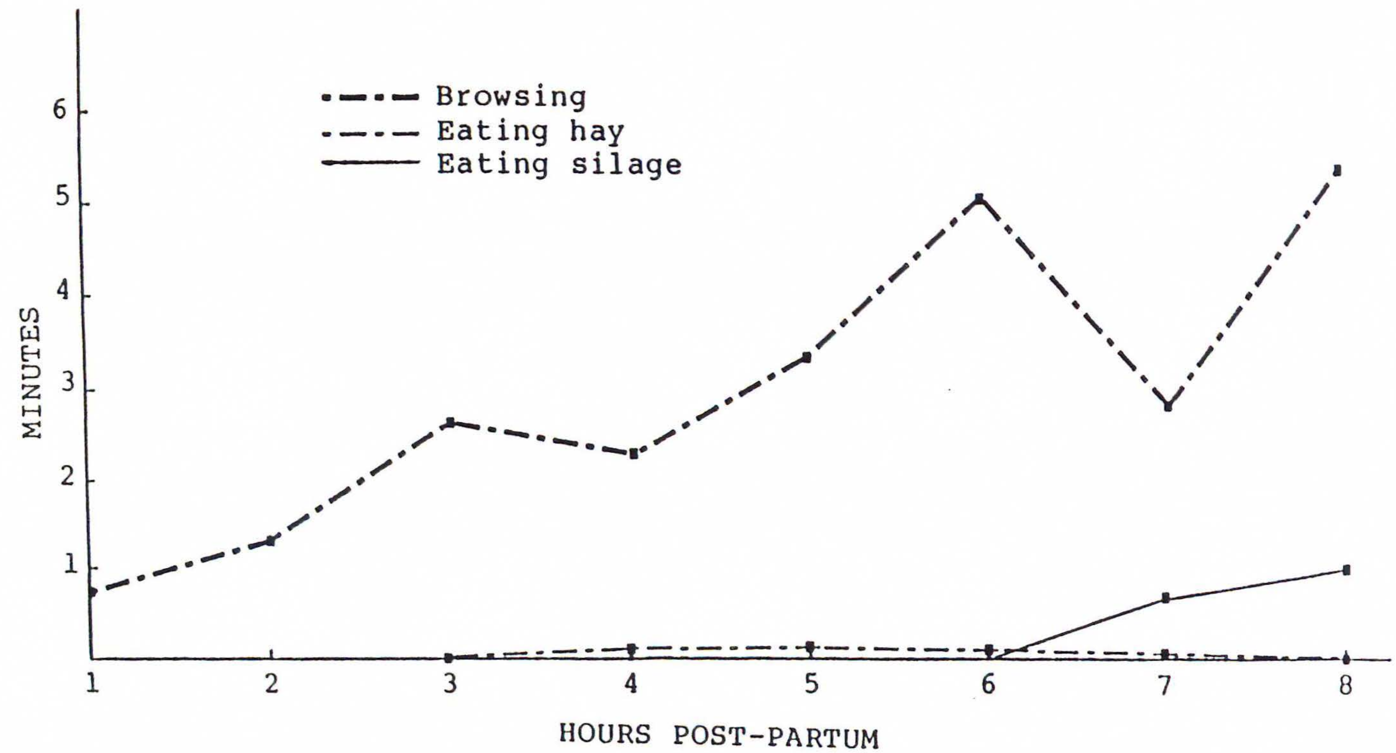

Figure V-2. Eating activities of beef dams during the first 8 h post-partum.

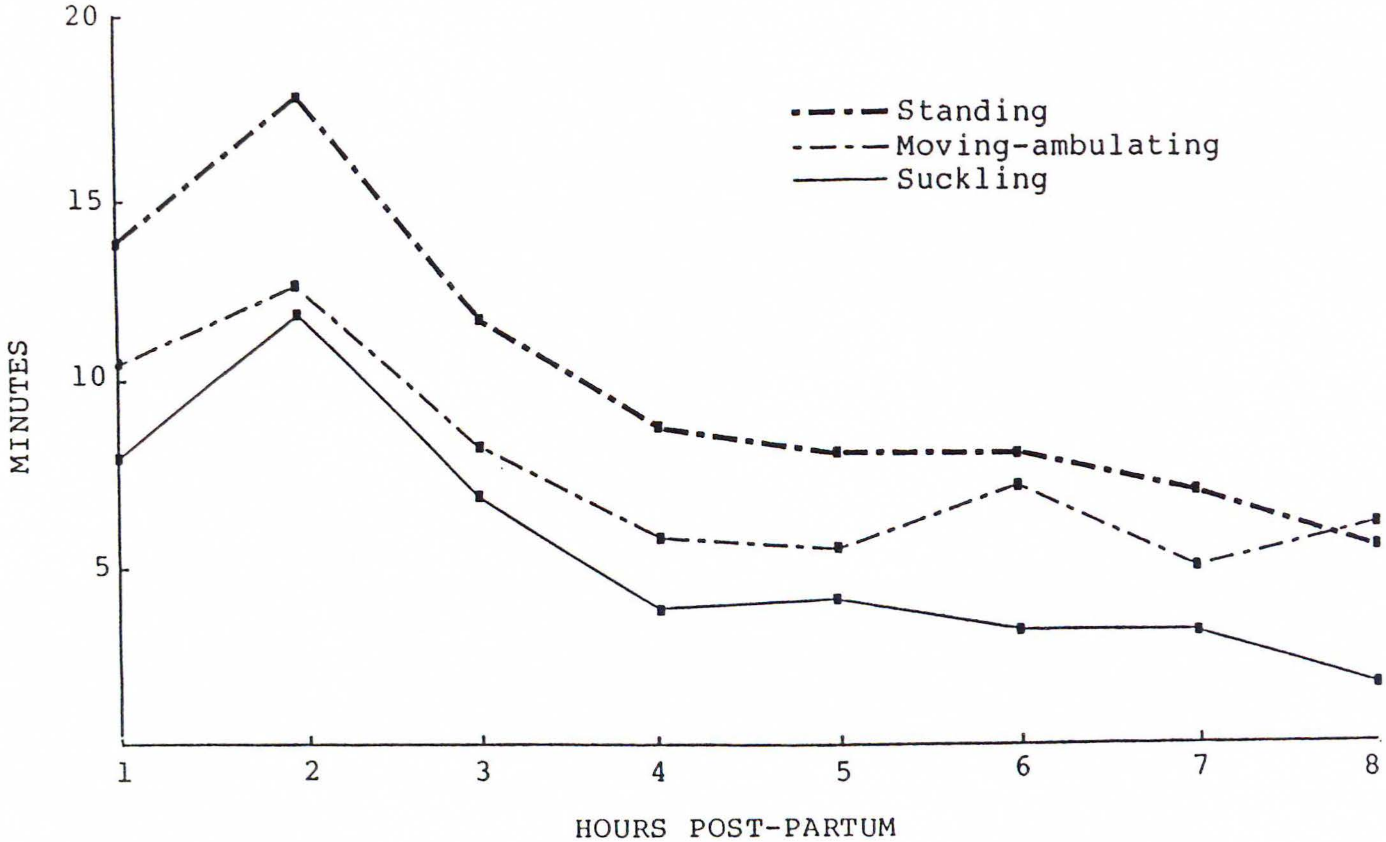

Figure V-3. Behavioral activities of beef calves during the first 8 h post-partum.

eighth hour postpartum. Peak mobility was recorded during the second hour (12.8 min) and then gradually decreased, before this activity stabilized from the fifth through the eighth hour.

Parity significantly influenced time spent browsing ($P<.10$) and the calf's mobility ($P<.05$) and lying ($P<.05$). Cows spent a longer time browsing each hour (2.9 min) when compared to heifer dams (1.9 min). Similarly, calves from multiparous dams were more active than calves from primiparous dams as indicated by the mean hourly time spent on ambulating-moving and lying. Hourly means for ambulating-moving and lying for calves out of multiparous dams were 7.6 and 41.9 min, respectively; and for primiparous dams were 6.2 and 43.6 min, respectively.

Differences due to breed of sire were only observed in the behavioral traits associated with the dam. Cows bred to Angus bulls spent an average of 8.9 min grooming their calves and browsed for 2.8 min during each hour. Cows bred to Hereford bulls spent 10.8 and 2.6 min each hour for the same two traits, respectively. Although traits associated with the calf were not significant, calves sired by Angus initiated teat seeking 40.5 min after parturition and successfully suckled 55.1 min postpartum. In contrast, calves sired by Hereford bulls initiated teat-seeking and succeeded suckling after 58.9 and 74.5 min, respectively.

Maternal breed-class affected mean hourly standing of the cow (P<.01), grooming (P<.10) and browsing (P<.05) and the calf's teat-seeking activity (P<.10). However, the effects of maternal breed-class might be inflated in the analysis of variances because a small number of AHA and HAH dams were included in the analysis. Angus-Hereford (AH) crossbred dams stood an average of 34.4 min while their reciprocal crossbred dams (HA) averaged 28.2 min standing during each hour. Mean hourly standing activity for other dam breed-classes were 34.0 and 35.3 min for Angus (A) and Hereford (H), respectively. Mean hourly grooming activity ranged from 9.5 min for Angus to 11.3 min for Hereford dams. Means for browsing were 1.3, 3.6, 3.8, 1.2, for Angus, Hereford, AH, HA, respectively. Calves out of Hereford dams had the longest interval from parturition to the onset of initial teat-seeking (70.3 min), but recorded the highest (P>.10) time spent suckling (6.3 min) per hour. Mean hourly time spent on teat seeking for other maternal breed-classes were 39.8, 48.2 and 34.3, for Angus, AH, and HA, respectively.

When breed effects were analyzed according to the breed of calf, the significant behavioral trait associated with the dam was total grooming (P<.01). Breed of calf significantly affected initial mobility (P<.05), teat-seeking (P<.01) and suckling (P<.05), and mean hourly mobility (P<.05).

Mean hourly grooming received by purebred Angus, Hereford and crossbred calves were 8.5, 11.5 and 9.7 min, respectively. Angus calves initiated mobility, teat-seeking and suckling 35.7, 40.3 and 56.4 min after parturition, respectively. Mean interval for Hereford calves for the same order of traits were 53.9, 70.3 and 81.8 min and for crossbreds calves were 42.4, 46.4 and 59.4 min after parturition. Mean hourly time spent on mobility was 7.9, 7.8 and 6.5 min for Angus, Hereford and crossbred calves.

When straightbred and crossbred calves were compared (table V-6), Angus calves tended to stand and suckle earlier, and be more vigorous. Hereford calves tended to be least active, and the crossbred calves were intermediate between Angus and Hereford.

Discussion

Regardless of parity, unassisted beef cows stood immediately following parturition which was in agreement with Hermann and Sternum (1982). Eighty-two percent of the cows stood within the first minute after parturition with a range of 0 to 4 min for 130 cows. The initial maternal response of a beef cow following parturition was to get up immediately and initiate grooming as quickly as possible. The time interval from parturition to the onset of grooming (1.42 min) and the time spent grooming during the first hour (33.9 min) emphasize that grooming is an important activity; it enhances the survivability of the neonate and initiates

TABLE V-6. LEAST-SQUARES MEANS FOR COW AND CALF BEHAVIORAL TRAITS DURING 8-H POSTPARTUM.

Behavioral traits	Least-squares means: Angus (A)	Hereford (H)	AH	HA	AHA	HAH	AAH
<u>Cows</u>[a] (n)	46	28	5	16			
Standing	34.0	35.3	34.4	28.2			
Lying	26.0	24.7	25.6	31.8			
Grooming	9.5	11.3	10.8	10.1			
Browsing	1.3	3.6	3.8	1.2			
Eating (combined)	2.0	3.9	1.6	1.5			
<u>Calves</u>[a] (n)	36	20	8	10	16	5	
Standing	10.5	10.2	10.0	11.2	9.4	10.4	
Lying	42.2	42.0	44.4	43.5	45.4	43.8	
Mobility	7.3	7.5	5.6	5.3	5.1	5.8	
Suckling	6.5	6.3	7.1	5.5	5.8	3.5	
<u>Calves</u>[b] (n)	43	29	10	11	20	10	3
Standing	31.8	44.1	66.3	40.5	34.5	42.6	26.7
Teat-seeking	40.3	70.3	74.4	54.4	39.3	55.8	30.3
Mobility	35.7	53.9	69.7	55.2	36.5	47.9	28.3
Suckling	56.4	81.8	79.7	68.6	46.9	72.7	42.4
Grooming received	.9	3.1	.3	.6	.9	1.4	.3

[a]Minutes per hour that cows and calves engaged in respective activities during the first 8 h postpartum.
[b]Interval between parturition and onset of activity.

rapid formation of the mother-infant relationship. Selman et al. (1970a) noted that calves that were groomed for the longer time periods following parturition were the quickest to stand. Grooming activity became less intense, and bouts became shorter as time progressed after parturition. This finding is in agreement with Edwards and Broom (1982) who observed a negative relationship between time spent licking and the age of the calves. They attributed this trend to the changes in the motivational state of the dams and the stimulus characteristics of the calves. These stimuli were in reference to the progressive removal of the amniotic fluids from the calf's body surface through early grooming.

The time spent standing decreased progressively over time. Edwards and Broom (1982) observed similar trends when dairy cows were observed continuously 6 h postpartum. However, peak standing activity of heifer dams in their study occurred in the second hour following parturition. The highest mean standing time for primiparous dams was recorded during the first hour in this study. The difference between heifer dams of dairy and beef breeds in the standing and grooming activity could be the result of artificial selection among dairy breeders favoring traits of early separation of cows from their calves. This selection probably resulted in the dairy cows loosing some of the fitness traits associated with early standing of the dam. Selman et al. (1970a) indicated a difference in time spent and the degree of grooming between beef and dairy breeds with regards to this behavioral trait. It is probable that the maternal behavior of a beef cow is less affected by the domestication process in which a strong kinship is necessary to keep a cow and her calf together through weaning. The need for the cow to stand and initiate grooming as early as possible may be related to the general fitness of the calf.

Initial grooming activity of the calves was directly related to the cows' standing activity. This was expected as almost all grooming was performed while a dam was standing. Early grooming activity was intermittent in some cows while continuous in others. Although parity did not influence time of grooming, average grooming activity per hour was higher in heifers (10.7 min) than in cows (9.4 min). It is possible that a heifer having a calf for the first time may be more motivated in her maternal response towards her newborn. Previous studies by Hermann and Stenum (1982), however, showed that dairy heifers spent significantly less time grooming their calves when compared to dairy or beef-dairy cows. All dairy heifers in their studies remained recumbent for 63 to 318 min, and the calves had to be placed in front of the dams in order to initiate and facilitate grooming.

Grooming activity was also affected by sex of calf. Female calves were groomed for a longer time period during the first 3 h; 35.4 vs 35.2, 18.2 vs 13.5 and 13.5 vs 9.8

min for female vs male calves during the first, second and third hours, postpartum, respectively. However, these sex-related differences did not influence time to initial standing, teat seeking, suckling or mean hourly time spent on these activities in calves. Initial teat seeking was significantly ($P<.01$) correlated with initial suckling (Appendix table A-6). Sluckin (1972) indicated that the early approaches of neonatal mammals towards their dams was stereotypic. However, Stephens and Linzell (1974) demonstrated that suckling behavior contained a significant learning component in newborn goats. Thus, a calf that initiated teat seeking activity early in life would be able to locate and suckle their dam earlier as indicated by the significant correlation coefficient ($r =.89$) between initial teat seeking and initial suckling in this study. The biological value of teat seeking may be related to reinforcing the maternal-filial relationship and stimulating earlier milk let-down, especially colostrum, necessary for life. Finger and Brumner (1969) indicated that a calf separated for more than 6 d of life might not be able to locate the teats which could suggest that this activity preceded suckling during the early stage of calf's life.

Most of calves stood and located the teat during the first hour, and peak suckling activity was recorded during the second hour after birth. The initial standing time of the calves in this study was similar to Odde et al. (1986) who observed that calves out of unassisted dams stood 39.8 min after parturition. The mean interval from parturition to initial standing was significant ($P<.05$), but negatively correlated to percent Angus breeding suggesting that purebred Angus calves stood much earlier than calves with more Hereford breeding. Evidence from this study, however, did not indicate that the significant effect of breed on time to initial standing of the calf was mediated by early grooming or time spent grooming by the dam. Percent Angus breeding was not significantly correlated to these two traits.

Differences in the mean hourly time spent lying were affected by maternal breed-classes but not by breed of sire. Calves out of AH dams had the highest mean hourly time spent standing. Correspondingly, AH dams also had the highest mean hourly time spent standing. This observation tends to support Selman et al. (1970a) who observed that cows were reluctant to lie while their calves were standing.

Differences due to maternal breed were not observed in mean hourly time spent suckling. However, there was a trend for Hereford dams to nurse their calves longer than dams of other breed-classes. Conversely, AH dams had the least mean hourly nursing time. Calves out of Hereford dams initiated teat seeking and suckling activities much later than herd-calves out of dams of other breed-classes. However, they compensated for the delay in suckling by spending more time on this activity once they started suckling. It was not known if longer or shorter duration of suckling was an indication of more milk let-down as this study made no measure of the quantity of milk produced.

A non-significant difference in the mean hourly time spent suckling was observed between multiparous (5.5 min) and primiparous dams (6.6 min). This could reflect differences in milk supply or teat accessibility. Butting of the udder by the calf was more frequently observed in calves from heifer dams, probably an indication of less milk supply. Heifer dams also appeared to have more sensitive udders and would flinch when touched, especially during early suckling bouts. Edwards and Broom (1982) also observed a greater mean time spent suckling in calves from heifers but attributed this to greater latency to first suckle and higher incidence of failure to suckle older cows during the 6 h observations, postparturition.

In the present study, all calves suckled within 8 h postpartum. Although calves from assisted dams were excluded from the analysis, periodic checkings of these cows indicated that nursing of calves occurred within the 8-h period. Hafez and Bouissou (1975) indicated that calves normally suckled within 2 to 5 h after parturition. Selman et al. (1970a) noted that 25% of the calves in their study failed to suckle before 8 h postpartum. In this study, however, the majority of the initial suckling bouts in both purebred Angus, Herefords and their crossbred calves occurred during the first 2 h after birth.

When data were reanalyzed according to the breed of calf, significant breed differences were observed in some of the traits associated with the dam and the calf. Within the purebred calves, Hereford received the most grooming compared to Angus. Crossbred calves were intermediate between the two in terms of the mean time spent grooming by their dams during each hour. Angus calves were the earliest to initiate mobility, teat-seeking and suckling and Hereford calves took a much longer time to initiate these activities compared to Angus and crossbred calves. Although differences in the onset of these behaviors were observed among crossbred calves, the mean hourly time spent on suckling was not significant. Angus tended to exhibit more mobility followed by Hereford and crossbred calves.

Hereford calves which took a longer time to initiate mobility, teat seeking and suckling received the most grooming from their dams. During the first and second hours combined, Hereford calves received 13 and 5 min more grooming compared to Angus and crossbred calves, respectively. This relationship tends to indicate that grooming activities are related to increasing the survivality of the calves. Since Hereford calves were least active during the first 2 h in this study, it would be most appropriate for the Hereford dam to groom her calf as long as possible to reduce the time it took to stand and perform other behavioral activities.

Data from this study indicated that significant behavioral differences existed among beef cows differing in breed, parity and the sex of their calf. These behavioral differences could be contributing factors to the subsequent production performance of the calf which will be discussed in the next chapter.

VI. RELATIONSHIP BETWEEN COW-CALF BEHAVIORS AND SUBSEQUENT PERFORMANCE OF BEEF CALVES

ABSTRACT

Postparturient behaviors of 216 purebred and crossbred Angus and Hereford cows and their calves were monitored during the 1985 spring-calving season. Eight hours of continuous observation postpartum were recorded on 99 cow-calf pairs. The parturition data were used in a multiple regression analysis to determine the relationship between periparturient behavior and subsequent 205-d weight of the calf. Cow-calf pairs were managed similarly. After calving cows were fed supplemental hay and silage until mid-April 1985, then placed on mixed grass-legume pastures until the calves were weaned. Adjusted 205-d weaning weights were calculated (corrected for age of dam, age of calf, and sex of calf). Multiple regression of weaning weight on periparturient behavioral traits and non-behavioral traits resulted in R^2 values of 54 and 24% for heifer and bull calves, respectively. The behavioral traits contributed more than non-behavioral traits to explaining variation in weaning weight. While the number of observations in this trial are small, these data indicate that the early postpartum behavioral activity of the cow and the calf may be related to lifetime productivity of the offspring.

Introduction

Maternal influences are an important source of variation in beef cattle production. A cow can influence her offspring through at least three pathways: direct genetic effects, prenatal environment and postnatal environment. After receiving one-half of its genes from each parent, the fetus is influenced by the prenatal environment of the dam from conception until parturition. Through maternal behavior and milking ability the cow influences the postnatal environment of the calf and has a major influence on development between birth and weaning.

The importance of early environment on the later development of calves could be reflected in their preweaning growth. Although the period is relatively short in terms of the calf's life, the behavioral activities of the cow and the calf occurring during the period immediately postpartum may have a permanent effect on the calf's lifetime performance. The common approach to investigating maternal influence on growth of calf has been to consider only the amount of milk produced by the dam and ignore the behavioral components.

The contribution of behavior during the first hours of the calf's life to the variation in weaning weight has not been investigated. The objective of this study was to determine the influence of cow and calf behavioral traits recorded continuously 8 h immediately postpartum on the calf's 205-d adjusted weaning weight.

Materials and Methods

Postparturient behavior of 216 purebred and crossbred gestating Angus(A) and Hereford(H) cows were monitored during the 1985 spring-calving season at the University of Maryland Sykesville Beef Research Station. The management procedure and the behavioral variables recorded have been discussed previously in chapter III and V. In addition, weaning weight of the calves were recorded and adjusted to 205-d weight.

Within 1 wk of calving, cow-calf pairs were removed from the observation paddocks and kept together as a herd. Supplemental hay and silage were provided through mid-April 1985. Subsequently, the cow-calf pairs were grazed on mixed grass-legumes pastures until weaning. The calves were weaned in groups on three different dates; September 20, October 7 and October 16, 1985. Calf bodyweights were recorded on the day of weaning.

The cow's and the calf's behavior data (discussed previously in chapter V) were used in an analysis of variance and in multiple regression analyses for predicting the 205-d weight for bulls and heifers separately.

Statistical Analyses. The factors affecting weaning were determined using general linear model procedure (SAS, 1985) and are presented in tables VI-1 for background information. Multiple regression analyses by sex were conducted (tables VI-2 and 3). Simple linear regressions were determined and are also presented as background information (table VI-4). The correlation coefficients for other behavioral traits and adjusted weaning weight based on pooled data are presented in Appendix table A-7.

Results

The average adjusted weaning weight for the 1985 calf crop was 225.6 $\pm$ 1.6 kg and ranged between 160 to 297 kg. Significant breed of sire ($P<.05$) and sex of calf ($P<.01$) effects were determined (table VI-1). Multiple regression of behavioral and descriptive traits on weaning weight explained 54 and 24 % of the variation in heifer and bull calves, respectively (tables VI-2 and 3).

Discussion

Two pairs of paternal twins were born during the 1985 spring-calving season. Calves of both pairs suckled their dams within the 8-h period postpartum. However, a calf from each pair constituting both sexes died within 1 wk of birth and showed symptoms of dehydration. These observations suggest that despite the early suckling activity, stronger

TABLE VI-1. ANALYSIS OF VARIANCE FOR FACTORS INFLUENCING 205-DAY ADJUSTED WEANING WEIGHT

Sources	df	Mean square	Prob>F
Breed of sire	1	1893.2	.02
Breed of dam	5	424.5	.25
Parity	1	180.7	.45
Birth weight	1	828.6	.11
Sex	1	5020.7	.01
Restraining score	2	291.3	.40
Calving score	2	139.0	.65
Chute score	3	148.5	.71
Dam weight	1	271.9	.36
Age of dam	1	1.9	.94
Attempt to stand	1	651.9	.16
Successfully standing	1	693.9	.14
Initial mobility	1	36.4	.74
Initial teat seeking	1	51.8	.69
Initial suckling	1	694.6	.14
Initial grooming	1	523.5	.20
Remainder	100	314.2	

TABLE VI-2. MULTIPLE REGRESSION OF TRAITS ON ADJUSTED WEANING WEIGHT OF FEMALE CALVES[a]

Predictive Equations[b]	R^2
1) 192.4 + 9.9RSC	.11
2) 186.2 + 4.4CSC + 9.0RSC	.18
3) 188.8 + 5.1CSC + 8.6RSC - 3.1IGR	.24
4) 194.8 + 5.2CSC + 8.8RSC - .19SST - 3.8IGR	.29
5) 193.1 + 5.1CSC + 8.1RSC - .30SST + .11ISK - 3.7IGR	.35
6) 193.7 + 3.5CSC + 8.6RSC + .48AST - .50SST + .11ISK - 3.2IGR	.41
7) 162.8 + .06DWT + 5.6CSC + 6.3RSC + .54ATS - .59SST + .12ISK - 4.1IGR	.47
8) 153.0 - 1.1AGE + .09DWT + 5.6CSC + 7.9RSC + 4.6AST - .59SST + .12ISK - 5.0IGR	.50
9) 166.5 - .04PAB - 1.2AGE + .09DWT + 5.6CSC + 5.4RSC + .41AST - .51SST + .13ISK - 5.1IGR - .04TST - .07TGR + .08TMB	.53

[a]48 observations

[b]Independent variables: RSC = restraining score, CSC = chute score, IGR = initial grooming, SST = successfully standing (calf), ISK = initial suckling, ATS = attempt to stand, DWT = dam bodyweight, AGE = dam's age, TMB = total mobility, TST = total standing, TGR = total grooming, PAB = percent Angus breeding.

TABLE VI-3. MULTIPLE REGRESSION OF TRAITS ON ADJUSTED WEANING WEIGHT ON MALE CALVES[a]

Prediction equations[b]	R^2
247.3 - .34TSK	.12
243.7 + .06PAB - .35TSK	.14
237.1 + .09PAB + .14IMB - .37TSK	.16
244.1 + .11PAB -4.12CSC + .16IMB - .38TSK	.18
248.7 + .13PAB - .95AGE -4.94CSC - .39SST + .53IMB - .38TSK	.20
226.5 + .14PAB -2.23AGE + .01DWT -4.49CSC + .23BWT + .01RSC + .09AST - .38SST + .53IMB - .16ITS + .15ISK - .68IGR + .06TST + .02TGR - .01TMB - .46TSK	.24

[a]50 observations

[b]Independent variables: TSK = total suckling, PAB = percent Angus breeding, IMB = initial mobility, CSC = chute score, AGE = dam's age, SST=successfully standing, BWT = birth weight, DWT = dam's wt, RSC = restraining score, AST = attempt standing, ITS = initial teat seeking, ISK = initial suckling, IGR = initial grooming, TST = total standing, TGR = total grooming, TMB = total mobility.

TABLE VI-4. CORRELATION COEFFICIENTS[a] BETWEEN PERIPARTURIENT VARIABLES AND 205-D WEIGHT OF BULL AND HEIFER CALVES.

Variables[b]	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	AWW
1) PAB	.25+	.26+	.16	.00	.04	.03	-.31*	-.30*	-.34*	-.38**	-.25+	-.22	.00	-.21	.04	.05	.11
	-.05	.02	.02	.12	-.23	-.14	-.38**	-.36*	.43**	-.39**	-.40**	.31*	-.06	-.41**	-.03	.00	-.18
2) AGE		.53**	-.14	.00	.24	.18	-.16	-.10	.01	-.06	.33*	-.32*	.17	-.17	.06	-.04	.02
		.53**	-.29*	-.17	-.13	.35*	-.22	-.00	.00	-.04	.05	.32*	-.06	-.42	-.03	.00	-.17
3) DWT			-.24	.00	.40**	.40**	-.28*	-.03	.00	-.01	.19	-.32*	-.06	-.13	-.08	-.01	.06
			-.40**	-.21	.34*	.22	-.05	.21	.08	.01	.08	.13	.15	.06	.19	-.06	.01
4) CSC				.00	-.09	-.19	-.15	-.03	-.02	-.02	-.04	.02	-.02	-.12	.08	-.00	-.08
				.04	-.21	.12	.23	-.01	-.01	.02	.01	.15	-.19	-.01	-.08	-.16	.30*
5) CLS					.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
					-.17	-.08	.11	-.07	-.11	-.11	-.14	-.09	.08	.05	.08	-.01	-.02
6) BWT						.53**	-.05	.07	.12	.05	.26	.03	.00	.05	.03	-.15	.18
						-.07	.14	.25	.29	.21	.25	-.12	-.16	.32	.01	-.17	.06
7) RSC							-.15	-.14	-.19	-.12	.08	-.10	.13	.03	-.05	.07	.02
							.00	.03	.02	.00	.10	-.03	-.09	-.07	.22	-.28	.34
8) AST								.59**	.59**	.30*	.19	.05	-.31*	.21	-.28*	.00	.05
								.70**	.70**	.57**	.33*	-.22	-.08	.37**	-.20	-.05	.13
9) SST									.93**	.66**	.52**	.12	-.22	.31*	-.16	.12	-.02
									.77**	.57**	.49**	-.21	-.02	.58**	-.15	-.02	-.16
10)IMB										.65**	.56**	.19	-.17	.27*	-.12	.12	.03
										.92**	.81**	-.24	-.04	.73**	-.10	.04	.00
11)ITS											.79**	.04	.01	.03	.10	-.02	-.01
											-.12	-.02	.70**	-.07	.07	.07	.05
12)ISK												.04	.04	.05	.15	-.06	.07
												-.12	.06	.58**	.04	-.10	.17
13)IGR													.08	.29*	.13	.02	.05
													-.02	-.29*	-.02	.16	-.21
14)TST														.19	.68**	.50**	-.17
														.14	.67**	.30*	-.08
15)TGR															.03	.47*	-.11
															.09	-.02	-.05
16)TMB																.04	.04
																-.13	.17
17)TSK																	-.35*
																	-.25+

[a]The first and second row of the same trait represents r values for bull (n=51) and heifer (n=48) calves, respectively.
[b]PAB=percent Angus breeding, AGE=age of dam; DWT=dam weight; CSC=chute score; CLS=calving score; BWT=birth weight; RSC=calf restraint score; AST=attempt to stand; SST=succesfully standing; IMB=initial mobility; ITS=initial teat seeking; ISK=initial suckling; IGR=initial grooming; TST=total standing; TGR=total grooming; TMB=total mobility; TSK=total suckling; AWW= 205 d adjusted weaning weight.
+ P<.10, * P<.05, **P<.01

mother-infant relationships, at least in twin calves may not have been fully established, resulting in later deprivation of adequate milk supply to one of the calves.

For the multiple regression of female's adjusted weaning weight, the order of significant variables entered into the models were restraining score, chute score, initial grooming, successfully standing for the first time, initial suckling, attempt to stand for the first time, dam's weight and age. These variables accounted for 49.7% of the variation in 205-d weight. Among these variables, restraining score was the most important single predictor of 205-d weight contributing to 11.3% of the observed variation in adjusted weaning weight. The correlation coefficients significantly related to weaning weight of female calves were chute score (r = .30), restraining score (.34) and total suckling (-.25). A positive chute score indicated that the most temperamental cows produced the heaviest female calves at 205-d. Younger cows tended to have higher chute scores (table VI-5), and younger cows are known to produce less milk.

Female calves that were more difficult to restrain when birth weight was recorded were also the heaviest at 205-d. A negative correlation coefficient between total suckling and adjusted weaning weight of female calves indicated that female calves that spent the most time suckling their dams were the lightest at 205-d. Total

TABLE VI-5. DESCRIPTIVE INFORMATION ON COW CHUTE SCORE AND OTHER COW AND CALF CHARACTERISTICS.

Cow chute score[a]	n	Cow age,yr	Cow weight,kg	Angus breeding,%	Calf vigor score[b]	Calf birth weight,kg
1	67	6.0	552.7	46.8	2.19	38.2
2	93	4.6	522.3	56.3	2.12	37.7
3	29	3.8	492.4	54.3	2.10	36.1
4	5	3.0	496.4	75.0	2.20	37.6

[a]1=most docile to 4=most aggressive.

[b]1=least vigorous to 3=most vigorous.

suckling time for the female calves ranged from 4 to 92 min, and the initial onset of suckling varied from 18 to 242 min postparturition.

Despite the age of dam adjustment, the contribution of dam's age was still significant in the equation predicting 205-d weight of female calves. This indicated that the influence of dam's age on 205-d weight was not adequately adjusted for by the correction factor on cows in the Sykesville herd.

When behavioral traits were regressed on weaning weight of bulls, only the total time spent suckling was significant. Total suckling time accounted 12% of the variation in adjusted weaning weight. With all the variables included in the multiple regression model, the R^2 value increased to 24%. This leads to speculation that postnatal environment, provided by the dams to their calves following the 8-h observations until the calves are weaned, may be more important in male calves in this study.

Sixty to 66% of the variation in weaning weight of the calves has been attributed to differences in the milk consumption by the calf (Gleddie and Berg, 1968 and Rutledge et al., 1971, Robinson et al., 1978). McGaughey and Nelson (1986) using a weigh-suckle-weigh technique, reported higher correlations between weaning weight and milk yield in the second, third and fourth months (.47, .54 and .44, respectively) than in the fifth month ($r = .16$) postcalving.

Average daily gain and the average daily milk production of the dam was significantly correlated only for the first period of the lactation curve (Melton et al., 1967). The influence of dam's milk production reduced progressively towards weaning (Todd et al., 1969). These reports indicate that the calf becomes less dependent on the milk production of the dam as it gets older.

This study is based on small numbers of animals, but the data from the heifers in this study indicate that the early postpartum behavioral activity of the cow and calf can be highly related to later productivity of the offspring in some groups. Including early behavioral scores of calves and scores for maternal behavior of cows as routine traits kept as part of breeding records could add further to understanding the relationship between early behavior and lifetime performance of cattle.

VII. GENERAL DISCUSSION

The periparturient behaviors of cows and calves are influenced by numerous factors. In the current investigation, feeding schedule, breed-class and parity effects were determined to be significant contributors to explaining variation in both calf and cow behavioral traits. The diurnal patterns of groups of cows fed at different times of the day were dramatically shifted as a result of feeding the cows at different times of the day. The activity patterns of cows within the groups, however, demonstrated considerable variability among individual cows.

Feeding cows at night was not an effective method of producing day-time calvings. This conclusion is in general agreement with the recent refereed publications concerning cattle. The normal greater percentage of calves born during the day-time during the latter part of the calving season could lead some persons to conclude that they were causing more calves to be born during the day. In the current investigation the control group tended to have more calves born during the day, and it was therefore possible to determine that the greater daylight calvings were not due to the time of feeding.

It was possible to shift the diurnal pattern of eating in late gestation beef cows. The diurnal pattern in the control-fed cows was similar to that reported for cattle under a variety of conditions. The eating behavior of beef cattle in the temperate climate has been associated with the times of sunrise, sunset and feeding itself. Gonyou and Stricklin (1984) and Hart (1985) indicated that beef cattle normally engaged in the grazing activity with greater social facilitation during the periods of sunrise and sunset. More individual grazing was observed at night. The eating activity has also been associated with the time of feeding (Bond et al., 1978).

The eating patterns of late gestating crossbred and purebred Angus and Hereford cows were in agreement with the trends documented. Peak periods of eating were observed following the morning feeding and also during the time of sunset. Feeding cows at 0900 h is a standard management practice in this country where gestating beef cows are normally fed adequately once daily to meet the daily protein and energy requirements.

A shift in the feeding pattern of late gestating cows was observed during the 1985 spring-calving season when time of feeding was altered from 0900 to 2100 h. Major peak eating periods corresponded with times of sunrise, sunset and night feeding itself. More than 90% of the cows in the night-fed group were engaged in eating activity (eating hay, silage and browsing) during the 2100 and 2200 h intervals. In contrast, less than 15% of the cows in the control group were observed eating during similar time intervals. The noise from the tractor bringing corn silage to the night-fed group at 2100 h did not affect cows eating or standing in the control group.

High percentages of cows in both groups were observed browsing between 1500 and 1800 h, despite very little pasture-forage available in either observation paddock for grazing. This suggests that browsing is possibly an innate behavior present in beef cows which they tend to exhibit even when fed adequately at one meal per day. A slightly higher percentage of cows in the night-fed group browsed during the daylight hours, and this was attributed to the restricted availability of hay between 0900 and 2100 h, and almost all the silage had been consumed by this time. Although hay was available free-choice to the control group, peak hay eating activity corresponded with the time of sunset. More cows in the night-fed group consumed hay during 2100 and 2200 h intervals which corresponded with the time when hay was first made available during a 24-h period.

Lowman et al. (1981) and Yartney et al. (1982) reported a significant shift in the occurrence of parturition to the daylight hours as the result of feeding gestating cows at night. However, no substantial increase (P>.10) in day-time parturitions due to night feeding were observed in this study. Albright and Pennington (1985) and Tucker et al. (1985) also recorded similar results, with slightly more cows fed at night giving birth during the day-time.

Studies on the influence of night feeding in inducing day-time parturitions have been based on the assumption that increases in night eating activity reduced night calving. A significant shift in the periods of eating were observed in this study, especially from 2100 to 2300 h. Nonetheless, no major changes in the distribution of parturitions were observed with this shift in the eating patterns. Low frequency of parturition between 2100 to 0100 h were observed in both treatment groups and therefore night-feeding activity per se does not cause cows to calve during the daytime.

Less calf mortality was recorded in the 1985 spring-calving season as the result of closer supervision and attention given at calving time. Only 4 calf death losses were recorded from birth to day 1 postpartum, contributing to less than 2% of the total parturitions. Location of calving sites can be contributing factor to calf mortality. Among both cows and heifers, some individuals chose calving sites close to stream banks and endangered the calf. In spite of 24-h observation in 1985, one heifer calved below the stream bank, and her calf apparently drowned.

Significant effects of breed of sire and breed of dam, parity and sex of calf were observed in most of the behavioral traits associated with the cow and the calf for the first 8 h postpartum. Time spent on each of these behavioral activities, but not lying and eating, decreased after each hour from birth to 8 h postpartum. Cows stood almost immediately after parturition, and initiated grooming of their calves. The adaptive strategy of grooming relates to the likelihood that a calf receiving adequate grooming will survive and continue to perpetuate its genes to the next generation. Early grooming has been associated with initial standing and suckling and most importantly, the development of maternal-filial relationship. Hudson and Mullard (1977) indicated that if no contact was allowed between a dairy cow and her calf for 5 h after birth, a maternal bond was not formed in half of the cow-calf pairs.

Differences in the grooming activity due to parity and sex of calf was observed in this study. Primiparous dams groomed their calves longer than multiparous during the 8 h period. These observations were different than those reported by Hermann and Stenum (1982) and Selman et al. (1970a) who recorded longer grooming activity in cows. Edwards and Broom (1982) noted that grooming was initially more tentative in heifers. Hediger (1955) suggested that the first parturition had no direct reproductive function in an animal in the wild and merely provided the mother with the experience to undergo subsequent parturitions. Although primiparous dams groomed their calves for a much longer period, their calves were less active and stood less often then their counterparts from multiparous dams.

Bull calves received less grooming from their dams compared to heifer calves. This difference, however, did not result in heifer calves being more active than bull calves.

Correlation coefficients between periparturient traits and weaning weight ranged between nil to moderate. Among the behavioral variables significantly correlated to 205-d weight were total suckling, chute score and restraining score. It is of note that total time spent suckling during the initial 8-h period of life was negatively correlated with 205-d weight in both bull and heifer calves. A result generally different than one would have expected at first. However, calves with dams that give more milk may have to spend less time obtaining its first meals.

The correlation coefficients between chute score and restraining score to weaning weight were positive and relatively high in both sexes of calves. Restraining score alone accounted for 12% of the variation in 205-d weight of heifer calves. Restraining score and chute score, although based on visual subjective scores, could have practical significance in animal breeding records and selection programs. Heisler (1979), concluded that the additive genetic variance in temperament was moderate to high and selection for ease of handling would result in more rapid gains, more subcutaneous fat and probably less muscle in feedlot cattle. Stricklin et al. (1979), concluded that less active animals reached heavier weights and grew faster than more active and nervous steers.

When all the periparturient traits were included in a multiple regression analysis, 54 and 24% of the variation in 205-d weight was explained among heifer and bull calves, respectively. The number of observations were small, but the trend in these data is strong enough to suggest that the contribution of periparturient behavior of cows and calves to subsequent growth performance of the calves should be a consideration in future research programs.

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IX. APPENDICIES

Tabular Material

TABLE A-1. GROUP COMPOSITION BY WEEK FOR 1985 TRIAL.

Date	No. of cows added		No. of cows removed		Total no. of cows in group	
	Night-fed	Control	Night-fed	Control	Night-fed	Control
2-12	17	17	0	0	17	17
2-20	15	17	0	0	32	34
2-25	22	20	5	3	49	51
3-4	10	7	7	4	52	54
3-11	11	10	14	15	49	49
3-18	7	6	22	16	34	39
3-21	11	9	7	10	38	38
3-27	17	20	15	20	40	38
4-4	0	0	14	15	26	23
4-11	0	0	7	4	19	19

TABLE A-2. **BEHAVIOR PATTERNS AND RESPECTIVE CHUTE SCORES OF GESTATING COWS IN A RESTRAINING CHUTE.**

Category	Description	Chute score
Docile	Stands quietly; may put head through headgate without prodding.	1
Restless	Tries to back out of chute; shakes head; flicks tail occasionally.	2
Nervous	Struggles, bellows, shakes head, may defecate or urinate, may attempt to turn around; moves continuously.	3
Tractable	Stands with head down and extended; stubborn; may kick; may kneel and refuse to get up.	4

Adopted from Ewbank (1961) and Heisler (1979).

TABLE A-3. **EASE OF CALVING SCORE.**

Description of calving	Score
No assistance	1
Easy pull (cow not removed from calving paddock)	2
Hard pull (by chain; cow usually in head-gate restraint)	3
Very hard pull (mechanical pull)	4

TABLE A-4. DESCRIPTIVE RESPONSES AND RESPECTIVE VIGOR (RESTRAINT) SCORES OF NEWBORN BEEF CALVES[a].

Response of calf to restraint	Vigor score
Easy to restrain. Calf remains calm and does not attempt to escape. Weak calf.	1
Vigorous calf but not extremely difficult to restrain. Typically active, alert calf.	2
Very vigorous calf an hard to restrain. Takes longer than average to restrain and treat the calf. Calf exhibits aggressiveness and tries to escape.	3

[a]Scores assigned by herdsman within 24 h of birth at the time of weighing, tattooing, ear-tagging and other routine health practices administered to newborn calves.

TABLE A-5. RECORDING SHEET -- POSTPARTUM BEHAVIOR.

FORM I ANIMAL NO.: BEHAVIOR TRAITS Time	Parturition	Lying	Standing	Eating	Licking/ Grooming	Vocalization		Initial Movement of Calf after Birth.	Attempt to stand up	Standing 1 min. and more.	Mobility of calf walking/running	Teat Seeking	Suckling	Lying Down	Vocalization	Nosing Dam
		D	A	M						C	A	L	F			
.00 0							0									
2							2									
4							4									
6							6									
8							8									
10							10									
12							12									
14							14									
16							16									
18							18									
20							20									
22							22									
24							24									
26							26									
28							28									
30							30									
32							32									
34							34									
36							36									
38							38									
40							40									
42							42									
44							44									
46							46									
48							48									
50							50									
52							52									
54							54									
56							56									
58							58									
60							60									

TABLE A-6. DEGREE OF INITIAL GROOMING OF CALF.

Level of grooming behavior by cow	Score
Moderate	1
Vigorous licking	2
Very vigorous licking	3

TABLE A-7. CORRELATION COEFFICIENTS AMONG PERIPARTURIENT VARIABLES AND 205-D WEIGHT OF ALL CALVES

Variables[a]	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1) PAB	.01	-.02	.16*	-.02	.20**	-.06	.17*	-.17*	-.23**	-.28**	-.24**	-.13	-.13	.09	.09	.07	-.13+
2) AGE		.56**	-.28**	-.19**	.00	.13+	-.04	-.06	-.02	-.06	.11	-.08	-.11	.08	.14	-.05	-.08
3) DWT			-.34**	-.27**	.31**	.15*	.01	.02	.01	-.01	.10	-.01	-.13	-.06	.01	-.08	.05
4) CSC				.13+	-.14*	-.06	.02	.02	.00	.03	.01	-.08	.03	.03	.04	.04	.00
5) CLS					.15*	-.19**	.54**	.35**	.31**	.24**	.18*	-.01	-.07	-.12	-.06	-.12	.06
6) BWT						.14*	-.03	.03	.07	.08	.18*	-.25**	.05	-.07	-.01	-.12	.34**
7) RSC							-.06	-.06	-.07	-.07	.04	-.05	.05	.08	.15+	-.01	.11
8) ATS								.81**	.75**	.62**	.56**	.24**	.19*	-.19*	-.25**	-.04	.03
9) SST									.92**	.79**	.72**	.11	.39**	-.11	-.20*	.01	-.05
10)IMB										.87**	.80**	.10	.47**	-.07	-.15+	.05	-.02
11)ITS											.89**	.04	.35**	-.01	-.03	.01	.00
12)ISK												.04	.29**	.04	-.10	.09	.13
13)IGR													-.16+	-.19*	-.13	-.14	-.09
14)TST														.19*	.44**	-.15+	-.10
15)TGR															.70**	.58**	-.10
16)TMB																.13	.05
17)TSK																	-.21*
18)AWW																	1.00

[a]PAB=percent Angus breeding; AGE=age of dam; DWT=dam weight; CSC=chute score; CLC=calving score; BWT=birth weight; RSC=calf restraint score; AST=attempt to stand; SST=successfully standing IMB=initial mobility; ITS=initial teat seeking; ISK=initial suckling; IGR=initial grooming; TST=total standing; TGR=total grooming; TMB=total mobility; TSK=total suckling; AWW=205 d adjusted weaning weight.

+ P<.10.

**P<.05.

***P<.01.