GROWTH, REPRODUCTIVE DEVELOPMENT AND PERFORMANCE OF HEREFORD HEIFERS CALVING AT 24 OR 30 MONTHS OF AGE

by

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CHAPTER I

INTRODUCTION

The practice of limiting the breeding season and subsequent calving season to a specific period of time is common among range beef cow herds. This practice allows intensified use of labor during these periods that are crucial to insure a high percentage of cows will wean a calf. This practice also places requirements on the replacement heifers entering the breeding herd. If the replacement heifers are to calve by two years of age, they must become pregnant by the time they are fifteen months of age. In addition, there are other important limitations and problems associated with calving heifers at two years of age. Therefore, a cattleman may make a decision to delay the calving of replacement heifers until they have reached three years of age. However, delaying calving of replacement heifers until three years of age results in the loss of one year of production from the cow.

This study was conducted to determine the feasibility of calving replacement heifers at thirty months of age in order to avoid, or at least reduce, the problems associated with calving replacement heifers at two or three years of age. Also included in this study is a comparison of two levels of nutrition prior to first breeding of heifers to calve first at thirty months of age in an effort to establish a recommended level of nutrition to achieve maximum reproductive performance at a minimum cost to the cattleman.

CHAPTER II

REVIEW OF LITERATURE

Factors Influencing the Onset of Puberty

Management schemes based on calving heifers at two years of age require that heifers be mated by 15 months of age. Thus, it is essential that heifers reach puberty by this age. Factors known to influence attainment of puberty include: growth rate and weight, breed, photoperiod, and season.

Growth Rate and Weight

Arije and Wiltbank (1971) studied 310 Hereford heifers born at the Fort Robinson Experiment Station (Nebraska) during two consecutive years and weaned in the fall at approximately 205 days of age. They were wintered on native range and supplemented with .40 kg of 40% crude protein supplement per head per day. The heifers gained .20 kg/head/day during the winter and .80 kg/head/day when grazing without supplementation during the subsequent spring and summer. Puberty was defined as the first ovulatory estrus as detected by marker bulls, and confirmed by rectal palpation of luteal structures on the ovaries. Year of birth had no significant effect on age or weight at puberty, with mean age and weight at puberty of 436 days and 251 kg. Heifers with greater preweaning weight gain tended to reach puberty at an earlier age and at a heavier weight. Average daily gain from weaning to puberty was positively associated with weight and age at puberty, indicating that heifers gaining faster after weaning reached puberty at a heavier weight but not necessarily a younger age. A positive correlation (.57) between age and weight at puberty indicated that older heifers were heavier at puberty. Although date of birth and weight at puberty were not highly associated, the negative correlation (-.24) between date of birth and age at puberty indicated heifers born later reached puberty at a younger age. This suggests that puberty in heifers born early in the calving season may have been delayed until sufficient forage was available for these heifers to grow.

Additional support for a nutritional influence on the critical body weight required for attainment of puberty comes from a study conducted at Miles City, Montana (Short and Bellows, 1971). Eighty nine Hereford x Angus and Angus x Hereford heifers were weaned in the fall, divided into three groups, and fed to achieve body weight gains of .23, .45, and .68 kg/head/day during the winter. Heifers wintered at the low, medium, and high levels of body weight gain reached puberty at an average of 433 days, 238 kg; 411 days, 248 kg; and 388 days, 259 kg, respectively.

Total gain following weaning has a greater influence on attainment of puberty than does the post weaning period in which the gain occurs (Clanton, Jones, and England, 1983). One hundred eighty Angus x Hereford heifers born during three consecutive years and weaned in the fall at approximately 200 days of age and 185 kg were fed in drylot for the entire wintering period of 170 to 185 days. The heifers were fed to gain a total of 100 kg during the wintering period at three different rates: (1) to gain .91 kg/day during the first half of the feeding period, and maintain their weight during the second half; (2) to maintain their weight during the first half of the feeding period, and gain .91 kg/day during the second half; or (3) to gain .45 kg/day during the entire feeding period. Initial and final weights were similar for all treatments. Mean body weight at the beginning of the breeding season on June 5 was 281 kg. Age at first estrus, as detected by vasectomized bulls, was 396 days and was similar for all treatments. The percentage of heifers exhibiting estrus by the beginning of the breeding season was also similar for all treatments, and averaged 88%.

Ferrel (1982) evaluated the effect of breed and post-weaning rate of gain on the attainment of puberty defined as the first standing estrus. His study utilized 405 heifers weaned at an average age of 198 days and fed either chopped brome hay to gain .4 kg/day, chopped brome hay plus corn silage and soybean meal to gain .6 kg/day, or corn silage plus soybean meal to gain .8 kg/day. All diets were fed for 184 days. Heifers fed to achieve the low rate of gain tended to be older (387 days) and weighed significantly less (301 kg) at puberty than those fed to achieve the high rate of gain (372 days; 322 kg). Heifers fed to gain at the medium rate were significantly younger at puberty (365 days) than those fed to gain at the low rate and reached puberty at a body weight intermediate (311 kg) to those fed to gain at low and high rates. Average age and weight at puberty for heifers of the various breeds were: Angus: 410 days and 309 kg; Hereford: 429 days and 302 kg; Red Poll: 355 days and 270 kg; Brown Swiss: 317 days and 305 kg; Charolais: 388 days and 355 kg; and Simmental: 248 days and 328 kg. The low rate of postweaning gain delayed puberty in Red Poll and Brown Swiss heifers but had little effect on the attainment of puberty by Hereford Heifers. Simmental and Red Poll heifers responded to the higher rate of gain by reaching puberty at a younger age, while Angus and Charolais heifers fed at the high level reached puberty at an older age compared to those gaining at the medium level.

Wiltbank, Kasson, and Ingalls (1969) used 74 Angus, Hereford, Angus x Hereford, and Hereford x Angus heifers to determine the influence of nutrition and breed on the attainment of puberty. Heifers were weaned at 127 to 175 days of age and placed on a high or low level of nutrition. There were no differences in age at puberty between breed groups on high nutrition (mean age 381 days), but the average weight at puberty of crossbred heifers was heavier than that of straightbred heifers (330 kg vs 299 kg). The heifers on the low level reached puberty at an older age and lighter weight than did those on the high level. Average age and weight at puberty for heifers on the low level were 572 days and 268 kg for straightbreds and 424 days and 254 kg for crossbreds. These data support other studies which indicate that a minimum body weight must be achieved before heifers attain puberty, and suggest that the body weight required may vary according to genetic makeup and rate of body weight gain.

A Montana study (Steffan, Kress, Doornbos, and Anderson, 1983) compared Hereford and Hereford crossbred heifers born during four consecutive years and weaned in the fall at an average age and weight of 187 days and 193 kg. Heifers were fed in drylot for 140 days. Hereford heifers reached puberty (first estrus) at an older age (407 days) than Angus x Hereford (371 days), 1/4 Simmental 3/4 Hereford (382 days), and 1/2 Simmental 1/2 Hereford (368 days). Weight at puberty was similar for Hereford, Angus x Hereford, and 1/4 Simmental 3/4 Hereford heifers (301, 302, and 305 kg, respectively), but 1/2 Simmental 1/2 Hereford heifers were heavier at puberty (313 kg) than Hereford heifers. A positive correlation (.54) between age and weight at puberty indicated that older heifers were heavier at puberty. This relationship agrees with the results of Arije and Wiltbank (1971).

Anderson, Steffan, Kress, and Doornbos (1983) utilized the same heifers as Steffan *et al*. (1983) to develop a prediction equation for age and weight at puberty. Puberty was defined as first standing estrus, but there was no confirmation of ovulation by palpation for luteal structures. Date of birth and average daily gain were significant predictors of age at puberty, with heifers born earlier in the year reaching puberty at an older age, and faster gaining heifers reaching puberty at an earlier date. Birth weight was a significant predictor of weight at puberty, with heifers having heavier birth weights reaching puberty at heavier weights.

A study was conducted in Nigeria with 60 Zebu heifers on isocaloric diets consisting of corn silage, corn, and cotton seed in varying proportions to yield rations of 19%, 13%, and 8% crude protein, respectively (Oyedipe, Osori, Akerejola, and Saror, 1982). Average age and weight at puberty were 570 days and 207 kg for high protein; 641 days and 187 kg for medium protein; and 704 days and 161 kg for low protein. As should be expected, growth rate also differed significantly between the three treatments and was inversely related to age at puberty.

These studies indicate that heifers gaining faster following weaning reach puberty at a heavier body weight than do heifers gaining at a slower rate. The heifers gaining faster may reach puberty at a younger age than heifers gaining slower because they reach a minimum required body weight sooner. The minimum required body weight required for the attainment of puberty may vary according to genetic makeup of the heifers and may also vary according to the postweaning rate of gain.

Breed

Breed of sire, and breed of dam influence growth rate as well as both age and weight at puberty. Laster, Smith and Gregory (1976) studied 945 heifers produced at the Meat Animal Research Center (Nebraska) from matings of Angus and Hereford cows to Angus, Hereford, Jersey, South Devon, Limousin, Charolais, and Simmental bulls. The heifers were weaned in the fall at an average age of 217 days and group fed a ration of 50% corn silage and 50% grass haylage *ad libitum* plus supplemental protein. Puberty was defined as the first observed standing estrus. Preweaning growth rate increased as age of dam increased from 2 to 5 or more years of age, with ages at puberty of 387, 368, 353, and 357 days, and weights at puberty of 258, 267, 269, and 276 kg for 2, 3, 4, and 5 years or older dams, respectively. Average daily gain from weaning to 400 days of age decreased as age of dam increased, indicating more rapid gain by heifer calves from younger dams. However, the compensatory gain did not allow these heifers to reach puberty at an earlier date. Calves from Angus dams were 11 kg heavier at weaning and 9 kg heavier at 400 days of age than calves from Hereford dams and reached puberty an average of 26 days younger and at an average weight 9 kg less than heifers from Hereford dams. Jersey crosses were youngest and lightest at puberty: 322 ± 7 days and 219 ± 5 kg; followed in order by South Devon crosses (364 ± 6 days and 274 ± 4 kg), straightbred Angus (366 ± 8 days and 255 ± 5 kg), Hereford-Angus crosses (371 ± 7 days and 266 ± 5 kg), Simmental crosses (372 ± 6 days and 286 ± 4 kg), Charolais crosses (398 ± 7 days and 303 ± 5 kg) and straightbred Herefords (415 ± 8 days and 274 ± 5 kg).

An earlier study by Laster, Glimp, and Gregory (1972) with 337 heifers produced from the same matings and managed in the same manner revealed that a significantly higher percentage of heifers from Angus dams attained puberty by 15 months of age (95 ± 3%) than those from Hereford dams (71 ± 3%). Fewer Hereford and Limousin-cross heifers reached puberty by 15 months of age than other breed groups, 48 ± 7% and 42 ± 6%, respectively vs 83 ± 2%. A correlation of .23 between age and weight at puberty was lower than estimates of .57 made by Arije and Wiltbank (1971) and .54 reported by Steffan et al. (1983).

Gregory, Laster, Cundiff, Koch, and Smith studied 536 heifers born in the spring during two consecutive years. Heifers were produced by a four breed diallel crossing design utilizing Red Poll, Brown Swiss, Hereford, and Angus breeds. Heifers from Brown Swiss dams were heavier at puberty (300 ± 5 kg) than those from Hereford and Angus dams (276 ± 2, and 279 ± 2 kg, respectively). Heifers from Red Poll dams were intermediate (288 ± 3 kg). Heifers from Brown Swiss dams were younger at puberty (322 ± 7 days) than were heifers from Red Poll and Angus dams (353 ± 5, and 353 ± 4 days, respectively). Heifers sired by Red Poll bulls were lighter at puberty (276 ± 3 kg) than those sired by Brown Swiss, Hereford, and Angus bulls (298 ± 3, 288 ± 3, and 290 ± 3 kg, respectively). Heifers sired by Hereford bulls were older at puberty (365 ± 5 days) than those sired by Angus, Red Poll, and Brown Swiss bulls (355 ± 5, 345 ± 5, and 340 ± 5 days, respectively).

A Nevada study (Dow, Moore, Dailey, and Foote, 1982) evaluated 146 Hereford, Red Poll, and Hereford-Red Poll reciprocal cross heifers born in the fall of four consecutive years. Breed differences were observed for heifers reaching puberty at 15 and 19.5 months of age. At 15 months of age, 38 ± 7% of the Hereford heifers had reached puberty, and at 19.5 months 68 ± 6% had reached puberty, while 82 ± 6%, and 96 ± 5% of the Red Poll heifers had reached puberty by 15 and 19.5 months of age, respectively. Percent of heifers reaching puberty by 15 and 19.5 months of age for the crossbred heifers were: Red Poll x Hereford: 90 ± 7% and 95 ± 6%; and Hereford x Red Poll: 92 ± 7% and 95 ± 6%. Body weights of Hereford, Red Poll x Hereford, and Red Poll heifers were similar at 19.5 months (300 ± 6, 297 ± 6, and 306 ± 6 kg, respectively), while Hereford x Red Poll heifers were heavier (324 ± 6 kg).

These studies indicate that Hereford heifers consistently reach puberty at an older age than the other breeds of heifers studied. However, the average weight at puberty of Hereford heifers is heavier than that of Angus, Jersey-crosses, and Red Polls, and lighter than that of Charolais, Charolais-crosses, Simmental, and Simmental-crosses. Therefore, Hereford heifers may not begin cycling as soon as Angus, Jersey-cross, or Red Poll heifers even though they are heavier at that point in time.

Photoperiod and Season

Exposure to increased amount of light has been demonstrated to hasten the onset of puberty in heifers and increase average daily gain and improve feed efficiency. Since photoperiod varies with season, it is logical to expect seasonal differences in the onset of puberty. Also, season of birth influences growth rate, which may be partially responsible for differences in age and weight at puberty.

Hansen, Kamwanja, and Hauser (1983) conducted two trials to determine the effect of photoperiod on age at puberty. In trial 1, 16 Angus and Angus-crossbred heifers born from April to July were paired according to birth date, and assigned within pair to chambers programmed for 18 hours of light per day or natural photoperiod. Puberty was considered to be age at first ovulation detected by concentration of progesterone in serum greater than 1.0 nanogram/milliliter for two bi-weekly samples in succession.

Average daily gain was similar for heifers exposed to 18 hours of light (.52 ± .07 kg/day) and those under natural photoperiod (.43 ± .07 kg/day). However, heifers exposed to 18 hours of light were younger at first extrus and first ovulation (318 ± 9, and 312 ± 12 days, respectively) than those exposed to natural photoperiod (367 ± 4, and 367 ± 4 days, respectively). Heifers exposed to 18 hours of light were lighter at first estrus (286 ± 8.5 kg) than those exposed to natural photoperiod (324 ± 8.5 kg).

The second trial involved 22 Angus x Holstein heifers born in March and May, and managed similarly to heifers in trial 1. Heifers were assigned within month of birth to photoperiod treatments beginning at 24 weeks of age. Results revealed that heifers exposed to increased photoperiod were lighter at first estrus (293 ± 13 kg), and tended to be younger (367 ± 17, and 360 ± 18 days) at first estrus and first ovulation, respectively, than those exposed to natural photoperiod (329 ± 13 kg, 394 ± 10, and 389 ± 12 days, respectively).

Effects of photoperiod and plane of nutrition on growth and attainment of puberty were studied by Petitclerc, Chapin, Emery and Tucker (1983) using 60 Holstein heifers on either a high or low plane of nutrition, and 8 hours light:16 hours dark or 16 hours light:8 hours dark. Average daily gain of heifers exposed to 16 hours light:8 hours dark was 18% and 10% greater than those exposed to 8 hours light:16 hours dark for high and low planes of nutrition, respectively. No photoperiod by plane of nutrition interaction was observed. A tendency existed for heifers exposed to increased light or the low plane of nutrition to reach puberty at a lighter weight, while heifers on the high plane of nutrition or exposed to increased light reached puberty at a younger age.

A study carried out at Madison, Wisconsin, by Schillo, Hansen, Kamwanja, Dierschke, and Hauser (1983) evaluated the effect of season during the first and second 6 months of life on growth and attainment of puberty in 28 Angus x Holstein heifers born in March or September. Heifers were developed under natural conditions from birth until 6 months of age when they were placed in photoperiod and temperature environmental chambers, and exposed to the naturally occurring changes typical of the following seasonal sequences; a consecutive spring-summer-fall environment; or a consecutive autumn-winter-spring environment. Puberty was considered to be first observed estrous activity with ovulation confirmed by palpation of ovaries, and an increase of progesterone concentration in serum. No clear-cut pattern of influence of season on average daily gain could be established. Heifers born in September reached puberty at a younger age (307 days) than those born in March (334 days), and exposure to spring-summer-fall conditions during the second six months of life hastened the onset of puberty (308 days) opposed to exposure to fall-winter-spring conditions (333 days). Heifers that were younger at puberty also tended to be lighter at puberty. Heifers exposed to two consecutive spring-summer-fall environments reached puberty at an age and weight similar to those exposed to two consecutive fall-winter-spring environments (321 days, 281 kg; and 319 days, 307 kg, respectively). Heifers exposed to normal seasonal changes reached puberty at ages and weights according to the respective seasonal environments under which they were developed during the second 6 months of life (spring-summer-fall were younger and lighter than fall-winter-spring).

Grass, Hansen, Rutledge, and Hauser (1982) studied 62 Hereford and Holstein heifers born at Madison, Wisconsin, in the winter or spring and placed on either a high plane (65% TDN) or low plane (52% TDN) of nutrition. Puberty was considered to be the first standing estrus with confirmation of ovulation by rectal palpation of ovaries. Their data revealed that Holstein heifers were younger at puberty (342 days) than Herefords (431 days). Holstein heifers also tended to be lighter at puberty (283 kg) than Hereford heifers (297 kg). Heifers on the high plane of nutrition were younger and heavier at puberty (369 days, 307 kg) than those on the low plane (404 days, 273 kg). Heifers born in winter tended to be older at puberty (394 days) than those born in spring (379 days), which disagrees with the results of Schillo _et al_. (1983). Similarly, heifers born in winter were heavier at puberty (303 kg) than those born in spring (278 kg), which also disagrees with the study by Schillo et al. (1983).

A study conducted by Little, Mallinson, Gibbons, and Rowlands (1981) used 116 British Friesian heifers born in all seasons, and developed on differing planes of nutrition. Their data support the results obtained by Grass et al. (1982) that heifers born in winter were older at puberty than those born in spring, but body weight at puberty was similar for heifers born in winter and heifers born in spring. Nutritional treatments resulted in average daily gains of .58, .68, .75, .82, and 1.06 kg/day. The correlation between age at puberty and body weight at puberty was .71, which was larger than previously published values (Arije and Wiltbank, 1971; Steffan et al., 1983; and Laster, Glimp, and Gregory, 1972). Average daily gain and weight at puberty were highly associated (.48), while average daily gain and age at puberty were negatively associated (-.10).

Artifically increased daylength hastens the onset of first estrus and first ovulation regardless of its effects on average daily gain. Seasonal influence on the onset of puberty was demonstrated by comparisons of age and weight at puberty of heifers born during different seasons of the year, however, mixed results were obtained. The seasonal changes were artifically produced, and heifers that gained faster reached puberty at a younger age and at a heavier weight.

Influence of Nutrition Prior to First Breeding on Conception and Pregnancy

The timing and magnitude of body weight gain prior to the breeding season affects the time interval to conception, and the rate of conception during the breeding season. Control of nutritional plane during the wintering period before the spring breeding season has been used to study the influence of body weight gain and reproductive performance.

Lemenager, Smith, Martin, Singleton, and Hodges (1980) conducted three trials with a total of 337 crossbred heifers born in the spring of three consecutive years. The heifers were weaned at approximately 210 days of age, and fed fescue hay <u>ad</u> <u>libitum</u> in drylot during the winter plus either no ground ear corn, 1.22 kg ground ear corn/head/day, or 2.45 kg ground ear corn/head/day. The duration of the winter feeding period varied, being 113, 153, and 150 days in trials 1, 2, and 3, respectively. At 13 to 15 months of age, the heifers were placed on pasture in late April near the beginning of a 60-day breeding season. The heifers in trials 1 and 2 received no supplemental feed on pasture during the breeding season. However, in trial 3, half of the heifers received 2.45 kg ground ear corn/head/day in addition to pasture during the breeding season while the other half were not supplemented. Results from trials 1, 2, and 3 revealed winter nutritional treatment differences for average daily gain (.03 kg/day with no ground ear corn: .22 kg/day with 1.22 kg ground ear corn; and .35 kg/day with 2.45 kg ground ear corn). Condition scores (scale = 1 to 5) at the end of the wintering period were also different, and averaged 2.02, 2.69, and 3.02 for heifers on the low, moderate, and high nutritional treatments, respectively. Conception rate and number of days pregnant were determined by rectal palpation 65 days after the breeding season had ended. Fewer of the heifers fed only hay conceived (69.25%), and conceived later (number of days pregnant = 42.8) than those fed 2.45 kg ground ear corn (83.5% and 63.6 days). Heifers fed 1.22 kg ground ear corn had reproductive performance that was intermediate compared to the other treatments, and did not differ from heifers on the other treatments (79.3% and 55.8 days).

Average daily gain for the heifers in trial 3 that were supplemented during the breeding season was .66 kg/day compared to .45 kg/day for the unsupplemented heifers. However, supplementation did not affect conception rate (85.1% vs 85.9%), number of days pregnant (73.2 vs 81.4 days), and weaning weight of calves (212.1 vs 196.2 kg).

Turman, Pope, and Stephens (1965) utilized 122 Hereford heifers in three repetitions at the Fort Reno Research Station. The heifers were born in the spring, weaned in the fall, and wintered from November 15 to April 15 on dormant native grass pasture supplemented with cottonseed meal and milo at low, moderate, or high nutritional intakes. The diets were defined on the basis of weight changes during the wintering period as follows: Low - no weight gain or loss during the wintering period; Moderate - average daily gain of .23 kg; and High - average daily gain of .45 kg. The heifers were exposed to bulls from May 1 until August 1 each year. Heifers on the high level of winter supplement calved 2.5 weeks earlier than did heifers on the low level, and 1.5 weeks earlier than heifers on the moderate level. Rebreeding performance of high level heifers was superior to that of the moderate and low level heifers. During the first 21 days of the breeding season, 66% of the high level heifers conceived, compared to 31% of the moderate level heifers and 3% of the low level heifers. Conception rates within 42 and 63 days of the breeding season were greater for the high level heifers (90% and 100%, respectively) than for the moderate level heifers (64% and 82%, respectively) or for the low level heifers (32% and 64%, respectively).

A Montana study by Varner, Bellows, and Christiansen (1977) evaluated 59 crossbred heifers (1/2 Charolais 1/4 Hereford 1/4 Angus) assigned on the basis of weight at 7 months of age to 3 feeding groups from November 20 to May 5 in a drylot. One complete, mixed ration of alfalfa-grass hay, grain, and mineral was fed to all three groups. The amount fed to each group was adjusted to obtain the desired weight gains. An average target weight of 295 kg for all heifers was set for May 5, at which time heifers were placed on native range through a 45 day A.I. period beginning June 15. Twenty heifers representative of all ages and weights (mean weight = 194 kg) were assigned to group 1. Twenty heavier heifers (mean weight = 210 kg) were assigned to group 2, and 19 lighter heifers (170 kg) were assigned to group 3. The lighter heifers in group 1 were lighter at the end of the wintering period, and at the beginning of the breeding season (266.8 kg and 281.8 kg, respectively) than the heifers in group 3 (306.8 kg and 304 kg, respectively). The lighter heifers in group 1 did exhibit compensatory gain on pasture (.71 kg/day) compared to the heifers in group 3 (.57 kg/day), but reproductive performance was still reduced compared to heifers in group 3. Sixty percent of the light heifers in group 1 were cycling by June 15, compared to 79% of the heifers in group 3 that were cycling. Heifers in group 3 also conceived earlier in the breeding season (average of 14 days) than the lighter heifers in group 1 (average of 19.9 days). Pregnancy rate in October for heifers in group 3 was greater (79%) than for the lighter heifers in group 1 (60%). These data indicate that for optimum reproductive performance, lighter heifers should be managed separately from heavier heifers.

Turman, Pope, Watkins, Pinney, McNutt, and Stephens (1963) conducted a trial at the Fort Reno Research Station to compare the response of heifers provided continuous or restricted summer grazing following a wintering period on three levels of supplemental feeding. The trial utilized a total of 105 Hereford heifers. During the wintering period from November 15 to April 15, three groups of 30 heifers each were supplemented on dormant native grass range at either a low, moderate, or high level as described previously (Turman, Pope, and Stephens, 1965). An additional group of 15 heifers were fed at a low-high level which was defined as the low level until March 15, followed by the high level until the beginning of the breeding season on May 1. At the end of the wintering period, one half of the heifers on the low, moderate, and high levels were allowed continuous grazing, and the other half were restricted to grazing only three days per week to simulate a drought year with short grass. The low-high level heifers were allowed continuous summer grazing.

As might be expected, the heifers on the high level of nutrition had the best reproductive development. Of the 30 heifers on the high level of winter gain, 19 had established regular estrous cycles before the start of the breeding season on May 1, compared to 16 of 30 heifers on the moderate level, none of the 15 heifers on the low level restricted grazing group, and only one of 16 heifers on the low-high level. Data were not available for the heifers wintered at the low level and allowed continuous summer grazing since they were not checked for estrus prior to the breeding season. Average ages at first estrus were:

high: 353 days; moderate: 373 days; and low: 386 days. Restricted summer grazing did not adversely affect age at first estrus for heifers on the high level, but age at first estrus was delayed 30 days in the moderate level heifers that were subjected to restricted summer grazing. Although average date of first breeding and average date of first conception were approximately one week later for the moderate level heifers than for the high level heifers, these dates were not affected by restricted summer grazing.

The low level of winter feeding did reduce breeding performance, especially if followed by a summer of restricted grazing. The heifers wintered at the low level and allowed continuous summer grazing had a conception rate of 73.3%, and an average conception date three weeks later than that of the heifers wintered at the high level. Heifers wintered at the low level and subjected to restricted summer grazing had a conception rate of 53.3% and average date of conception was one month later than the average for the high group. In comparison, the conception rate for the moderate and high level groups was 93.3%. Breeding performance of the low-high level heifers was very similar to that of heifers on the moderate level, except their average date of conception was one week later. This study indicates that the low level of winter feeding does not allow satisfactory reproductive performance, even under conditions of good summer grazing. The moderate level would be recommended as the level that permits satisfactory reproductive performance while keeping feed costs to a minimum.

A Kansas study by Fleck, Schalles, and Kiracoffe (1980) utilized 156 Polled Hereford heifers over a three-year period. The heifers were born in the spring, and weaned in the fall. During the winter, the heifers were on various high roughage diets that allowed gains from .09 to .9 kg/head/day. Heifers with low body weight gains during the wintering period (<95 kg total gain) had first service conception rates during the 60-day breeding season of only 19% as compared to 49% for heifers with moderate weight gain (95-132 kg total). Conception rate of heifers with high weight gains (>132 kg) was intermediate (33%), and not different from the low and moderate level heifers. Final conception rates for the 60-day breeding season did not differ among winter gain groups (90%, 93%, and 94%) for low, moderate, and high, respectively.

An Arkansas study by Aman, Brown, and Ray (1981) evaluated the reproductive performance of 332 crossbred heifers over a three-year period. The heifers were born in the fall, and weaned in the summer at average ages of 272, 280, and 268 days for the three years, respectively. Heifers were placed with bulls at an average age of 15 months for a 90-day breeding season. Calving rate for the three years of the study was 63.9%. Heifers that calved were heavier at weaning (224 ± 3 kg) than heifers that did not calve (209 ± 3 kg). Fall weight prior to breeding was heavier for heifers that calved (290 ± 3 kg) than for heifers that did not calve (258 ± 5 kg). Heifers that calved gained more weight from weaning to the fall prior to breeding (.3 ± .01 kg/day) than heifers that did not calve (.1 + .03 kg/day).

Factors Influencing Dystocia in Heifers and Subsequent Reproductive Performance

Calf Birth Weight

Increased calf birth weight has been found to be associated with increased dystocia in heifers. Unless specified otherwise, calving difficulty scores presented in the following sections are based on a scale of 1 to 4, with a score of 1 meaning no difficulty during parturition, and a score of 4 meaning extreme difficulty requiring the use of a mechanical puller or a Cesarean section.

Bellows, Short, Anderson, Knapp, and Pahnish (1971) studied 95 Hereford and 103 Angus heifers bred to Angus or Hereford bulls to produce crossbred calves at 24 months of age. Heifers were fed a ration of grass-alfalfa hay plus a grain mix in drylot for the entire gestation period. Male Angus x Hereford calves were heavier at birth (33.3 kg) than female calves (30.7 kg), but there was no significant difference due to sex for Hereford x Angus calves (male: 31.2 kg, and female: 30.2 kg). Sixty-eight percent of Hereford heifers, and 62.7% of Angus heifers giving birth to bull calves required assistance (mean calving score = 2.05 ± .9, and 1.85 ± .8, respectively), while only 27.3% of Hereford heifers and 34.1% of Angus heifers giving birth to heifer calves required assistance (mean calving score = 1.31 ± .5, and 1.45 ± .7, respectively). Correlation coefficients for calving difficulty and calf birth weight was .54 and .48 for Hereford and Angus dams, respectively. Birth weight was also positively associated with weight of dam at the end of the breeding season (.33 and .33); at midgestation (.39 and .38); and prior to calving (.37 and .36); and with weight gain of dam during the first half of gestation (.28 and .18) for Hereford and Angus dams, respectively. Weight gain of the dam during the second half of gestation was not associated (-.01 and .04) with calf birth weight.

Rutter, Ray, and Roubicek (1983) evaluated 476 Charolais heifers in southeast Arizona that were artificially inseminated at approximately 15 months of age with semen from Charolais or Brahman bulls. Calf birth weights were classified into six categories for statistical analysis: 13.5 to 32.5 kg, 32.5 to 36.4 kg, 36.5 to 40.4 kg, 40.5 to 45.4 kg, 45.5 to 50.0 kg, and >50 kg. The regression model, which included calf birth weight, calf sex, breed of sire, pelvic height, yearling weight, gestation length, and age at conception, accounted for 24% of the variation in dystocia at first parturition. Calf birth weight accounted for the greatest portion of the explained variation (71%). A greater number of bull calves were classified in the three heaviest birth weight categories (45%) than were heifers (25%), and mean calving difficulty score increased with birth weight category. There was no significant increase in calving difficulty score for heifer calves until the heaviest category (>50 kg) was reached, and heifers producing bull calves with birth weights >50 kg exhibited the greatest degree of calving difficulty.

A New Mexico study by Ruttle, Javalera, Wallace, and Parker (1982) used 67 range-raised Hereford x Angus heifers artifically mated at approximately 14 months of age to one Angus bull. Heifers remained on range during gestation until shortly before calving. Mean birth weight was lighter (31.2 kg) for heifers with calving scores of no assistance and slight assistance (grouped) than for heifers with scores of considerable and extreme assistance (34.1 kg). Calf birth weight was also found to be correlated with head width (.23) and shoulder width (.34).

Bolze, Pruitt, and Corah (1983) studied records from two herds in Kansas from 1,495 Simmental heifers calving in spring and fall, and Angus heifers calving in the fall. Heifers requiring assistance gave birth to heavier calves than those calving unassisted: Simmental-spring (36.7 vs 32.0 kg): Simmental-fall (34.9 vs 32.4 kg); and Angus-vall (32.9 vs 30.1 kg).

Laster, Glimp, Cundiff, and Gregory (1973) evaluated calving difficulty over a four-year period in 1,889 Angus and Hereford cows mated to Angus, Hereford, Jersey, South Devon, Limousin, Simmental, and Charolais bulls. Ninety-five heifers calved as two-year-olds in year one. With each kilogram increase in calf birth weight, calving difficulty increased 2.3 ± .21%. Hereford-Angus reciprocal cross calves were 1.55 ± 2.6 kg heavier than straightbred Hereford and Angus. Bull calves were heavier (35.1 ± 1.8 kg) than heifer calves (32.1 ± 1.8 kg), and their dams exhibited more dystocia than dams producing heifer calves (28.4 ± 1.7% vs 17 ± 1.7%). Mean calf birth weights were 17.7 ± 3.4 kg, and 35.17 ± 3.3 kg in Hereford and Angus cows, respectively. Mean calf birth weight for all crosses increased from two-year-old dams (31.5 ± 1.9 kg) to three, and four- and five-year old dams (34.2 ± 2.5, and 35.1 ± 2.5 kg, respectively).

Burfening, Kress, Friedrich, and Vaniman (1978) studied records from the American Simmental Association involving 350,000 calves sired by 565+ Simmental bulls, and found that bull calves were heavier at birth (39.8 .4 kg) than heifer calves (36.8 ± .4 kg), and birth weight increased approximately .25 kg/day during gestation, but the increase was not linear. Birth weight increased with age of dam, but no increase was observed from two-year-old to three-year-old dams. Gestation length had little influence on calving difficulty independent of birth weight. They observed a 2.64% increase in assisted births per kilogram increase in birth weight.

An Australian study of 375 Angus, Friesian, and Angus-Friesian crosses mated to Angus bulls (Alexson, Cunningham, and Pullen, 1981) also found that calves from heifers that exhibited dystocia were 2.3 kg heavier than those from heifers that did not. Bull calves weighed 1.8 kg more than heifer calves.

Bellows and Short (1978) reported an association between birth weight and calving difficulty in an experiment carried out at Miles City, Montana. Trial 1 involves 62 Angus x Hereford heifers on high energy (6.3 kg TDN) or low energy (3.4 kg TDN) rations for 90 days in drylot prior to calving. Mean birth weight for calves from the high level heifers was heavier (28.5 kg) than for those from the low level heifers (26.6 kg). The mean birth weight of heifer calves from high level heifers tended to be lighter (27.8 kg) than that of bull calves (29.1 kg). As a result of heavier birth weights, the high level heifers producing bull calves exhibited a higher percentage of difficult calving (50%) than did the heifers producing heifer calves (22%). The low level diminished differences in birth weight of heifer and bull calves, and there was less difference in calving difficulty (46% and 34% for heifers producing bull and heifer calves, respectively). Trial 2 utilized 23 Angus x Hereford and Hereford x Angus heifers bred to calve at two years of age, and 51 Angus and Hereford cows (four years old). Both heifers and cows were fed either a high energy (6.4 kg TDN) or low energy (3.2 kg TDN) ration for 90 days in drylot prior to calving. The low level of nutrition reduced the birth weight of calves produced by the heifers (28.6 kg) compared to those from heifers on the high level of nutrition (32.7 kg). The same effect was not observed in the cows (33.8 kg vs 33.7 kg). Calving difficulty was neither different between high level (59%) and low level heifers (60%), nor between high and low level cows (0% in each level).

Another Montana study by Bellows, Short, and Richardson (1982) evaluated 48 Angus x Hereford heifers bred to calve at two years of age, and 54 Angus x Hereford cows. They were bred to one of two Charolais sires selected for either a moderate or heavy birth weight, and then fed either high energy (6.8 kg TDN) or low energy (3.6 kg TDN) rations for 90 days in drylot prior to calving. Cows gave birth to heavier calves (38.0 kg) than heifers (34.0 kg), and calves by the sire selected for heavier birth weight were heavier (37.4 kg) than those by the sire selected for moderate birth weight (34.6 kg). As expected, bull calves were heavier (38.0 kg) than heifer calves (34.1 kg). Birth weight differences paralleled calving difficulty score differences for male and female calves (2.44 vs 1.86), but not for sire groups (2.14 and 2.16), or nutrition treatment (2.30 and 1.99), which indicates the influence of additional factors such as body dimensions on the incidence of dystocia since bull calves exceeded heifer calves in all skeletal dimensions studied with the exception of body length.

A Canadian study by Dufour, Fahmy, and Roy (1981) involved 167 Holstein and Ayrshire heifers bred at 12 months of age to Angus, Limousin, and Chianina bulls. Calves born to heifers in the difficult calving classification were 4.6 kg heavier than those in the easy calving category. The heifers were bred to Chianina and Simmental bulls the second year, and heifers classified in the difficult calving group had calves that were 4.1 kg heavier than those from heifers classified as easy calving.

A two-year experiment by Wiltbank and Remmenga (1982) studied 439 yearling Angus and Hereford heifers artifically mated to Angus and Hereford bulls in the feedlot. The heifers were kept in drylot from the time pregnancy was diagnosed (35-50 days post-breeding) until approximately 120 days prior to parturition when they were placed on a high energy (13.3 Mcal ME) or low energy (7.3 Mcal ME) diet. Mean birth weight for calves from heifers on high energy diets was heavier (33.1 kg) than for those on the low energy diet (30.4 kg) even though gestation length was shorter (280 vs 283 days). There was no difference in calving score between the two groups (1.77 and 1.70, respectively). Hereford heifers gave birth to heavier calves (32.7 kg) than did Angus heifers (30.9 kg), and mean calving score and percent difficult births paralleled birth weights (Herefords 1.86 and 41%; Angus 1.6 and 29%).

The gestation length was three days longer for Hereford heifers (283 days) than for Angus heifers (280 days). Heifers bred to Angus bulls also had gestation intervals three days shorter (280 days) than did heifers bred to Hereford bulls (283 days). Similar results were obtained during the second year of the study, but heifers on the high level of nutrition experienced greater calving difficulty (mean score = 1.72, and 33% difficult calvings) than those on the low level of nutrition (1.3 and 16%, respectively). Breed differences were not observed in year two. Correlations between calving difficulty and birth weight were .21 and .30 for years one and two, respectively. Correlations for birth weight and gestation length were .26 and .02 for years one and two, respectively.

A Texas study by Elliot, Riggs, and Long (1981) analyzed records of 3,493 Charolais calves from heifers and cows in a single herd. Calves from difficult births were 4.5 kg heavier than the mean birth weight for all calves. Bull calves were 2.7 kg heavier than heifer calves, and experienced 5.7% more difficult births.

Sex of Calf

There is general agreement among researchers that bull calves have heavier birth weights than do heifer calves, and cows producing bull calves experience more calving difficulty. Bellows *et al.* (1971) reported that heifers giving birth to bull calves required assistance more frequently (64.6%) and experienced more difficulty (mean score = 1.93) than heifers giving birth to heifer calves (30.3%, and 1.37). The independent effect of sex ranked second to birth weight for influence on calving difficulty, and suggested there were other factors associated with bull calves that resulted in more calving difficulty.

Rutter, Ray, and Roubicek (1983) also found calf sex to be the second most important factor influencing dystocia since it accounted for 14% of the explained variation (R^2 = .24). As discussed in a previous section, there was a significant increase in calving difficulty among heifers producing bull calves heavier than 45.5 kg, while heifers producing heifer calves showed no significant increase in calving difficulty until birth weights of >50 kg were reached. These observations demonstrate an effect due to sex of calf which is separate from calf birth weight.

Laster et al. (1973) found the predicted difference in calving difficulty between male and female calves was 6.95% using a regression coefficient, while the observed difference was 11.42%. These authors believed calf anatomy could have been a contributing factor.

Burfening et al. (1978) noted that bull calves had gestation intervals 1.1 days longer than heifer calves, and as previously stated, were heavier at birth with 12.7% more requiring assistance.

Wiltbank and Remmenga (1982) found that heifers giving birth to bull calves experienced dystocia approximately twice as often as those giving birth to heifer calves, and that level of nutrition did not influence calving difficulty. They felt the difference in calving difficulty between sexes was related to birth weight.

Bellows, Short, and Richardson (1982) examined skeletal dimensions, and found that male calves exceeded female calves in head width (12.6 vs 12.2 cm); head circumference (49.4 vs 48.4 cm); heart girth (74.6 vs 72.7 cm); hip width (16.1 vs 15.7 cm); thigh width (19.6 vs 18.9 cm); and leg length (69.5 vs 66.3 cm). Gestation interval and body length were not different, but mean calving difficulty score for males was greater (2.44) than for females (1.86).

Dufour, Fahmy, and Roy (1981) conducted two experiments, and classified calves as easy or difficult calvers. In both experiments, there were no differences in either nose or head circumference between easy and difficult calving groups of bull calves. However, there were differences in both nose and head circumference between easy and difficult calving groups for heifer calves.

Axelson, Cunningham, and Pullen (1981) obtained head circumference and shoulder measurements which influenced calving difficulty. However, they felt these measurements could be unreliable since they were difficult to obtain.

Thomson and Wiltbank (1983) measured the heart girth of 127 calves and found that 15% more heifer calves than bull calves had a heart girth <72 cm, and 9% more bull calves than heifer calves had a heart girth >76 cm.

However, heart girth did not explain the increased occurrence of calving difficulty in bull calves (20%) vs heifer calves (9%).

Ruttle et al. (1982) reported correlations of .23 between head width and birth weight, and of .34 between shoulder width and birth weight. They also found that head and shoulder width differed between dystocia groups when scores were grouped into no assistance and slight assistance, and compared against considerable assistance and extreme dystocia.

Laster (1974) used data taken from 599 two-year-old heifers, and reported that calf shape measurements had no effect of dystocia when analyzed separately from birth weight. A multiple correlation between five calf shape measurements (shoulder width, hip width, chest depth, wither height, and body length) and birth weight was .75.

Pelvic Area

Many researchers have taken pelvic measurements of heifers at various times prior to or after parturition in an effort to account for some of the difficulty experienced during parturition. A common measurement used is pelvic area, which is determined by multiplying internal pelvic width by internal pelvic height. Some studies have been able to account for a portion of calving difficulty due to pelvic dimensions, but others have found that pelvic area accounts for very little or none of the difficulty.

Ruttle *et al.* (1982) reported that heifers calving with no assistance or slight assistance had significantly larger pelvic areas than those requiring assistance. However, he found a non-significant correlation between body weight and pelvic area (.09) at approximately two months prior to calving.

Bellows *et al.* (1971) obtained pelvic measurements five days prior to the start of the calving season, and found that of all factors contributed by the dam, pelvic area had the most influence on dystocia in Hereford heifers and the second most influence in Angus heifers. They reported that pelvic height and width were highly correlated with pelvic area (Hereford: .80 and .71; Angus: .74 and .67, respectively). Pelvic area was also positively associated with weight at the end of the breeding season (Hereford: .40, Angus: .46); weight at mid-gestation (.45 and .52, respectively); and precalving weight (.41 and .48, respectively).

Axelson, Cunningham, and Pullen (1981) observed that Angus heifers with dystocia had smaller pelvic areas at the beginning of the breeding season (157 vs 164 cm^2), and before calving (208 vs 222 cm^2) than those calving without assistance. In addition, they reported that heifers experiencing dystocia also gave birth to calves that were 2.3 kg heavier than those calving normally.

Dufour, Fahmy, and Roy (1981) obtained pelvic measurements at time of first breeding, and at 270 days of gestation for two consecutive years. Cows experiencing two difficult calvings had smaller pelvic areas at first breeding (150.6 cm^2) than did cows with two easy calvings (170.1 cm^2); an easy calving followed by a difficult calving (171.7 cm^2); or a difficult calving followed by an easy calving (173.2 cm^2). Cows that did not experience dystocia the first year were 23.0 kg heavier and had pelvic openings 21.7 cm^2 larger at day 150 of the first year gestation than did those that experienced dystocia. Cows that experienced dystocia at second calving had smaller pelvic areas at 270 days of gestation (281 cm^2) than those experiencing no calving difficulty (297 cm^2). These researchers also found that cows experiencing calving difficulty also gave birth to heavier calves (8.5% heavier) than did cows experiencing no calving difficulty.

Not all researchers have found a relationship between pelvic size and dystocia. Rutter, Ray and Roubicek (1983) observed that pelvic height measured at one year of age accounted for only approximately 5% of the explained variation in calving difficulty, and therefore was of little value for predicting dystocia.

Thomson and Wilbank (1980) did not find a relationship between pelvic size and dystocia in dairy heifers as has been reported for beef heifers. Pelvic area measurements within 60 days prior to calving in 127 Holstein heifers were divided into three groups (<294 cm^2, 294-332 cm^2, and

>332 cm^2). Incidence of heifers requiring hard pulls were 11%, 14%, and 12% for the three pelvic area groups, respectively. The correlation between pelvic area and dystocia was zero. Vertical and horizontal pelvic measurements were positively correlated with pelvic area (.89 and .79, respectively).

Laster (1974) investigated factors influencing pelvic size in 312 crossbred yearling heifers, and 611 crossbred two-year-old heifers. Yearling heifers were measured seven days prior to the breeding season when they were 13 to 14 months of age. Two-year-old heifers were measured 20 to 25 days prior to the calving season when they were 22 to 23 months of age. The two-year-old heifers were in two groups, one of which (group 2) was on low, medium, and high levels of nutrition prior to calving. Mean pelvic area of the yearling heifers was 214 ± 1 cm^2 and was influenced by breed of sire and breed of dam. Mean pelvic area in the two-year-old heifers of group 2 that were fed three different energy levels prior to calving was 236 ± 1 cm^2, and was influenced by breed of sire, breed of dam, precalving energy level, age, body weight at time of pelvic measurement, condition score, and muscling score. These variables accounted for 33% of the variation in pelvic area, and body weight was the largest source of variation. Pelvic area of two-year-old heifers in group 1 was 232 + 1 cm^2, and was influenced by breed of sire and breed of sire x breed of dam interaction, which accounted for 24% of the variation. Dystocia in the two-year-old heifers from group 1 was influenced by breed of sire of cow, breed of sire of calf, pelvic height, and condition score, which accounted for 26% of the variation. Inclusion of calf sex, calf birth weight, and five calf skeletal measurements allowed the model to account for 39% of the variation. Dystocia in two-year-old heifers from group 2 was significantly influenced by pelvic width, which, along with all variables studied before calving, accounted for 5% of the variation. Addition of calf sex, calf birth weight, and five calf skeletal measurements allowed the model to account for 25% of the variation in dystocia. No threshold points for the influence of pelvic size on dystocia were revealed, and percentage of dystocia did not decrease as pelvic size increased in 19 cm^2 increments.

Regression of pelvic area and calf birth weight on heifer weight indicated that larger heifers have larger pelvic areas, but proportionately even larger calves. This relationship was similar in the different breed groups, and has been reported by others (Bellows et al., 1971; and Fleck, Schalles, and Kiracoffe, 1980).

Bellows and Short (1978) measured pelvic area in heifers and cows, and in a trial with heifers found no difference between heifers on a high level of nutrition prior to calving and those on a lower level of nutrition in precalving pelvic area, the incidence of calving difficulty, or in mean calving score. In a trial with heifers and cows, those cows on a high level of nutrition prior to calving had larger pelvic areas (354.5 cm^2) than heifers on the high level of nutrition (263 cm^2). Differences in pelvic area between high and low levels of nutrition were significant for both cows and heifers. However, there were no differences in calving difficulty between the high and low levels of nutrition in either heifers or cows.

Bellows, Short, and Richardson (1982) evaluated pelvic measurements of heifers and cows at 90 ± 7 and 10 ± 7 days before predicted calving date. They found that pelvic area of cows was greater (301.6 cm^2) than that of heifers (228 cm^2). There was no difference in pelvic area between heifers and cows on a high level of nutrition prior to calving and those on the low level. Mean dystocia scores for heifers were higher (2.72) than for cows (1.58), but no difference in mean dystocia score was observed between high level (1.99) and low level (2.30) precalving nutrition groups.

Wiltbank and Remmenga (1982) analyzed pelvic measurements of heifers taken 113 to 120 days prior to calving when heifers were placed on either a high or low plane of nutrition in the first year of a two-year study. There was no difference in pelvic area at this time. Pelvic measurements taken one week prior to calving revealed that heifers on the high level had a greater pelvic area (249 cm^2) compared to those on the low level (239 cm^2). Calving difficulty score and percent requiring assistance did not differ between high and low nutrition groups. Weight and pelvic area one week prior to calving were positively correlated (.45), and pelvic area 113 - 120 days prior to calving and one week prior to calving were positively associated (.76).

Fleck, Schalles, and Kiracoffe (1980) obtained pre-calving pelvic measurements of heifers fed to gain either <95 kg during the first wintering period following weaning, 95 to 132 kg during the same time period, or more than 132 kg during this time. Pelvic areas were similar for heifers on the low level of gain (250 + 8.4 cm^2) and those on moderate gain (247 + 5.4 cm^2), but pelvic areas of heifers on the high level of gain were larger (270 + 10.1 cm^2). There were slightly more difficult births for heifers with pelvic areas less than 230 cm^2, but these same heifers required fewer Cesarean sections.

Brown, Perkins, Featherstone, and Johnson (1982) measured pelvic area of Angus, Polled Hereford, and Charolais cows that had not experienced calving difficulty. Post-calving pelvic areas for Angus (186.9 cm^2), Polled Hereford (176.8 cm^2), and Charolais cows (293.9 cm^2) were influenced by breed, condition, condition x breed interaction, and calf birth weight x breed interaction. Pelvic area of Angus and Polled Hereford cows decreased 3 cm^2, and 4 cm^2, respectively, for each 1 unit increase in condition score (scale = 1 to 9). Each 1 unit increase in condition score of Charolais cows corresponded with a 24 cm^2 increase in pelvic area. Correlations between pelvic area and pelvic height (.64), and pelvic width (.80) agree with previous reports.

Nutrition of Dam

Nutritional plane of heifers prior to calving may affect calving difficulty, but it has been shown to consistently influence post-partum reproductive performance to a greater degree. Bellows and Short (1978) observed no differences in calving difficulty between heifers on high and low planes of nutrition prior to calving, but compared to heifers on the high plane of nutrition, heifers on the low plane had a longer post-partum interval to first estrus (87 days vs 66 days), fewer heifers exhibiting estrus by the beginning of the breeding season (47% vs 79%), and fewer heifers diagnosed pregnant the following fall (60% vs. 78%).

Bellows, Short, and Richardson (1982) reported similar results with heifers on a low level of nutrition prior to calving. They had an extended post-partum interval (79.5 days) when compared to heifers on a higher plane of nutrition prior to calving (68.5 days). Heifers had a longer post-partum interval (88.9 days) than cows (59.1 days), and fewer heifers exhibited estrus by the beginning of the breeding season (31.6%) when compared to cows (90.6%). Heifers and cows giving birth to bull calves had a lower pregnancy rate in the fall (62.7%) than did heifers and cows giving birth to heifer calves (83.6%).

Turman, Smithson, Pope, Renbarger, and Stephens (1964) evaluated 80 Hereford heifers at the Fort Reno Research Station. Bred heifers were placed on nutritional treatments of dry native grass pasture plus appropriate amounts of milo and cottonseed meal beginning in early November to achieve desired weight changes up to and including weight losses at calving. Heifers on the low level were fed to lose 20% or more of their fall weight through calving, and those heifers on the high level were fed to lose less than 5% of their fall weight through calving. Fewer heifers on the low level of nutrition prior to calving required assistance at calving (59%) than those on the high level (71%). The groups of heifers on low and high precalving nutrition levels were split following calving, and placed on either low or high post-calving nutritional treatments. Rebreeding performance of these four groups expressed as length of the post-partum interval and pregnancy rate were, respectively: low-low, 92.6 days and 53%; low-high, 70.4 days and 75%; high-low, 63.6 days and 100%; and high-high, 55.6 days and 93%.

Dunn, Ingalls, Zimmerman, and Wiltbank (1969) studied 240 Angus and Hereford heifers at the Fort Robinson Beef Cattle Research Station in Nebraska. The heifers were fed either 8.7 Mcal DE/day or 17.3 Mcal DE/day for 135 to 142 days before calving. Following calving, the low precalving nutrition group was divided into low-moderate (27.3 Mcal

DE/day), and low-high (48.2 Mcal DE/day). The high precalving group was divided into high-low (14.2 Mcal DE/day); high-moderate (27.3 Mcal DE/day); and high-high (48.2 Mcal DE/day). Pregnancy rate by the end of the first 20 days of the breeding season (maximum of 80 days post-calving) was influenced by post-calving energy level regardless of precalving energy level as follows: high, 54%; moderate, 42%; and low, 33%. Pregnancy rates by the end of the 60-day breeding season (maximum of 120 days after calving) were: high, 87%; moderate, 72%; and low, 64%.

The precalving energy levels affected pregnancy rate at 80 days post-calving regardless of post-calving energy level (high, 47%; low, 41%), and at 100 days post-calving (high, 68%; low, 60%). Precalving energy level also affected conception rate at first service regardless of post-calving energy level, but there was a precalving energy level x breed of cow interaction. Fifty percent of the Angus cows on the low level conceived at first service, compared to 76% of the Hereford cows. Angus and Hereford cows on the high level had a first service conception rate of 61%. Overall conception rates were: Angus, 57%; and Hereford, 67%.

Effect of Dystocia on Reproductive Performance

It has been demonstrated that the occurrence of dystocia may have a detrimental effect on subsequent reproductive performance. Laster et al. (1973) compared two-year-old heifers experiencing dystocia with those that did not. Fewer of the heifers experiencing dystocia were detected in estrus during the 45 day A.I. period (59 ± 2% vs 68 ± 2%), fewer heifers conceived during the same period (51 ± 3% vs 66 ± 2%), and fewer conceived by the end of the breeding season which included a 23 to 27 day cleanup period following the A.I. period (71 ± 2% vs 80 ± 2%). Neither number of inseminations required per conception nor the incidence of retained placental membranes was influenced by dystocia.

Dufour, Fahmy, and Roy (1981) observed that postpartum intervals to conception for heifers experiencing dystocia were longer (88 days) than for those calving with no difficulty (74 days). Services per conception were increased in heifers experiencing dystocia (2.3) over those calving easily (1.9). Bolze et al. (1983) also reported lower conception rates during a 63-day breeding period for Simmental and Angus heifers requiring assistance during calving.

Fleck, Schalles, and Kiracoffe (1980) observed that the greatest number of heifers conceiving at first service during the breeding season were heifers that had experienced difficult parturition. The average date of conception and post-partum interval to conception were longer for heifers that had undergone Cesarean sections.

Effect of Age at First Calving and Plane of Nutrition Prior to Calving on Growth and Reproductive Performance of Heifers

Several studies have been concerned with the effects of age at first calving on the growth and reproductive performance of heifers. The majority of these studies have compared heifers calving first at 24 and 36 months of age, and most have included comparisons of different nutritional planes prior to first calving.

Pinney, Stephens, and Pope (1972) investigated the effects of age at first parturition and level of winter supplement on growth and reproductive performance of Hereford heifers. The study was conducted at the Fort Reno Research Station using 90 Hereford heifers born in the spring. The heifers were assigned to calve at either 24 or 36 months of age, and, within each calving age group, were allotted at random into one of three groups to receive either a low, medium, or high level of winter supplement while grazing dormant native grass range. The supplement levels were: low, .45 kg cottonseed meal/head/day; medium, 1.13 kg cottonseed meal/head/day; and high, 1.13 kg cottonseed meal plus 1.31 kg whole oats/head/day. All heifers were pasture mated to Hereford bulls for 90 days beginning May 1. There were significant differences in winter gains and losses due to winter feed level through the fifth winter. There was an inverse relationship between winter gain and summer gain through the first five summers with summer gain increasing as winter gain decreased.

Cow weight in November of the eighth year represented mature weight. Heaviest cows were those calving at three years of age, and on the high level of winter feed (555 kg); and the lightest cows were those calving at two years of age, and on the low level of winter feed (500 kg). Skeletal measurements to indicate mature size were taken one year later than mature weights. There were no differences in height at withers, and this measurement followed the same pattern as mature weight. Length of body and width of hips were not different, and did not exhibit the same trend as height at withers.

The average lifespan of cows calving at two years of age, and wintered at the high level was 10.88 years, compared to 13.07 years, and 14.65 years for those wintered at the medium and low levels, respectively.

The low level of winter supplement tended to delay calving date by 7 to 12 days each year for the first six years when compared to the high level of winter supplement. No differences in birth weight due to level of winter supplement or age at first calving were observed in any year of the study. Over the lifetime of the cows, no differences in adjusted weaning weight of calves were observed, but there was a tendency for greater survival of calves from cows on the low level of winter supplement when compared to calves from cows on the medium and high levels of supplement (percent calf crop weaned over a ten-year period = 88.4% vs 82.7% and 81.4%, respectively).

An earlier report from the Fort Reno Research Station, Pinney, Pope, Stephens, and Henderson (1962) compared 60 Hereford heifers calving for the first time at 24 months of age and 60 Hereford heifers calving for the first time at 36 months of age. Forty-seven percent of the heifers calving at 24 months of age required assistance at first calving, and 1.7% of the heifers calving at 36 months of age were assisted. Average calving date was approximately one week later through four years of age for heifers calving at 24 months of age when compared to those calving at 36 months of age. No difference was found between the two groups for number of cows open during their productive lifespan (Turman, Pope, and Stephens, 1963).

A Canadian study by Bernard and Lalande (1967) examined weight changes of 85 Shorthorn cows calving at either 24 or 36 months of age. The heifers were born in the spring and weaned in the fall, and were managed similarly during the first winter. Heifers to calve at 24 months of age were pasture bred at 15 months of age for six weeks beginning near the first of July. All heifers were fed either a ration of hay and grass silage or hay and grass silage plus .5 kg concentrate per 100 kg body weight during the second winter. The second breeding season extended from early June to mid August.

At the end of the second wintering period, the heifers that had calved at 24 months of age and had raised calves were 54 kg lighter on the average than those heifers that had been kept open to be bred at 27 months of age. These results agree with those found by Pinney, Stephens, and Pope (1972). After their first calves were weaned, the cows calving at 24 months of age made more rapid weight gains than those calving at 36 months, allowing them to reach a weight only slightly less than those calving at 36 months by 5.5 years of age.

Bernard, Fahmy, and Lalande (1973) reported an additional analysis of the effects of age at first calving and level of winter nutrition on the productivity of 76 Shorthorn heifers used in the study previously reported by Bernard and Lalande (1967). Conception rate was slightly but not significantly greater for heifers supplemented during winter or calving first at 36 months of age (90.7% and 91.2%, respectively) when compared to heifers that were not supplemented or calved first at 24 months of age (87.5% and 87.1%, respectively). Survival rate of calves was not influenced by age at calving. Survival rate of calves from cows receiving supplement during the winter (95.1%) was superior to that of calves born to heifers not receiving supplement (76.8%). However, this difference in survival was observed only in the calving season immediately following the imposed nutritional treatments. Calves from cows calving at 36 months of age were heavier at birth and at weaning (32.4 kg, and 205 kg, respectively) than calves from heifers calving at 24 months of age (31.6 kg, and 197.3 kg, respectively). Supplemented cows also had heavier calves at birth and at weaning (32.5 kg and 205.2 kg, respectively) than those cows not supplemented (31.5 kg and 197.1 kg, respectively).

Chapman, Young, Morrison, and Edwards (1978) evaluated the effect of calving at 24 or 36 months of age, and winter nutritional plane on productivity of 80 Hereford cows over a ten-year period in Mississippi. The heifers were born in the spring and weaned in the fall. During the first two years of the study the winter nutritional treatments were wheat and ryegrass pasture, and corn silage in drylot. Cows that calved first at 24 months of age were consistently lighter at the beginning of the breeding season and at weaning time (384 ± 8 kg and 428 ± 6 kg) than cows that had calved first at 36 months of age (404 ± 10 kg and 442 ± 6 kg). However, there were no differences in calving percentage (84 ± 2% vs 83 ± 3%), or Julian date of calving (37 ± 3 vs 32 ± 3). There were no differences in any traits measured between heifers calving first at 24 months and those calving first at 36 months wintered on wheat and ryegrass pasture. However, heifers calving at 36 months and wintered on corn silage in drylot were heavier in the spring and in the fall (406 ± 12 kg and 446 ± 9 kg, respectively). A difference was observed between weaning weight of calves produced from heifers calving at 24 months of age (166 ± 7 kg), and calves produced from heifers calving at 36 months of age (177 ± 7 kg) when heifers were wintered on wheat and ryegrass pasture.

A Texas study conducted by Randel (1981a) used 27 Brahman x Hereford heifers calving first at 36 months of age and 35 Brahman x Hereford heifers calving first at 24 months of age. All heifers were assigned to normal or once daily suckling treatments. Heifers calving at 36 months of age and with normal suckling became pregnant in 81.5 ± 7.5 days post-partum, while those heifers calving at 24 months of age with normal suckling became pregnant in 159 ± 17.8 days. Heifers calving at 36 months and 24 months, and suckled once daily had shorter post-partum intervals (56.3 ± 5.3 days, and 78.7 ± 8.8 days, respectively). It appears that once daily suckling of heifers calving at 24 months of age allows them to rebreed as soon as normally suckled heifers calving at 36 months of age. Wettemann, Turman, Wyatt, and Totusek (1978) observed an extended period of anestrus in cows raising twins when compared to cows suckling one calf. Reeves and Gaskins (1981) and Randel (1981b) observed that cows suckled once daily had shorter intervals from calving to first estrus than normally suckled cows. Wyatt, Gould, and Totusek (1977) observed that fewer cows suckling twin calves exhibited estrus by 90 days post-partum (43%) than cows raising single calves (71%). These findings demonstrate the negative effect of suckling on the rebreeding performance of cows. Randel

(1981a) also found that calves from normally suckled heifers calving at 36 months of age were heavier (224.4 ± 5.1 kg) than calves from normally suckled heifers calving at 24 months of age (196.1 ± 3.9 kg). Normally suckled calves were heavier at weaning than those suckled once daily, but this loss may be offset by a heavier weight of the second calf as a result of increased age.

Most studies have compared heifers calving for the first time at 24 months of age or 36 months of age. Only one study was found that compared heifers calving at 24 or 30 months of age. Lusby, Enis, and McNew (1979) reported a study conducted near Stillwater, Oklahoma, utilizing 65 Hereford Heifers, 29 born in the spring and 36 born during the previous fall. All heifers were managed similarly after the younger heifers were weaned, and were exposed to Hereford bulls for a 60-day spring breeding season. Summer forage during the first breeding season was native range, and summer forage during the second breeding season was Bermuda grass. All heifers were wintered on native tall grass range, supplemented with cottonseed meal. The heifers born in the spring gave birth to their first calves at approximately 24 months of age, and the heifers born in the fall gave birth to their first calves at approximately 30 months of age.

The heifers bred to calve at 24 months of age were lighter at the beginning of the first breeding season (237 kg) than those bred to calve at 30 months of age (289.5 kg).

The heifers calving at 24 months of age were also lighter in the fall (330 kg vs 386 kg), and in the spring before calving (353 kg vs 501 kg). There was a trend for heifers calving at 24 months of age to have reduced conception rates (76%) when compared to those calving at 30 months of age (89%).

The younger heifers also conceived later (19 days) than heifers giving birth at 30 months of age. Heifers calving at 30 months of age tended to have heavier calves (30.5 kg) when compared to those calving at 24 months of age (29.0 kg). Calving difficulty score was similar for the gwo groups of heifers (1.8, and 1.9; scale = 1 to 5). Mean adjusted weaning weight of calves produced by heifers calving at 30 months of age was heavier (203 kg) than for calves produced by heifers calving at 24 months of age (182 kg).

At the beginning of the second breeding season, the heifers that had calved at 24 months of age were lighter (304 kg) than those heifers that had calved at 30 months of age (329 kg). Conception rate for heifers calving at 24 months was decreased (42%) when compared to conception rate for heifers calving at 30 months (82%). This study indicates possible merit for calving heifers at 30 months of age because of heavier weaning weights of first calves and improved rebreeding performance during the second breeding season.

CHAPTER III

METHODS AND MATERIALS

This project was carried out at the Livestock and Forage Research Laboratory, Oklahoma Agricultural Experiment Station and USDA-ARS, El Reno, Oklahoma. The project involved a total of 129 Hereford heifers from the Range Cow Research Station near Stillwater. The heifers were obtained in the fall of three years, and the heifers in each group were born in either the spring or the fall to cows of similar breeding bred to similar bulls in both seasons of a given year.

The project consisted of two trials. Trial 1 was initiated in November, 1979, and completed in October, 1981. Trial 2 consisted of two replications initiated in November, 1980 and 1981, respectively, and completed in October, 1982 and 1983, respectively. Trial 1 utilized 20 heifers born in the spring of 1979 and 20 heifers born during the previous fall. The two replications of trial 2 utilized 30 heifers born in the spring of 1980 and 1981 and 59 heifers born during the fall previous to each year. The heifers were transported to the Livestock and Forage Research Laboratory in November of each year and allotted to their respective winter treatments. All heifers born in the fall were bred in the spring when they were 21 months old to calve at 30 months of age, and all heifers of that repetition that were born the following spring were bred during the same breeding season at 15 months of age to calve at 24 months of age.

All heifers were weighed at the beginning of the wintering period (approximately November 15 of each year) and were weighed at two-week intervals until the end of the wintering period (approximately April 15 of each year). Heifers were maintained on dormant native grass range and were supplemented with cottonseed meal and milo or corn according to their respective treatments. All heifers were weighed at the beginning and end of the first breeding season (May 1 and July 1, respectively), at the beginning of the second wintering period (November 15), at monthly intervals during the second wintering period, at the beginning and end of the second breeding season (May 1 and July 1), and at the conclusion of the trial when the first calf was weaned (October). Body weights were taken in the morning following an overnight shrink away from feed and water.

Skeletal measurements (height at hips and withers and width across the hooks) were taken at the beginning of the trial, at the end of the first wintering period, and at the beginning and end of the second wintering period. Pelvic measurements (height and width) were taken with a Rice pelvimeter (Rice and Wiltbank, 1970) at the end of the first wintering period.

Heifers were maintained on native tall-grass pasture during the summer with no effort made to control weight changes. Heifers were assigned to single-sire breeding groups blocked across treatment. Heifers were diagnosed pregnant or open via rectal palpation in October.

During the second wintering period all heifers were fed similar to the moderate level used in previous studies (Turman _et al_., 1964) conducted at the Fort Reno Research Station. This level is the appropriate amount of cotton-seed meal fed to heifers grazine dormant native grass range to allow them to lose 10 percent of their fall weight (November 15) including the loss at calving.

Heifers were group fed to achieve the planned treatment weight gains (Appendix). The heifers were weighed at two-week intervals during both wintering periods, and individual heifers were changed between feeding groups to achieve the planned treatment weight gains (heifers were switched between gain and maintain groups).

Calving difficulty scores were assigned on a scale of 1 to 5, where 1 = no assistance necessary, 2 some difficulty with light assistance required, 3 = moderate assistance necessary, 4 = a hard pull, and 5 = a Cesarean section. Calves were weighed as soon after birth as possible, and the cows were weighed within two days after calving.

Before the second breeding season, the heifers were randomly assigned to one of two single-sire breeding groups blocked across treatment. They were diagnosed pregnant or open via rectal palpation at weaning in early October, approximately three months after the bulls were removed.

Weaning weight of calves was adjusted to a 205-day steer equivalent by subtracting birth weight from actual weaning weight, dividing by age at weaning, multiplying by 205, multiplying by the adjustment factor of 1.05 for heifers (1.0 for steers), and adding birth weight after adjustment. The cows were returned to the Range Cow Research Center near Stillwater and date of subsequent calving was determined.

In trial 1, the first wintering period began on November 29 and ended on April 17. Heifers to be bred at 15 months of age were fed appropriate amounts of ground milo and cottonseed meal to achieve an average gain of .45 kg/day during the entire period (treatment 1). The heifers to be bred at 21 months of age were fed at the same level as the younger heifers until they reached a mean body weight of 273 kg, after which they were fed at the moderate level so they gained approximately .23 kg/day until the end of the wintering period (treatment 2). Two Hereford bulls were used in single-sire breeding groups during the first breeding season, which lasted from May 1 to July 20.

In trial 2, the first wintering period began on November 14 and November 12 for replications 1 and 2, respectively, and ended on April 15 for each replication. The heifers to be bred at 15 months of age were fed similarly to those in trial 1, with the exception that ground corn replaced ground milo in the ration (treatment 1). The heifers to be bred at 21 months of age were randomly divided into two treatment groups (treatments 2 and 3) and were fed at the same level as the heifers of treatment 1 until each heifer reached a weight of 273 kg. At that time the heifers of treatment 2 were fed at a low level to maintain their weight until the end of the wintering period, and the other group was fed to gain .23 kg/day until the end of the wintering period. The first breeding season began on May 7 and ended on July 7 of reach respective year. Three Angus bulls were used in repetition 1, and two different Angus bulls were used in repetition 2.

Weekly blood samples were taken via the tail vein for three weeks in succession prior to the start of the first breeding season for all heifers in both years. Plasma samples were analyzed for progesterone by a valid double antibody radioimmunoassay (Lusby, Wettemann, and Turman, 1981). A concentration of progesterone greater than 1 nanogram/milliliter of plasma for two of the three samples was considered to be an indication of ovarian activity.

Condition scores (scale: 1 = very thin; 9 = obese) were assigned at the beginning of the second wintering period, at the end of the second winter, at the beginning of the second breeding season, and when calves were weaned from the cows.

Statistical Analysis

Trials 1 and 2 were analyzed separately. The effect of treatment on body weight, weight changes, skeletal measurements, and pelvic measurements of heifers in trial 1 were determined using the Student's t-test (Steel and Torrie, 1980). The influence of treatment on body weight, weight changes, skeletal measurements, pelvic measurements, condition scores, and condition score changes of heifers in trial 2 were determined by least squares analysis of variance and orthogonal contrasts. Calving difficulty score, calf birth weight, calf weight at weaning, 205-day adjusted calf weight at weaning, date of conception during the first breeding season, and postpartum interval after first calving were analyzed by least squares analysis of variance. The model included year, sex of calf, breeding group within year, and treatment as classification variables. When classification variables were found to be significant effectors and more than two least squares means were compared, Duncan's New Multiple Range Test was used (Steel and Torrie, 1980).

Date of conception during the first and second breeding seasons were calculated by subtracting 283 days from the calving date. Date of conception during the second breeding season in year 2 of trial 2 was based on age of the fetus at the time of pregnancy diagnosis. Postpartum interval to conception after first calving was calculated.

A second least squares analysis of variance was performed on the incidence of ovarian activity by the beginning of the first breeding season. The response variable, ovarian activity, was treated as a discrete "yes" or "no" observation. The model included year and treatment as classification variables.

To develop a prediction equation for calving difficulty score, a third least squares analysis was conducted which included pelvic width, depth, and area as covariables in addition to the class variables used in the first analysis.

CHAPTER IV

RESULTS AND DISCUSSION

Trial 1

Body weights and weight changes of heifers are summarized in Table I. The heifers to calve at 30 months of age (treatment 2) were 47.3 kg heavier at the beginning of the first wintering period ($P < .01$) than were the heifers to be bred to calve at 24 months of age (treatment 1). This was expected since the heifers of treatment 2 were approximately 6 months older. The older heifers continued to maintain this weight advantage through the first year of the trial: 29 kg at the end of the first wintering period ($P < .05$); 19.8 kg at the beginning of the first breeding season ($P < .10$); and 46.9 kg by the beginning of the second wintering period ($P < .01$).

The average daily gain of the heifers of treatment 1 during the first wintering period (.44 kg/day, Table I) was almost exactly what was planned (.45 kg/day). The average daily gain of heifers on treatment 2 was less during this time period because they were fed to gain .23 kg/day after they had reached a mean body weight of 273 kg. The weight gains from the beginning of the first wintering period to

TABLE I

BODY WEIGHTS AND BODY WEIGHT CHANGES OF HEIFERS FROM NOVEMBER 1979 UNTIL NOVEMBER 1980 (TRIAL 1)

		Calve at 24 Mo. (Treatment 1)		Calve at 30 Mo. (Treatment 2)	
		N	Mean	N	Mean
Weight (kg)					
Beg. 1st winter (11/29/79)[a]		19	183.7±2.9	20	231.0±4.0
End 1st winter (4/17/80)[b]		20	245.9±3.4	20	274.9±3.5
Beg. 1st brdg season (5/1/80)[c]		19	249.9±3.1	20	269.7±2.1
End 1st brdg season (7/1/80)[a]		19	298.9±3.4	20	332.0±3.2
Beg. 2nd winter (11/13/80)[a]		19	373.2±4.1	20	420.1±3.9
Weight Changes (kg)					
Period	Interval				
1	Beg.-end 1st winter[b]	19	61.7±2.0	20	43.8±2.3
2	Beg. 1st winter-beg. 1st brdg.[b]	18	65.6±1.8	20	38.7±3.4
3	Beg.-end 1st brdg.[c]	19	48.9±1.9	20	62.3±2.5
4	End 1st brdg.-beg. 2nd winter[c]	19	74.3±1.6	20	88.1±2.3
5	Beg. 1st winter-beg. 2nd winter	18	189.4±3.2	20	189.1±3.5

TABLE I (CONTINUED)

		Calve at 24 Mo. (Treatment 1)		Calve at 30 Mo. (Treatment 2)	
		N	Mean	N	Mean
Average Daily Gains[d] (kg/day)					
Period	Interval Length (days)				
1	139	19	.44	20	.32
2	153	18	.43	20	.25
3	61	19	.80	20	1.02
4	135	19	.55	20	.65
5	349	18	.54	20	.54

[a]Treatment effect ($P < .01$)
[b]Treatment effect ($P < .05$)
[c]Treatment effect ($P < .10$)
[d]No statistical comparisons made (calculated from mean weight changes)

the beginning of the breeding season were 65.6 ± 1.8 kg (.43 kg/day) for heifers on treatment 1 and 38.7 ± 3.4 kg (.25 kg/day) for heifers on treatment 2 ($P < .05$). The total winter gain of heifers on treatment 1 (61.7 ± 2.0 kg) was greater ($P < .05$) than that for the heifers on treatment 2 (43.8 ± 2.3 kg). Heifers on treatment 2 lost weight for the two weeks between the end of the wintering period (4/17/80) and the beginning of the breeding season (5/1/80) while the heifers on treatment 1 maintained their weight.

The heifers on treatment 2 gained more ($P < .10$) during the breeding season (5/1/80 to 7/1/80), probably to compensate for their lower winter gains. The total gain of heifers on treatment 2 during this time period was 62.3 ± 2.5 kg compared to 48.9 ± 1.9 kg for heifers on treatment 1 (Table I). The heifers on treatment 2 also exhibited greater gains from the end of the breeding season (7/1/80) until the beginning of the second wintering period (11/13/80). However, the total weight change from the beginning of the first wintering period until the beginning of the second wintering period was nearly identical for heifers on the two treatments: treatment 1, 189.4 ± 3.2 kg and treatment 2, 189.1 ± 3.5 kg.

Body weights and weight changes of heifers from the beginning of the second wintering period through the end of the trial are summarized in Table II. The heifers on both treatments were fed during the second winter to lose approximately 10 percent of their fall weight (11/13/80) through

TABLE II

BODY WEIGHTS AND BODY WEIGHT CHANGES OF HEIFERS FROM NOVEMBER 1980 UNTIL OCTOBER 1981 (TRIAL 1)

		Calve at 24 Mo. (Treatment 1)		Calve at 30 Mo. (Treatment 2)	
		N	Mean	N	Mean
Weight (kg)					
	Beg. 2nd winter (11/13/80)[a]	19	373.2±4.1	20	420.1±3.9
	Immed. post-calving[b]	19	334.9±6.5	16	384.2±6.3
	End 2nd winter (4/14/81)	16	329.5±5.5	19	355.5±5.9
	Beg. 2nd brdg. season (5/5/81)[e]	9	360.4±9.5	13	383.4±6.5
	End 2nd brdg. season (7/23/81)[e]	9	415.1±8.8	13	434.2±9.7
	Final (10/13/81)[e]	9	441.4±9.5	13	466.6±9.6
Weight Changes (kg)					
Period	Interval				
6	Beg 2nd winter-post calv.	19	-38.3±5.6	16	-37.5±8.5
7	Post calv.-beg. 2nd brdg.[e]	9	12.8±4.3	12	-1.4±4.2
8	Beg.-end 2nd brdg.[e]	9	54.7±3.2	13	50.8±4.9
9	Post calv.-final[e]	9	93.8±4.9	13	86.2±7.7

[a]Treatment effect (P < .01)
[b]Treatment effect (P < .05)
[e]Includes only those heifers nursing calves

and including their weight loss at calving. This was accomplished and heifers on treatments 1 and 2 lost 10.3% and 8.9% of their weight, respectively (Table II). The heifers calving at 24 months of age (treatment 1) tended to be lighter at the end of the second wintering period (4/14/81), at the beginning (5/5/81) and end (7/23/81) of the second breeding season, and at the time their calves were weaned (10/13/81). However, the heifers on treatment 1 gained more weight between calving and the beginning of the breeding season, and during the breeding season, which helps to account for the minimal difference in weight between the two treatments at the conclusion of the trial (441.4 ± 9.5 kg vs 466.6 ± 9.6 kg for treatments 1 and 2, respectively).

Body measurements of heifers taken at the beginning and end of the first and second wintering periods are presented in Table III. The height measurements indicate that the older heifers on treatment 2 were taller at the hips ($P < .01$) and at the withers ($P < .05$) at the beginning of the first winter than were the heifers on treatment 1. The heifers on treatment 2 tended ($P < .25$) to be taller at the hips and withers at the end of the first wintering period; and at the beginning and end of the second wintering period. As discussed previously, the older heifers (treatment 2) were also heavier as well as taller than the younger heifers (treatment 1) at these times (Tables I and II). The diminished difference in height between the two treatments by the end of the second wintering period implies that a

TABLE III

HEIGHT MEASUREMENTS, WIDTH ACROSS HOOKS, AND PELVIC AREA OF HEIFERS (TRIAL 1)

	Calve at 24 Mo. (Treatment 1)		Calve at 30 Mo. (Treatment 2)	
	N	Mean	N	Mean
Beg. 1st Winter (11/29/79)				
Hip height[a] (cm)	20	100.8± .35	20	107.3± .71
Withers height[b] (cm)	20	94.6±1.30	20	99.8± .48
Width across hooks[c] (cm)	20	30.2± .96	20	35.9± .40
End 1st Winter (4/17/80)				
Hip height	20	111.0± .51	20	114.3± .81
Withers height	20	104.1± .64	20	106.8± .43
Width across hooks[b]	20	38.0± .29	20	40.1± .20
Pelvic area[b] (cm^2)	18	142.1±4.06	19	173.1±3.40
Beg. 2nd Winter (11/13/80)				
Hip height	19	117.8± .43	20	120.6± .56
Withers height	19	112.0± .56	20	114.0± .47
Width across hooks[c]	19	42.4± .46	20	45.2± .47

TABLE III (CONTINUED)

	Calve at 24 Mo. (Treatment 1)		Calve at 30 Mo. (Treatment 2)	
	N	Mean	N	Mean
End 2nd Winter (4/14/81)				
Hip height	19	121.2± .53	20	122.9± .61
Withers height	19	114.4± .64	20	115.8± .53
Width across hooks[b]	19	46.1± .38	20	48.5± .38

[a]Treatment effect (P < .01)
[b]Treatment effect (P < .05)
[c]Treatment effect (P < .10)

portion of skeletal growth by the heifers of treatment 1 was delayed until the second wintering period.

The influence of winter nutrition on skeletal growth was expected and agrees with others. Anderson et al. (1983) found 180-day and yearling hip heights of Hereford and Hereford-cross heifers to be 100.1 ± 3.4 cm and 115.8 ± 4.1 cm, respectively. Hughes et al. (1978) reported initial treatment means for withers height of Hereford heifers at 255 days of age to be between 97.2 cm and 98.2 cm. Steffan et al. (1983) reported mean hip height at puberty (487 days of age) of Hereford heifers to be 114.6 cm. Ferrell (1982) reported hip heights of Hereford heifers at 635 and 980 days of age to be 120 cm and 122 cm, respectively. Gregory et al. (1978) found the 550-day hip height of Hereford heifers to be 116.2 ± .58 cm.

The heifers of treatment 2 were wider across the hooks at each measurement time than were heifers of treatment 1, and the measurements made at the end of each wintering period were significantly larger ($P < .05$). The heifers on treatment 2 also had a larger pelvic area than heifers of treatment 1 ($P < .05$).

Treatment differences in width across the hooks and pelvic area were expected, and the actual measurements were similar to those reported by others. Short and Bellows (1971) reported pelvic areas of Hereford-Angus crossbred heifers of 135 cm^2, 144 cm^2, and 153 cm^2 at the end of the first wintering period for heifers wintered on low, medium, and high levels of supplement, respectively. Varner et al. (1977) found pelvic areas at the end of the first wintering period for heavy and light crossbred heifers fed in the same group to be 170.4 cm^2 and 147.3 cm^2, respectively. Heavy and light heifers fed separately had pelvic areas of 164.5 cm^2 and 153.0 cm^2, respectively. Hughes et al. (1978) measured width at the hips of Hereford heifers at 255 days of age, and found mean widths to be between 33.9 cm and 34.2 cm.

Classification variables (main effects) and interactions used in the least squares analysis of variance models for the seven production traits are presented in Table IV. All possible interactions were included in the initial model for each trait, and the models for individual traits were reduced by excluding any interaction with a probability level greater than .25. Least squares means of the seven production traits are presented in Tables V and VI, and reproductive performance of the heifers is summarized in Table VII.

Though not statistically significant, the heifers on treatment 1 had a later date of conception during the first breeding season (Table V). These heifers were also lighter and younger at the beginning of the breeding season (249.9 ± 3.1 kg, 398.3 ± 17.1 days) when compared to heifers of treatment 2 (269.7 ± 2.1 kg, 574.4 ± 10.8 days) (Table I). Final pregnancy rate was similar for treatment 1, 95%, and treatment 2, 100% (Table VII). Fleck, Schalles, and

TABLE IV

LEAST SQUARES ANALYSIS OF VARIANCE MODELS USED FOR PRODUCTION TRAITS OF HEIFERS (TRIAL 1)

Production Traits	Main Effects (Classification Variables)						
	Calf Sex	Breeding Group	Treat- ment	CSEX*BGRP	CSEX*TRMT	BGRP*TRMT	CSEX*BGRP*TRMT
Date of conception during the 1st breeding season	--	*	*	--	--	*	--
Calf birth weight	*	*	*	--	--	--	--
Calving difficulty score	*	*	***	--	--	--	--
Date of conception during the 2nd breeding season	*	*	*	--	--	--	--
Post partum interval	*	*	*	***	****	**	--
Calf weight at weaning	*	*	*	--	**	__	--

TABLE IV (CONTINUED)

Production Traits	Main Effects (Classification Variables) Calf Sex	Breeding Group	Treatment	CSEX*BGRP	CSEX*TRMT	BGRP*TRMT	CSEX*BGRP*TRMT
205 day adjusted calf weight at weaning	*	*	*	--	*	--	--

*Used in analysis, not significant
** (P <.10)
*** (P <.05)
**** (P <.01)

TABLE V

LEAST SQUARES MEANS OF DATE OF CONCEPTION DURING THE FIRST AND SECOND BREEDING SEASONS, AND POST-PARTUM INTERVAL (TRIAL 1)

	Calve at 24 Mo. (Treatment 1)		Calve at 30 Mo. (Treatment 2)	
	N	L. Sq. Mean	N	L. Sq. Mean
Date of conc. 1st brdg.[h]	18	151.2 ± 5.0[i]	29	143.7 ± 4.8[i]
Date of conc. 2nd brdg.[h]	14	163.5 ± 5.5[i]	16	151.7 ± 5.1[i]
Post-partum interval[ck] (days)	14	98.0 ± 9.3[i]	16	75.1 ± 7.6[i]
	8	86.4 ± 12.3[j]	10	63.4 ± 12.1[j]

[c] Treatment effect (P<.10)
[h] Expressed as days from January 1 of that year
[i] Includes heifers nursing calves and those not nursing calves
[j] Includes only those heifers nursing calves
[k] Calculated from days to conception minus Julian calving date

TABLE VI

LEAST SQUARES MEANS FOR CALVING DIFFICULTY SCORE, CALF BIRTH WEIGHT, CALF WEIGHT AT WEANING, AND 205 DAY ADJ. WEIGHT AT WEANING (TRIAL 1)

	Calve at 24 Mo. (Treatment 1)	Calve at 30 Mo. (Treatment 2)	Male Calves	Female Calves
Calving difficulty score[cm]	(17)[a] 3.21±.34[b]	(18) 1.89±.35	(19) 2.96±.33	(16) 2.15±.38
Calf birth weight (kg)	(17) 36.1±.9	(18) 35.1±.9	(19) 36.3±.9	(16) 34.9±1.0
Calf wt. at weaning (kg)	(9) 170.3±12.3	(13) 183.7±12.3	(13) 187.3±12.3	(9) 166.7±12.3
205 day adj. wt. at weaning[L]	(9) 185.1±9.1	(13) 192.7±9.1	(13) 192.5±9.1	(9) 185.3±9.1

[a]Number of observations

[b]Least squares mean ± standard error

[c]Treatment effect (P <.05)

[L]Adjusted to 205-day steer equivalent by the following formula:

(((actual wn. wt. - birth wt.)/age at weaning) X 205) X adj. factor) + birth wt.

[L]Adjusted factor for heifers is 1.05

[M]Scale = 1 to 5

TABLE VII

SUMMARY OF REPRODUCTIVE PERFORMANCE OF HEIFERS (TRIAL 1)

	Calve at 24 Mo. (Treatment 1)	Calve at 30 Mo. (Treatment 2)
Initial no. of heifers (11/29/79)	20	20
No. exposed, 1st breeding	20	20
Number pregnant (10/2/80)	19	20
Number calved	18	20
No. of live calves	9	14
Mean birth weight (kg)		
Bull calves	38.0	33.5
Heifer calves	35.9	35.2
Live calves	34.1	35.3
Dead calves	37.4	37.0
No. of heifers with calving score > =2	13	10
No. of live calves, calving score > =2	6	6
No. of dead calves, calving score > =2	9	13
No. of cows exposed, 2nd breeding	19	18[w]
Number pregnant (10/13/81)	16	16

[w]Two heifers killed by lightning 6/3/81

Kiracoffe (1980) also found that body weight gain during the previous wintering period did not influence pregnancy rate. However, pregnancy rate may be reduced because of decreased body weight gain during the breeding season (Turman et al., 1963), so compensatory gain during the breeding season cannot offset the reduced gain during the previous wintering period (Varner, Bellows, and Christiansen, 1977).

It is possible that a greater treatment difference in date of conception would have been observed had the heifers on treatment 2 continued to gain weight between the end of the wintering period and the beginning of the breeding season (Table I). Lemenager et al. (1980); Turman, Pope, and Stephens (1965); Varner, Bellows, and Christiansen (1977); and Turman et al. (1963) all observed delayed dates of conception after decreased body weight gain prior to breeding.

The heifers on treatment 2 also tended to conceive sooner ($p < .25$) during the second breeding season than did the heifers on treatment 1 (151.7 ± 5.1 days vs. 163.5 ± 5.5 days). The nearly equal conception rates of the heifers on treatments 1, 84% and 2, 88% (Table VII) may have been because the heifers on treatment 1 gained more weight between calving and the beginning of the breeding season (Table II). All heifers, whether nursing calves or not, were included in this analysis since approximately equal numbers of calves were lost in each treatment group. In addition, since only one bull calf survived in treatment 1, and only one heifer calf survived in treatment 2, any comparisons between suckled cows would be confounded with sex of calf. The trend observed for date of conception during the second breeding season was expected, but because of the nature of the comparison it may only be said that heifers calving at 24 months of age may have a slightly prolonged post-partum interval when compared to those heifers calving at 30 months of age, regardless of whether they are nursing their first calf. These results agree with reports by Turman, Pope, and Stephens (1963), and Randel (1981a) in that heifers calving at 24 months of age had delayed rebreeding dates when compared to heifers calving at 36 months of age. However, Chapman et al. (1978) found no difference in rebreeding date in a similar comparison.

Post-partum interval to conception was influenced by interactions between calf sex and breeding group, calf sex and treatment, and breeding group and treatment. However, the heifers on treatment 1 had a longer post-partum interval (90.8 ± 9.3 days) than the heifers of treatment 2 (75 ± 7.6 days). This difference approached significance ($P < .10$). Both suckled and non-suckled cows were included in this analysis for the reasons stated previously. These facts make the interactions involving sex of calf meaningless. The breeding group by treatment interaction may be explained by merely the chance that heifers calving at 30 months of age with longer post-partum intervals had been assigned to breeding group II. A separate least squares analysis of post-partum interval included calf sex, treatment, and suckling status as classification variables. Influence by interactions between calf sex and treatment, calf sex and suckling status, and calf sex, treatment, and suckling status approached significance ($P < .10$). The least squares means for post-partum interval from this model (Table V) show that suckled heifers on treatment 2 had a post-partum interval 23 days shorter than did the heifers on treatment 1 ($P > .50$). Suckled cows had a post-partum interval 10 days shorter than did non-suckled cows ($P > .50$).

Least squares means for calf birth weight and calving difficulty score are presented in Table VI. Calf birth weight did not differ significantly between treatments, breeding groups, or between bull and heifer calves. Even though they were not statistically significant, sex and treatment differences in calf birth weight were similar to those reported by other researchers who found that bull calves were heavier at birth than heifer calves, and that older heifers gave birth to heavier calves. Mean calving difficulty score was greater for the heifers on treatment 1 (3.21 ± .34) than for the heifers on treatment 2 (1.89 ± .35) ($P < .05$). Heifers giving birth to bull calves tended ($P < .25$) to have more difficulty (mean score = 2.96 ± .35) than those heifers giving birth to heifer calves (2.15 ± .38). No differences were observed between breeding groups. The treatment difference in calving difficulty score was expected, but was greater than the difference reported by Lusby, Enis, and McNew (1979). Sex differences in calving difficulty score were as expected, but were not as great as those reported with more observations (Bellows et al., 1971 and Bellows, Short, and Richardson, 1982).

The analysis of variance table for a regression model used to predict calving difficulty is presented in Table VIII. The addition of pelvic measurements for use in the development of a prediction equation did not improve the model. The model was able to account for approximately 20% of the observed variation (Table VIII), and therefore, a reliable prediction equation could not be developed.

TABLE VIII

ANALYSIS OF VARIANCE FOR PELVIC MEASUREMENTS AS COVARIABLES FOR THE PREDICTION OF CALVING SCORE (TRIAL 1)

Source	D.F.	Mean Square	F Value	Prob. > F
Calf Sex	1	2.163	1.30	0.264
Breeding Group	1	0.001	0.00	0.984
Treatment	1	1.593	0.96	0.337
Pelvic Width	1	0.120	0.07	0.790
Pelvic Depth	1	0.190	0.11	0.738
Pelvic Area	1	0.222	0.13	0.718
Error	28	1.667		

Source	D.F.	Mean Square	F Value	Prob. > F
Model	6	1.983	1.19	0.340
Error	28	1.667		

R-Square = 0.203

More heifers calving at 24 months of age suffered dystocia (72%) than those calving at 30 months of age (50%; Table VII). These results agree with those reported by Pinney et al. (1962) of calving difficulty in heifers calving at 24 and 36 months of age. The heifers on treatment 1 had a greater calf death loss due to dystocia (54%) than the heifers on treatment 2 (40%). Though the differences were not statistically significant, the mean birth weight of calves of both treatments that died during birth or shortly thereafter was heavier than that of calves that survived, and the mean calving score for calves of both treatments that died during birth or shortly thereafter was greater (3.15 ± .36) than for those calves that survived (2.17 ± .26).

One explanation for the extremely high death loss of calves was the unavoidable change of herdsmen immediately prior to the calving season. This factor demonstrates the increased detrimental effect of lack of attention during calving on the heifers calving at 24 months of age over the heifers calving at 30 months of age.

Least squares means for actual weaning weight of calves and 205 day adjusted weaning weight of calves are presented in Table VI. Actual weaning weight of calves was influenced by the interaction between calf sex and treatment, which is difficult to interpret because of the uneven numbers of each sex in each treatment. However, steer calves were heavier at weaning than heifer calves. Breeding group (sire) did not affect weaning weight, and calves from the heifers calving at 30 months of age were not significantly heavier than calves from heifers calving at 24 months.

Adjusting the weaning weight of calves diminished differences due to sex and treatment, and thereby greatly reduced the effect of the interaction between calf sex and treatment. The diminished treatment difference could be a result of calving dates (Mean calving date: treatment 1 = 71.1 ± 5.2; and treatment 2 = 63.65 ± 4.4). These mean calving dates were not statistically different. The results obtained for adjusted weaning weight agree with reports by Chapman _et al_. (1978); Randel (1981a); Lusby, Enis, and McNew (1979); and Bernard, Fahmy, and Lalande (1973) who found that older heifers weaned heavier calves, but disagree with results reported by Pinney, Stephens, and Pope (1972) who found no difference in weaning weight due to age at calving.

When considering all heifers that calved, the heifers of treatment 2 weaned a greater precentage of their first calves, 65%, than the heifers of treatment 1, 50% (Table VII).

Results and Discussion

Trial 2

Analysis of variance models for the orthogonal contrasts used for treatment comparisons for body weights, body weight changes, body condition scores, body condition score changes, hip height, withers height, width across the hooks, and pelvic area of the heifers in trial 2 are summarized in Table IX. All possible interactions were included in the initial model for each trait, and the models were reduced by excluding any interaction with a probability of significance greater than .25.

Body weights, body weight changes, and body condition scores of heifers through the beginning of the second wintering period are summarized in Table X. The heifers on treatments 2 and 3 bred to calve at 30 months of age were 54.5 kg and 58.1 kg heavier ($P < .01$) at the beginning of the first wintering period, respectively, than the heifers bred to calve at 24 months of age (treatment 1). As was the case in trial 1, this was to be expected since the heifers of treatments 2 and 3 were approximately 6 months older. The older heifers continued to maintain this weight advantage through the first year of the trial. The heifers on treatment 3 were heavier than the heifers on treatment 2 because they were fed to gain .23 kg/day after they had reached a mean body weight of 273 kg, while the heifers on treatment 2 were fed to maintain that weight. The heifers on treatment 3 were 12.6 kg ($P < .01$), 29 kg ($P < .01$), 15.8 kg ($P < .01$), and 14.7 kg ($P < .05$) heavier than the heifers on treatment 2 at the end of the first wintering period, the beginning of the first breeding season, the end of the first breeding season, and the beginning of the second winter, respectively. The heifers on treatment 2 were 33 kg ($P < .01$),

TABLE IX

LEAST SQUARES ANALYSIS OF VARIANCE MODELS USED FOR ORTHOGONAL CONTRASTS OF GROWTH TRAITS OF HEIFERS (TRIAL 2, REPLICATIONS 1 AND 2)

Growth Traits	Main Effects and Interactions						
	Repli-cation	Calf Sex	Treat-ment	REP*CSEX	REP*TRMT	CSEX*TRMT	REP*CSEX*TRMT
Weight							
Beg. 1st winter	*	--	****	--	--	--	--
End 1st winter	****	--	****	--	**	--	--
Beg. 1st brdg. season	*	--	****	--	***	--	--
End 1st brdg. season	*	--	****	--	****	--	--
Beg. 2nd winter	****	--	****	--	***	--	--
Immed. post calving	*	--	****	--	*	--	--
End 2nd winter	*	*	****	--	--	--	--
Beg. 2nd brdg. season	***	*	****	--	--	--	--
End 2nd brdg. season	*	*	****	--	**	--	--
Final	****	*	****	--	**	--	--
Weight Changes							
Beg.-end 1st winter	****	--	****	--	****	--	--
Beg. 1st winter-Beg. 1st brdg.	***	--	**	--	****	--	--

TABLE IX (Continued)

Growth Traits	Repli-cation	Calf Sex	Main Effects and Interactions Treat-ment	REP*CSEX	REP*TRMT	CSEX*TRMT	REP*CSEX*TRMT
Beg.-end 1st brdg.	*	--	*	--	*	--	--
End 1st brdg. - beg. 2nd winter	****	--	*	--	*	--	--
Beg. 1st winter - beg. 2nd winter	****	--	***	--	****	--	--
Beg. 2nd winter - post calv.	****	**	*	--	--	***	*
Post calv. - beg. 2nd brdg.	****	*	****	--	--	--	--
Beg - end 2nd brdg.	****	*	*	--	--	****	*
Post calv. - final	****	*	*	--	--	--	--
Condition Scores							
Beg. 2nd winter	****	--	****	--	--	--	--
End 2nd winter	****	--	****	--	--	--	--
Beg. 2nd brdg.	***	*	***	--	--	--	*
End 2nd brdg.	****	*	***	--	--	**	--
Condition Sc. Changes							
Beg.-end 2nd winter	*	--	*	--	--	--	--
End 2nd winter - beg. 2nd brdg.	****	*	*	--	*	--	--
Beg.-end 2nd brdg.	***	*	*	--	*	****	*

TABLE IX (Continued)

Growth Traits	Main Effects and Interactions Repli-cation	Calf Sex	Treat-ment	REP*CSEX	REP*TRMT	CSEX*TRMT	REP*CSEX*TRMT
Hip Height							
Beg. 1st winter	****	--	****	--	--	--	--
End 1st winter	****	--	****	--	***	--	--
Beg. 2nd winter	***	--	****	--	*	--	--
End 2nd winter	****	--	****	--	--	--	--
Withers Height							
Beg. 1st winter	****	--	****	--	--	--	--
End 1st winter	****	--	****	--	**	--	--
Beg. 2nd winter	***	--	*	--	--	--	--
End 2nd winter	*	--	***	--	*	--	--
Width Across Hooks							
Beg. 1st winter	****	--	****	--	--	--	--
End 1st winter	*	--	****	--	--	--	--
Beg. 2nd winter	*	--	****	--	*	--	--
End 2nd Winter	*	--	****	--	***	--	--
Pelvic Area							
End 1st winter	**	--	****	--	--	--	--

* Used in analysis, not significant
** ($P<.10$)
*** ($P<.05$)
**** ($P<.01$)

TABLE X

BODY WEIGHTS, BODY WEIGHT CHANGES, AND CONDITION SCORES OF HEIFERS FROM NOVEMBER 1980 AND 1981 UNTIL NOVEMBER 1981 AND 1982 (TRIAL 2, REPLICATIONS 1 AND 2)

	Calve at 24 Mo.		Calve at 30 Mo.				Sig. Level[c]
		(Treatment 1)		273 kg-Maintain (Treatment 2)		273 kg-Gain (Treatment 3)	TRT 1 vs. 2,3 TRT 2 vs. 3
Weight (Kg)							
Beg. 1st winter	30[a]	179.6±3.7[b]	31	234.1±3.6	28	237.7±3.8	<.01
End 1st winter	30	239.3±3.1	30	272.3±3.1	28	284.9±3.3	<.01, <.01
Beg. 1st brdg. season	30	256.0±8.0	30	290.5±8.0	28	319.5±8.2	<.01, .01
End 1st brdg. season	30	306.8±6.0	29	361.7±6.0	28	377.5±6.2	<.01, <.10
Beg. 2nd winter	29	362.5±5.3	30	419.0±5.2	28	433.7±5.4	<.01, .05
Weight Changes (Kg)							
Period and Interval							
1. Beg.-end 1st winter	30	59.9±2.5	30	37.5±2.5	28	47.2±2.5	<.01, <.01
2. Beg. 1st winter-Beg. 1st brdg.	30	76.6±7.4	30	55.9±7.4	28	81.8±7.7	.01
3. Beg.-end 1st brdg.	30	50.8±6.1	29	69.1±6.2	28	58.0±6.3	<.10
4. End 1st brdg. - beg. 2nd winter	29	55.5±3.2	29	59.8±3.2	28	56.2±3.3	--
5. Beg. 1st winter - beg. 2nd winter	29	182.5±3.7	30	184.2±3.7	28	196.0±3.8	<.05
Average Daily Gains[d] (Kg/day)							
Period/Interval Length							
1. 153 days	30	.39	30	.25	28	.31	
2. 174 days	30	.44	30	.32	28	.47	
3. 62 days	30	.82	29	1.11	28	.94	
4. 131 days	29	.42	29	.46	28	.43	
5. 367 days	29	.50	30	.50	28	.53	

TABLE X (CONTINUED)

	CALVE AT 24 MO.	CALVE AT 30 MO.			
	(Treatment 1)	273 kg - MAINTAIN (Treatment 2)	273 kg - GAIN (Treatment 3)	Sig. Level[c] TRT 1 vs 2,3	Sig. Level[c] TRT 2 vs 3
<u>Condition Score</u> (Scale = 1 to 9)					
Beginning 2nd winter	29[a] 6.26 ± .07[b]	30 6.61 ± .07	28 6.53 ± .08	<.01	

[a] Number of observations
[b] Least squares means ± standard error
[c] Orthogonal contrasts
[d] No statistical comparisons made (Calc. from mean weight changes)

34.5 kg ($P < > .01$), 54.9 kg ($P < .01$), and 56.5 kg ($P < .01$) heavier than the heifers on treatment 1 at the same respective measurement times. These treatment differences in body weight were expected, and were somewhat greater than the differences achieved in trial 1.

The average daily gain during the first wintering period of the heifers on treatment 1 (.39 kg/day) was near the desired rate (.45 kg/day), but was less than the .44 kg/day achieved in trial 1 (Table I). The average daily gains during this time of the older heifers on treatments 2 and 3 were .25 kg/day and .31 kg/day, respectively. The total weight gains during the first wintering period were 59.9 ± 2.5 kg, 37.5 ± 2.5 kg, and 47.2 ± 2.5 kg for heifers on treatments 1, 2, and 3, respectively, ($P < .01$).

The average daily gain of the heifers from the beginning of the first wintering period until the beginning of the first breeding season (.44 kg/day, .32 kg/day, and .47 kg/day for treatments 1, 2, and 3, respectively) indicate that the heifers on all 3 treatments continued to gain for the three weeks between the end of the wintering period and the beginning of the breeding season. This was not the case with the heifers on treatment 2 in trial 1 (Table I). The total weight change during this time differed only between the heifers of treatments 2 and 3 (55.9 ± 7.4 kg vs. 81.8 ± 7.7 kg, $P < .01$) and the gain for heifers on treatment 1 was intermediate (76.6 ± 7.4 kg).

The heifers on treatment 2 gained the most during the breeding season (69.1 ± 6.2 kg, 1.11 kg/day), the heifers on treatment 3 gained slightly less (58 ± 6.3 kg, .94 kg/day), and those on treatment 1 gained the least (50.8 kg, .82 kg/day) ($P < .10$). This inverse relationship between winter gain and subsequent gains during the grazing season suggests that compensatory growth occurred (Short and Bellows, 1971 and Ferrel, 1982).

The weight gain of heifers from the end of the first breeding season until the beginning of the second wintering period was similar for the three treatment groups (55.5 ± 3.2 kg, .42 kg/day; 59.8 ± 3.2 kg, .46 kg/day; and 56.3 ± 3.3 kg, .43 kg/day for treatments 1, 2, and 3, respectively).

Body condition score at the beginning of the second wintering period was similar for the heifers on treatments 2 and 3 (6.61 ± .07 and 6.53 ± .08), and was greater than the score for the heifers on treatment 1 (6.26 ± .07, $P < .05$). These similarities in body condition score would be expected since the body weight gains following the breeding season were similar for heifers of all 3 treatment groups.

Body weights, body weight changes, body condition scores, and body condition score changes of heifers from the beginning of the second wintering period through the end of the trial are presented in Table XI. The bred heifers of all 3 treatment groups were fed during the second winter at the moderate level defined in trial 1. The heifers on treatments 1, 2, and 3 lost 7.7%, 7.4%, and 8.1% of their weight, respectively, during this period, somewhat less than

TABLE XI

BODY WEIGHTS AND BODY WEIGHT CHANGES OF HEIFERS FROM NOVEMBER 1981 AND 1982 UNTIL OCTOBER 1982 AND 1983 (TRIAL 2, REPLICATIONS 1 AND 2)

	CALVE AT 24 MO.		CALVE AT 30 MO.					
		(Treatment 1)		273 kg - MAINTAIN (Treatment 2)		273 kg - GAIN (Treatment 3)	Sig. Level[c] TRT 1 vs 2,3	TRT 2 vs 3
Weight (Kg)								
Beg. 2nd winter	29[a]	362.5 ± 5.3[b]	30	419.0 ± 5.2	28	433.7 ± 5.4	<.01,	.05
Immed. post-calving	28	334.3 ± 6.0	27	387.8 ± 6.0	28	398.5 ± 6.0	<.01	
End 2nd winter	29	325.1 ± 6.6	27	371.2 ± 6.9	28	382.9 ± 6.8	<.01	
Beg. 2nd brdg. season	27	320.8 ± 6.3	28	366.0 ± 6.2	28	374.0 ± 6.2	<.01	
End 2nd brdg. season	27	367.8 ± 6.7	28	414.6 ± 6.6	28	419.2 ± 6.6	<.01	
Final	27	394.9 ± 7.4	28	441.5 ± 7.3	28	447.1 ± 7.3	<.01	
Weight Changes (Kg)								
Period and Interval								
6. Beg. 2nd wntr/post calv.	27	-29.5 ± 4.1	28	-31.6 ± 4.0	28	-36.0 ± 3.8	--	
7. Post calv./beg 2nd brdg.	27	-12.3 ± 3.2	27	-22.9 ± 3.3	28	-24.5 ± 3.2	<.01	
8. Beg.-end 2nd brdg.	27	46.9 ± 1.9	28	47.9 ± 1.9	28	45.8 ± 1.8	--	
9. Post calv. - final	27	61.3 ± 5.1	27	51.7 ± 5.1	28	49.0 ± 5.0	<.01	

[a]Number of observations
[b]Least squares means ± standard error
[c]Orthogonal contrasts

TABLE XI (CONTINUED)

CONDITION SCORES AND CONDITION SCORE CHANGES OF HEIFERS FROM NOVEMBER 1981 AND 1982 UNTIL OCTOBER 1982 AND 1983 (TRIAL 2, REPLICATIONS 1 AND 2)

	CALVE AT 24 MO.		CALVE AT 30 MO.					
			273 kg - MAINTAIN		273 kg - GAIN		Sig. Level[c]	
		(Treatment 1)		(Treatment 2)		(Treatment 3)	TRT 1 vs 2,3	TRT 2 vs 3
<u>Condition</u> <u>Scores</u>								
Beg. 2nd winter	29[a]	6.26 ± .07[b]	30	6.61 ± .07	28	6.53 ± .08	<.01	
End 2nd winter	29	5.68 ± .07	30	5.97 ± .06	28	5.92 ± .07	<.01	
Beg. 2nd brdg.	27	5.01 ± .08	27	5.31 ± .08	28	5.27 ± .08	<.01	
End 2nd brdg.	28	5.67 ± .10	28	5.98 ± .10	28	5.82 ± .10	.05	
<u>Condition</u> <u>Score</u> <u>Changes</u>								
Beg.-end 2nd winter	29	-.58 ± .09	30	-.64 ± .08	28	-.61 ± .09	--	
End 2nd wntr/beg. 2nd brdg.	27	-.65 ± .08	27	-.66 ± .08	28	-.66 ± .07	--	
Beginning-end 2nd brdg.	27	.63 ± .09	27	.65 ± .08	28	.55 ± .08	--	

[a]Number of observations
[b]Least squares means ± standard error
[c]Orthogonal contrasts

the planned loss of 10%.

The heifers on treatment 1 were not only lighter than the heifers on treatments 2 and 3 at the beginning of the second wintering period, but remained lighter from immediately post calving through the end of the trial. The heifers on treatment 1 were 53.5 kg, 46.1 kg, 45.2 kg, 46.8 kg, and 46.6 kg lighter than the heifers on treatment 2, and 64.2 kg, 57.8 kg, 53.2 kg, 51.4 kg, and 52.2 kg lighter than those on treatment 3 immediately post calving, at the end of the second wintering period, at the beginning of the second breeding season, at the end of the second breading season, and at the end of the trial, respectively ($P < .01$). Although not statistically significant, the heifers on treatment 3 were 10.7 kg, 8 kg, 4.6 kg, and 5.6 kg heavier than the heifers of treatment 2 at the same measurement times. The small difference in weight between the heifers of treatments 2 and 3 by the end of the second breeding season implies that the heifers of treatment 2 gained more during the second wintering period and second breeding season so were nearly equal the weight of the heifers on treatment 3.

The heifers on all 3 treatments lost weight between calving and the beginning of the breeding season (-12.3 ± 3.2 kg, -22.9 ± 3.3 kg, and -24.5 ± 3.2 kg for treatments 1, 2, and 3, respectively). The heifers on treatment 1 lost less weight ($P < .01$) than the heifers on treatments 2 and 3. The heifers on treatment 1 gained more weight ($P < .10$) from calving through the end of the trial (61.3 ± 5.1 kg) than the heifers of treatments 2 and 3 (51.7 ± 5.1 kg and 49.0 ± 5.0 kg.

Body condition scores of the heifers on treatment 1 were consistently lower than the heifers on treatments 2 and 3 at the beginning and end of the second wintering period ($P < .01$), and the beginning ($P < .01$) and end ($P <$ .05) of the second breeding season (Table XI). However, none of the changes in condition score were significantly different between any treatment group (Table XI).

Body measurements of heifers at the beginning and end of the two wintering periods during the trial are presented in Table XII. The height measurements indicate that the older heifers on treatments 2 and 3 were taller at the hips and at the withers than the heifers on treatment 1 at the beginning and end of the first and second wintering periods ($P < .01$). The heifers on treatment 3 were taller at the hips ($P < .05$) and at the withers ($P < .01$) than the heifers on treatment 2 at the end of the first wintering period. The difference in height between the heifers on treatments 2 and 3 at the end of the first wintering period indicates that the increased level of feeding increased skeletal growth as well as body weight. The minimal difference in height between the heifers on treatment 1 and the heifers on treatments 2 and 3 by the end of the second wintering period was expected based on trial 1.

The older heifers on treatments 2 and 3 were wider across the hooks at the beginning of each wintering period

TABLE XII

HEIGHT MEASUREMENTS, WIDTH ACROSS HOOKS, AND PELVIC AREA OF HEIFERS
(TRIAL 2, REPLICATIONS 1 AND 2)

	CALVE AT 24 MO.		CALVE AT 30 MO.					
			273 kg - MAINTAIN		273 kg - GAIN		Sig. Level[c]	
	(Treatment 1)		(Treatment 2)		(Treatment 3)		TRT 1 vs 2,3	TRT 2 vs 3
Beg. 1st Winter								
Hip height (cm)	26[a]	102.8 ± .5[b]	31	108.8 ± .5	28	109.7 ± .5	<.01	
Withers height (cm)	26	95.1 ± .6	31	100.7 ± .5	28	102.5 ± .6	<.01,	.05
Width across hooks (cm)	26	31.8 ± .3	31	36.0 ± .3	28	36.7 ± .3	<.01	
End 1st Winter								
Hip height	30	111.5 ± .5	31	115.1 ± .5	28	116.6 ± .5	<.01,	<.05
Withers Height	30	103.9 ± .5	30	107.5 ± .5	28	109.3 ± .5	<.01,	.01
Width across hooks	30	36.2 ± .3	30	39.9 ± .3	28	40.0 ± .3	<.01	
Pelvic area (cm)	30	130.9 ± 2.7	28	163.6 ± 2.8	28	166.7 ± 2.8	<.01	
Beg. 2nd Winter								
Hip height	29	119.1 ± .6	30	121.9 ± .6	28	122.9 ± .6	<.01	
Withers height	29	112.7 ± 1.1	30	116.1 ± 1.1	28	116.1 ± 1.1	.01	
Width across hooks	29	42.6 ± .3	30	45.5 ± .3	28	46.3 ± .3	<.01	
End 2nd Winter								
Hip height	29	120.8 ± .6	30	123.5 ± .6	28	124.2 ± .6	<.01	
Withers height	29	114.2 ± .8	30	115.7 ± .8	28	117.2 ± .9	<.05	
Width across hooks	29	43.6 ± .4	30	45.9 ± .4	28	46.9 ± .4	<.01,	.05

[a]Number of observations
[b]LS Means ± standard error
[c]Orthogonal contrasts

(P < .01), and had a larger pelvic area than did the heifers on treatment 1 (P < .01; Table XII). The heifers on treatment 3 were slightly (P < .10) wider across the hooks than the heifers on treatment 2 at the end of the first wintering period and the beginning of the second wintering period, and were wider (P < .05) at the end of the second winter. Heifers on treatment 3 also had slightly larger pelvic areas (P < .10). The increased width across the hooks and pelvic area of the heifers on treatment 3 supports the observed increase in skeletal growth as measured by height.

Classification variables (main effects) and interactions used in the least squares analysis of variance models for the eight production traits measured are summarized in Table XIII. Initial models for each trait were reduced according to the procedure described for trial 1. The least squares means for the production traits are summarized in Tables XIV, XV, XVII, and XVIII. Reproductive performance of all heifers in trail 2 is presented in Table XIX.

Fewer heifers on treatment 1 exhibited ovarian activity by the beginning of the breeding season (10.7 ± 7.3%) than heifers on treatments 2 and 3 (55.4 ± 7.4% and 47.6 ± 7.8%, respectively, Table XIV). This was to be expected since the heifers of treatment 1 were younger and lighter. Arije and Wiltbank (1971) suggest that the heifers on treatment 1 could possibly be too young to have reached puberty by this age, and observations reported by Ferrel (1982), Wiltbank, Kasson, and Ingalls (1969), Steffan _et al_. (1983), and

TABLE XIII

LEAST SQUARES ANALYSIS OF VARIANCE MODELS USED FOR PRODUCTION TRAITS OF HEIFERS

PRODUCTION TRAITS	Main Effects and Interactions										
	REP	CSEX	BGRP (REP)	TRMT	REP* CSEX	REP* TRMT	CSEX* BBRP (REP)	CSEX* TRMT	BGRP (REP)* TRMT	REP* CSEX* TRMT	CSEX BGRP (REP)* TRMT
% CYCLING PRIOR TO 1ST BREEDING	****	—	—	****	—	*	—	—	—	—	—
DATE OF CONCEPTION DURING 1ST BREEDING	**	—	*	*	—	—	—	—	*	—	—
CALF BIRTH WEIGHT	*	****	*	****	—	—	—	—	—	—	—
CALVING DIFFICULTY SCORE	*	**	*	**	**	***	—	—	—	—	*
DATE OF CONCEPTION DURING 2ND BRDG.	*	*	*	*	—	—	—	—	***	—	—
POST PARTUM INTERVAL	*	*	*	*	—	—	—	—	****	—	—
CALF WEIGHT AT WEANING	*	****	*	****	**	***	—	—	—	****	—
205 DAY ADJUSTED CALF WEIGHT AT WEANING	****	*	*	****	**	***	—	—	—	*	—

* USED IN ANALYSIS, NOT SIGNIFICANT
**(P<.10)
*** (P<.05)
****(P<.01)

TABLE XIV

LEAST SQUARES MEANS FOR HEIFERS EXHIBITING OVARIAN ACTIVITY BY THE BEGINNING OF THE FIRST BREEDING SEASON AND DATE OF CONCEPTION DURING THE FIRST BREEDING SEASON (TRIAL 2, REPLICATIONS 1 AND 2)

	% OVARIAN ACTIVITY		DATE OF CONC.[e]	
	N	LS MEAN	N	LS MEAN
CALVE AT 24 MO. (TREATMENT 1)	27	10.7 ± 7.3^{a}	29	142.1 ± 2.8
CALVE AT 30 MO. - MAINT. (TREATMENT 2)	26	55.4 ± 7.4^{b}	28	145.2 ± 2.8
CALVE AT 30 MO. - GAIN (TREATMENT 3)	24	47.6 ± 7.8^{b}	28	144.8 ± 2.8

[ab] LS MEANS IN COLUMN WITH DIFFERENT SUPERSCRIPTS DIFFER (P<.01)
[e] EXPRESSED AS DAYS FROM JANUARY 1 OF THAT YEAR

Replication 1	36	14.4 ± 6.4	45	144.8 ± 2.2
Replication 2	41	61.4 ± 5.9	40	142.8 ± 2.3

[e] EXPRESSED AS DAYS FROM JANUARY 1 OF THAT YEAR

Laster, Smith, and Gregory (1976) suggest that the heifers on treatment 1 could possibly be too light to have reached puberty at this time.

Though not significant, there was a difference between the two replications (years) for percent of heifers exhibiting ovarian activity by the beginning of the breeding season (Table XIV). In replication 1, only 14.4 ± 6.4% of all heifers exhibited ovarian activity by the beginning of the breeding season compared to 61.4 ± 5.9% for all heifers in replication 2. The replication by treatment interaction approached significance ($P = .11$), with 0% and 21.4% of the heifers on treatment 1 exhibiting ovarian activity in replications 1 and 2, respectively. Twenty-five percent and 85.8% of the heifers on treatment 2 exhibited ovarian activity in replications 1 and 2, respectively. Replication (year) had no influence on weight at the beginning of the first breeding season, however, it did influence weight at the end of the first wintering period, weight changes during the first wintering period, and weight changes from the beginning of the first wintering until the beginning of the first breeding season. The reduced number of heifers on all 3 treatment groups exhibiting ovarian activity by the beginning of the first breeding season in replication 1 is accompanied by lighter body weights at the end of the first wintering period (treatment 1, 223.9 ± 4.3 kg vs. 254.8 ± 4.5 kg; treatment 2, 267.1 ± 43 kg vs. 277.4 ± 4.6 kg, and treatment 3, 276.4 ± 4.5 kg vs. 293.4 ± 4.8 kg, for replication 1 vs. replication 2 respectively, Table X). Weight gain during the first wintering period was greater for heifers on treatments 1 and 3 in replication 2 (75.5 ± 3.6 kg and 52.2 ± 3.7 kg) compared to replication 1 (44.4 ± 3.4 kg and 42.3 ± 3.5 kg). The heifers on treatment 2 gained similarly in both replications (37.5 ± 2.5 kg). Weight gain through the wintering period, until the beginning of the first breeding season was greater for those heifers on treatments 2 and 3 in replication 1 (Table I), but lesser for the heifers on treatment 1 in replication 1 (Table I), when compared to the heifers on treatments 1, 2, and 3 in replication 2 (Table X). These observations suggest that weight at the end of the wintering period prior to first breeding had the most consistent yearly influence on ovarian activity by the beginning of the first breeding season. Weight gain during the wintering period and through the wintering period, and until the beginning of the breeding season, were not consistent between the two years.

Date of conception during the first breeding season was not influenced by treatment or replication (Table XIV), and the actual dates were similar to those of the heifers on treatment 2 in trial 1. However, the absence of differences between the older and younger heifers disagrees with the results of trial 1, and no difference between the older heifers gaining at different rates during the wintering period disagrees with a report by Ludwig et al. (1967) that heifers wintered at lower levels of gain prior to breeding had delayed calving dates when compared to heifers wintered at greater levels of gain prior to breeding. These differences may be related to body conditions of cows in different studies.

The heifers on treatment 3 had calves that were 3.5 kg heavier at birth than the calves from the heifers on treatment 1 ($P < .01$, Table XV). Birth weight of calves from heifers on treatment 2 were 1.9 kg heavier than the calves from the heifers on treatment 1 ($P > .10$). Bull calves from all heifers were 2.2 kg heavier than heifer calves ($P < .01$).

Calving difficulty score was not influenced as much by treatments as in trial 1. The heifers on treatment 1 had slightly more difficulty than the heifers on treatments 2 and 3. Heifers giving birth to bull calves experienced only slightly more difficulty than heifers giving birth to heifer calves (Table XV). These reduced differences in calving difficulty score compared to trial 1 may be due to the use of Angus bulls in trial 2. Birth weights of bull and heifer calves in trial 1 were approximately 1 kg heavier than those of bull and heifer calves in trial 2. The birth weights of calves born to heifers of treatment 1 in trial 1 were 3.3 kg heavier than the calves born to heifers of treatment 1 in trial 2 (Tables VI and XV). These observations imply that the Hereford bulls used in trial 1 may have been partly responsible for the increased birth weight of calves in trial 1, and this increase in birth weight may have been partially responsible for the increased incidence of calving difficulty. Pelvic area of the heifers in trial 1 was approximately 10 cm^2 greater for heifers of both treatments when compared to the heifers in trial 2 (Tables III and XII).

TABLE XV

LEAST SQUARES MEANS FOR CALF BIRTH WEIGHT AND CALVING DIFFICULTY SCORE (TRIAL 2, REPLICATIONS 1 AND 2)

	CALF BIRTH WT. (kg)		CALVING DIFF. SCORE[f]	
	N	LS MEAN	N	LS MEAN
CALVE AT 24 MO. (TREATMENT 1)	29	$32.8 \pm .7^{a}$	29	$2.9 \pm .3$
CALVE AT 30 MO. - MAINT. (TREATMENT 2)	28	$34.7 \pm .7^{ab}$	28	$2.2 \pm .3$
CALVE AT 30 MO. - GAIN (TREATMENT 3)	28	$36.3 \pm .7^{b}$	27	$2.2 \pm .3$

[ab]LS MEANS IN A COLUMN WITH DIFFERENT SUPERSCRIPTS DIFFER (P<.01)
[f]SCALE = 1 TO 5

BULL CALVES	45	$35.7 \pm .5^{a}$	45	$2.6 \pm .3$
HEIFER CALVES	40	$33.5 \pm .6^{b}$	39	$2.2 \pm .3$

[ab]LS MEANS IN A COLUMN WITH DIFFERENT SUPERSCRIPTS DIFFER (P<.01)
[f]SCALE = 1 TO 5

These observations suggest that calf birth weight may influence calving difficulty to a greater degree than pelvic area.

Table XVI is the analysis of variance for the regression model used to predict calving difficulty. A reliable prediction equation could not be developed by adding pelvic measurements to the main effects of the model. The model accounted for 14% of the observed variation, which is slightly less than that explained by the same model used in trial 1 (Table VIII). The inclusion of calf birth weight in the analysis of calving difficulty in trials 1 and 2 revealed that it did have a significant effect ($P < .01$). The model used in trial 1 included calf sex, breeding group (sire), calf birth weight, and width across the hooks at the end of the first wintering period, and was able to account for approximately 55% of the observed variation. The model used in trial 2 included replication, calf sex, breeding group (sire), calf birth weight, mid-winter weight prior to calving, weight change from mid-winter to the post-calving weight, and width across the hooks at the end of the first winter, and was able to account for approximately 34% of the observed variation. Date of conception was not influenced by treatment or by sex of calf (Table XVII). Though not significant, the heifers on treatment 1 had a post partum interval approximately 7 days longer than the heifers on treatment 3, approximately 3 days longer than the heifers on treatment 2. The 7 day difference between the heifers on

TABLE XVI

ANALYSIS OF VARIANCE INCLUDING PELVIC MEASUREMENTS AS COVARIABLES FOR THE PREDICTION OF CALVING SCORE (TRIAL 2, REPLICATIONS 1 AND 2)

SOURCE	D.F.	MEAN SQUARE	F VALUE	PROB. > F
REPLICATION	1	3.565	2.50	0.118
CALF SEX	1	5.725	4.02	0.049
BREEDING GROUP (REP)	3	0.595	0.42	0.745
TREATMENT	2	0.436	0.31	0.738
PELVIC WIDTH	1	0.449	0.31	0.577
PELVIC DEPTH	1	0.531	0.37	0.544
PELVIC AREA	1	0.452	0.32	0.575

SOURCE	D.F.	MEAN SQUARE	F VALUE	PROB. > F
MODEL	10	1.677	1.18	0.321
ERROR	72	1.426		

R-SQUARE = 0.140

TABLE XVII

LEAST SQUARES MEANS FOR DATE OF CONCEPTION DURING THE SECOND BREEDING SEASON AND POST PARTUM INTERVAL (TRIAL 2, REPLICATIONS 1 AND 2)

	DATE OF CONC.		POST PARTUM INTERVAL (days)	
	N	LS MEAN	N	LS MEAN
CALVE AT 24 MO. (TREATMENT 1)	22	151.6 ± 3.2	22	90.7 ± 4.1
CALVE AT 30 MO. - MAINT (TREATMENT 2)	21	151.0 ± 3.2	21	87.4 ± 4.1
CALVE AT 30 MO. - GAIN (TREATMENT 3)	25	149.6 ± 3.0	25	83.9 ± 3.8
NURSG. MALE CALVES	35	150.6 ± 2.6	35	88.9 ± 3.3
NURSG. FEMALE CALVES	33	151.0 ± 2.7	33	85.8 ± 3.4

treatment 1 and the heifers on treatment 3 is approximately half as great as the difference reported in trial 1 (Table V). A comparison was made between the post partum interval of the heifers nursing bull calves and the heifers nursing heifer calves since increased suckling intensity extended the post partum interval of cows (Wettemann *et al.*, 1978; Wyatt *et al.*, 1977). Results from this trial indicate a post partum interval only 3 days longer ($P > .10$) for those heifers nursing bull calves when compared to the heifers nursing heifer calves.

Steer calves were 13.8 kg heavier at weaning than heifer calves (Table XVIII). This difference was expected. The 205 day adjusted weaning weight of calves on treatment 1 was 25.7 kg, and 23.3 kg less ($P < .01$) than the calves on treatments 2 and 3, respectively. These greater differences agree with the 7.2 kg difference in 205 day adjusted weight between the calves on treatment 1 and the calves on treatment 2 in trial 1.

Milk production studies of 2 and 3 year old cows were reported by Notter, Cundiff, Smith, Laster, and Gregory (1978). The comparisons were made in different years, and the 3 year old cows had undergone a previous lactation. Two year old cows of diverse breed types gave 4.5 ± 4 kg/24 hr., 5.1 ± .6 kg/24 hr., and 3.9 ± .4 kg/24 hr. on days 131, 157, and 187 of lactation, respectively. Three year old cows gave 3.7 ± .2 kg/12 hr., 2.9 ± .2 kg/12 hr., and 2.1 ± .2 kg/12 hr. on days 128, 156, and 184 of lactation, respectively. These

TABLE XVIII

LEAST SQUARES MEANS FOR CALF WEIGHT AT WEANING
AND 205 DAY ADJUSTED CALF WEIGHT AT WEANING
(TRIAL 2, REPLICATIONS 1 AND 2)

	CALF WT. AT WEANING (kg)	
	N	LS MEAN
STEER CALVES	41	205.6 ± 4.0^{a}
HEIFER CALVES	36	191.8 ± 4.3^{b}

[ab] LS MEANS IN A COLUMN WITH DIFFERENT SUPERSCRIPTS DIFFER (P<.01)

		205 DAY ADJ. WN. WT.[g] (kg)	
		N	LS MEAN
CALVE AT 24 MO. (TREATMENT 1)		27	182.3 ± 4.7^{a}
CALVE AT 30 MO. (TREATMENT 2)	273 kg - MAINT.	24	208.0 ± 4.8^{b}
CALVE AT 30 MO. (TREATMENT 2)	273 kg - GAIN	26	205.6 ± 4.5^{b}

[ab] LS MEANS IN A COLUMN WITH DIFFERENT SUPERSCRIPTS DIFFER (P<.01)
[g] ADJSUSTED TO 205 DAY STEER EQUIVALENT BY THE FORMULA SPECIFIED IN TRIAL 1

observations indicate that the increased 205 day adj. weaning weights of calves nursing the older heifers in trials 1 and 2 could be due in part to the increased milk production by their dams.

The heifers on treatments 1, 2, and 3 had similar conception rates during the first breeding season (96%, 100%, and 100%, respectively; Table XIX) and date of conception was also similar (Table XIV). These observations imply that the younger heifers on treatment 1 were able to conceive as soon as the older heifers on treatments 2 and 3 even though they had less ovarian activity immediately prior to the breeding season (Table XIV). The number of heifers calving per number pregnant was also similar for all treatments (100%, 93%, and 100%, respectively). The number of live calves per number of heifers exposed was slightly less ($P > .10$) for the heifers on treatments 1 and 2 when compared to the heifers on treatment 3 (90% and 90%, vs. 100%).

The heifers on treatment 3 gave birth to the heaviest calves (37.4 ± 1.5 kg and 35.3 ± 1.7 kg for bull and heifer calves, respectively); the heifers on treatment 2 gave birth to slightly lighter calves (35.9 ± 1.1 kg, and 33.2 ± 1.6 kg, respectively); and the heifers on treatment 1 gave birth to the lightest calves (33.7 ± .9 kg, and 32.1 ± .9 kg, respectively).

A greater number of heifers on treatment 1 had dystocia (72%) than the heifers on treatments 2 and 3 (53% and 50%, respectively). However, the number of calves lost to the

TABLE XIX
SUMMARY OF REPRODUCTIVE PERFORMANCE OF HEIFERS
(TRIAL 2, REPLICATIONS 1 AND 2)

	CALVE AT 24 MO.	CALVE AT 30 MO.	
	(TREATMENT 1)	273 kg - MAINTAIN (TREATMENT 2)	263 kg - GAIN (TREATMENT 3)
INITIAL NO. HEIFERS	30	31	28
NO. EXPOSED, 1st BRDG.	30	30	28
NO. PREGNANT	29	30	28
NO. CALVED	29	28	28
NO. LIVE CALVES	27	27	28
MEAN BIRTH WEIGHT (kg)			
BULL CALVES	33.7 ± .9	35.9 ± 1.1	37.3 ± 1.5
HEIFER CALVES	32.0 ± .9	33.1 ± 1.6	35.2 ± 1.7
LIVE CALVES	33.1 ± .9	34.6 ± 1.3	36.1 ± 1.6
DEAD CALVES	32.2 ± .3	37.2 ± 0.0	
NO. HEIFERS CALV. SCORE >=2	21	15	14
NO. DEAD CALVES, SCORE >=2	1	1	0
NO. CALVES WEANED	27	25	26
NO. COWS EXPOSED, 2nd BRDG.	30	30	28
NO. PREGNANT	24	25	26

heifers experiencing dystocia was very similar (3%, 3.5%, and 0% for treatments 1, 2, and 3, respectively).

The number of calves weaned per number of heifers exposed was 90%, 83%, and 93% for heifers of treatments 1, 2, and 3, respectively. Two calves in treatments 2 and 3 died between calving and weaning.

Rebreeding performance of the heifers of treatments 1 and 2 was similar (80% and 83%, respectively), and was slightly less ($P > .10$) than for heifers on treatment 3 (93%). Although not significant, it appears that the heifers on treatment 3 had the best reproductive performance when considering conception during the first breeding season, calving difficulty, calf survival, and rebreeding performance.

CHAPTER V

SUMMARY

This study consisted of two trials involving a total of 129 seven and thirteen month old Hereford heifers obtained in the fall of three consecutive years. The heifers obtained in any given year were born the previous spring or fall to cows of similar breeding and similar bulls in both seasons. The heifers were placed on their respective winter treatments and bred the following spring to calve at either 24 or 30 months of age.

The bred heifers of both treatments were managed similarly during the second winter, and calving and rebreeding data were obtained. The trial was terminated when a set of heifers had their first calves weaned in October. Trial 1, initiated in the fall of 1979, consisted of forty heifers in two treatments: heifers on treatment 1 were bred to calve in the spring at 24 months of age, and heifers on treatment 2 were bred to calve in the spring at 30 months of age. The heifers were maintained on dormant native grass range supplemented with the necessary ground milo and cottonseed meal to achieve the desired weight gain during the wintering period (November 29 to April 17). The initial weight of the heifers on treatment 1 was 183.7 ± 2.9 kg and they gained .44 kg/day during the winter feeding period. The heifers on on treatment 2 averaged 231.0 ± 4.0 kg initially, and gained .32 kg/day so they weighed 273 kg by the end of the wintering period.

The heifers on treatment 2 were taller at the hips and withers ($P < .05$) at the beginning of the trial, and wider across the hooks ($P < .10$) than the heifers on treatment 1 throughout the trial, however, the difference in height was somewhat diminished ($P > .25$) by the end of the trial. The heifers of treatment 2 also had larger pelvic areas ($P < .05$) at the end of the first wintering period (173.1 ± 3.4 cm^2 vs. 142.1 ± 4.1 cm^2).

Conception rates were similar for the two groups of heifers, 95% and 100% for treatments 1 and 2, respectively). However, the average date of conception was 1 week later ($P > .25$) for the heifers on treatment 1 (May 31 vs. May 24).

The heifers on both treatments were fed during the second wintering period at a moderate level to achieve a weight loss at calving of 10% of their fall (November 15) weight. Actual weight loss was near the desired amount (trmt. 1 = 10.3%, and trmt. 2 = 8.9%).

Calf birth weight did not differ between treatments, but calving difficutly score (scale: 1 = no assistance; 5 = cesarean section) was greater ($P < .05$) for the heifers on treatment 1 (mean score = 3.21 ± .34) than for the heifers on treatment 2 (mean score = 1.89 ± .35). Heifers giving birth to bull calves tended to have more difficulty (mean score = 2.96 ± .35) than heifers that had heifer calves

(2.15 ± .38). An effort to predict calving difficulty prior to parturition by using a regression model including pelvic measurements was not significant. Although not significant, a greater number of the heifers on treatment 1 suffered dystocia (72%), and lost more claves due to dystocia (54%) than did the heifers on treatment 2 (50% and 40%, respectively).

Analysis of heifers nursing calves and those not nursing calves revealed that heifers on treatment 2 conceived earlier (P > .15) during the second breeding season (ave. date = June 1) than the heifers on treatment 1 (ave. date = June 13), but the conception rate of both groups was similar (trmt. 1 = 84%, and trmt. 2 = 88%). Although not significant, post partum interval to conception of only those heifers nursing calves was 23 days shorter for the heifers on treatment 2 than for the heifers on treatment 1.

The actual and adjusted weaning weights of calves from the heifers on treatment 2 were heavier (P > .25; 183.7 ± 12.3 kg and 192.7 ± 9.1 kg, respectively) than those of the calves from the heifers on treatment 1 (170.3 ± 12.3 kg and 185.1 ± 9.1 kg, respectively). When considering all heifers that calved, the heifers on treatment 2 weaned a greater percentage of calves (65%) than did the heifers on treatment 1 (50%).

The two replications of trial 2 were initiated in the falls of 1980 and 1981, and involved 89 heifers. Treatment 1 included 30 heifers assigned to treatment in November at an average weight of 179.6 ± 3.7 kg following weaning at 7 months, and fed supplemental ground corn and cottonseed meal to gain .45 kg/day during the first wintering period. They were bred to calve in the spring at 24 months of age. Fifty-nine fall-born heifers were bred to calve at 30 months of age, and were supplemented during the first wintering period either to maintain their weight after reaching a mean body weight of 273 kg (treatment 2, n = 31, initial wt. = 234.1 ± 3.6 kg), or to gain .23 kg/day after reaching the same body weight (treatment 3, n = 28, initial wt. = 237.7 ± 3.8 kg).

The heifers on treatment 1 gained less than the desired winter weight gain (.39 kg/day), and the heifers on treatments 2 and 3 gained at different rates during the first wintering period in order to reach their respective weights of 273 kg and 285 kg (.25 kg/day and .31 kg/day, respectively).

The heifers on treatments 2 and 3 were taller at the hips and withers, and wider across the hooks than were the heifers on treatment 1 throughout the trial ($P < .01$). The heifers on treatments 2 and 3 also had larger pelvic areas ($P < .01$) than did the heifers on treatment 1 (163.6 ± 2.8 cm^2 and 166.7 ± 2.8 cm^2 vs. 130.9 ± 2.7 cm^2). The heifers on treatment 3 were taller ($P < .01$) at the hips and withers, slightly wider across the hooks, and had slightly larger pelvic areas than did the heifers on treatment 2 at the end of the first wintering period, suggesting that the increased level of feeding increased skeletal growth as well as body weight.

Fewer heifers on treatment 1 exhibited ovarian activity ($P < .01$) by the beginning of the first breeding season (10.7 ± 7.3%) as compared to the heifers on treatments 2 and 3 (55.4 ± 7.4% and 47.6 ± 7.8%, respectively). However, even though ovarian activity varied between treatments, there was no difference between treatments in date of conception during the first breeding season (May 22, May 25, and May 25 for treatments 1, 2, and 3, respectively).

The bred heifers on all 3 treatments were fed during the second wintering period to lose 10% of their fall weight through calving. Their actual losses were -7.7%, -7.4%, and -8.1% of their November 15 weight for treatments 1, 2, and 3, respectively.

The heifers on treatment 3 gave birth to the heaviest calves (36.3 ± .7 kg), followed by the calves from heifers on treatment 2 (34.7 ± .7 kg), and treatment 1 (32.8 ± .7 kg). Bull calves from heifers on all treatments were heavier ($P < .01$; 35.7 ± .5 kg) than the heifer calves (33.5 ± .6 kg). However, only slight differences ($P > .25$) in calving difficulty score were observed. Slightly higher scores were recorded for heifers on treatment 1 (2.9 ± .3) than for the heifers on treatments 2 and 3 (2.2 ± .3 and 2.2 ± 3, respectively), and for the heifers giving birth to bull calves (2.6 ± .3) than for the heifers giving birth to heifer calves (2.2 ± .3). Although not significant, a greater number of heifers on treatment 1 suffered dystocia (72%) than on treatments 2 and 3 (53% and 50%, respectively). Calf losses due to dystocia were not significantly different due to treatment. Calf survival was slightly ($P > .25$) greater for heifers on treatment 3 (100%) than for heifers on treatments 1 and 2 (90%). Calf birth weights and calving difficulty scores were greater for trial 1 when compared to trial 2, which suggests an influence by sires, since Hereford bulls were used in trial 1, and Angus bulls were used in trial 2.

An effort to predict calving difficulty prior to parturition by adding pelvic measurements to a regression analysis yielded no significant effects, which was similar to results observed in trial 1. However, the inclusion of calf birth weight in the analysis of calving difficulty for trials 1 and 2 showed that calf birth weight did have a significant effect.

Body condition scores (scale: 1 = very thin; 9 = obese) of the heifers ranged from 5.0 to 6.6, and the heifers on treatment 1 were consistently 0.3 of a score lower than the heifers on treatments 2 and 3 from the beginning of the second wintering period through the end of the trial.

The heifers on treatment 2 were nearly as heavy (441.5 ± 7.3 kg) as the heifers on treatment 3 (447.1 ± 7.3 kg) by the end of the trial, which indicates they were able to gain more during the second wintering period and second breeding season in order to catch up with the heifers on treatment 3.

The post partum interval to conception for the heifers on treatment 1 (91 days) was 7 days longer than that for the heifers on treatments 2 and 3 (84 days). This difference was not significant, and was only half as large as the difference observed in trial 1. Heifers on treatments 2 and 3 had similar intervals from post partum to conception (87 and 84 days, respectively). Sex of calf did not influence the post partum interval to conception. Date of conception during the second breeding season was not influenced by treatment or sex of calf, but conception rates were slightly less for the heifers on treatments 1 and 2 (80% and 83%, respectively) than for the heifers on treatment 3 (93%).

The 205 day adjusted weaning weight of calves from the heifers on treatment 1 (182.3 ± 4.7 kg) was lighter ($P < .01$) than that for the calves from the heifers on treatment 2 (208 ± 4.8 kg) and treatment 3 (205.6 ± 4.5 kg). The number of calves weaned per number of heifers exposed was not significantly influenced by treatment.

Considering the results from both trials, more of the heifers calving at 24 months of age suffered dystocia than did the heifers calving at 30 months of age, and their dystocia was more severe. Even though the heifers calving at 30 months of age had larger pelvic areas, the use of pelvic measurements was not adequate to predict dystocia prior to parturition.

The treatments imposed in this study did not significantly effect conception rates or average date of conception at either the initial or second breeding season, or the post partum interval from calving to conception. Heifers calving at 30 months of age weaned heavier calves than heifers calving at 24 months of age.

Although the heifers calving at 24 months of age were significantly shorter ($P < .05$) than the heifers calving at 30 months of age by the end of the second wintering period in trial 2 the difference was very small (3 cm), and there was no difference between treatments in trial 1, which indicates that under the conditions imposed in this study there were no adverse effects on growth due to calving at 24 months of age.

Calving heifers at 30 months of age tended to reduce the incidence and severity of dystocia. However, since approximately half of the heifers calving at 30 months experienced dystocia there would be little opportunity to reduce the amount of time and labor required to observe heifers at calving. A marked reduction in severity of dystocia for heifers calving at 30 months occured when Hereford bulls were used, but the reduction was only very slight when Angus bulls sired the calves.

Heifers calving at 30 months of age and fed to gain weight after reaching 273 kg did not have improved reproductive performance compared to heifers calving at 30 months and fed to maintain their weight after reaching 273 kg.

Since conception rate and interval to conception for first and second pregnancies were similar for heifers calving at 24 and 30 months of age the apparent advantages to calving at 30 months rather than 24 months are a possible reduction in dystocia, and the increased weaning weights of the calves.

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TABLE XX

Description of Variables used in Data Analysis

HFR	= Identification number of heifer
BRDT	= Birth date of heifer (month/day/year)
BRWT	= Birth weight of heifer (lbs.)
AGWN	= Heifer age at weaning (days)
WTWN	= Heifer weight at weaning (lbs.)
WT01	= Initial Fall weight of heifer (lbs.)
HIP01	= Initial Fall hip height of heifer (in.)
WIT01	= Initial Fall withers height of heifer (in.)
HOO01	= Initial Fall width across hooks of heifer (cm.)
WT02	= Heifer weight end of 1st wintering period (lbs.)
HIP02	= Heifer hip height end of 1st wintering period (in.)
HOO02	= Heifer width across hooks end 1st wintering period (cm.)
WT03	= Heifer weight beginning 1st breeding season (lbs.)
WT04	= Heifer weight end 1st breeding season (lbs.)
WT05	= Heifer weight beginning 2nd wintering period (lbs.)
HIP05	= Heifer hip height beginning 2nd wintering period (in.)
WIT05	= Heifer withers height begining 2nd wintering period (in.)
HOO05	= Heifer width across hooks beginning 2nd wintering period (cm.)
WT06	= Heifer weight mid 2nd wintering period (lbs.)
WT07	= Heifer weight end 2nd wintering period (lbs.)
HIP07	= Heifer hip height end 2nd wintering period (in.)
WIT07	= Heifer withers height end 2nd wintering period (in.)
HOO07	= Heifer width across hooks end 2nd wintering period (cm.)
PCWT	= Post-calving weight of heifer (lbs.)
DPCWT	= Date of post-calving weight (month/day/year)
BGRP	= Breeding group for 1st breeding season
LD	= Live/Dead calf after birth (1 = live, 2 = dead)
CS	= Calving difficulty score (scale = 1 - 5)
CBWT	= Calf birth weight (lbs)

APPENDIXES

TABLE XX (CONTINUED)

Description of Variables used in Data Analysis

PVW	= Internal pelvic width end 1st wintering period (cm.)
PVD	= Internal pelvic depth end 1st wintering period (cm.)
PVA	= Pvw x pvd (cm)
WT08	= Heifer weight beginning 2nd breeding season (lbs.)
WT09	= Heifer weight end 2nd breeding season (lbs.)
WT10	= Heifer weight when calves were weaned (lbs.)
CWTWN	= Actual calf weaning weight (lbs.)
CAWTWN	= 205 Day steer equivalent weaning weight (lbs.)
JCD1	= Julian date of calving (1st calf)
JCD2	= Julian date of calving (2nd calf)
CSEX	= Sex of 1st calf (1 = bull, 2 = heifer)
DTC1	= Julian date of conception (1st brdg)
DTC2	= Julian date of conception (2nd brdg)
CNS1	= Body condition score beginning 2nd wintering period (scale = 1 to 9)
CNS2	= Body condition score end 2nd wintering period
CNS3	= Body condition score beginning 2nd breeding season
CNS4	= Body condition score when calves were weaned
PPI	= Post partum interval to conception (DTC2 - JCD1)

TABLE XXI

DATA: HEIFERS TO CALVE AT 24 MO. (TREATMENT 1, TRIAL 1)

OBS	HFR	BRDT	BRWT	AGWN	WTWN	WTO1	HIPO1	WITO1	HOOO1	WTO2	HIPO2	HOOO2	WTO3	WTO4	WTO5	HIPO5	WITO5	HOOO5	WTO6	WTO7	HIPO7	WITO7
1	7	30779	52	197	415	443	39 7	37 7	31 8	590	43 5	38.5	594	665	840	46.0	43 5	40.6	843	712	46.0	44.2
2	110	42379	72	150	330	356	38.0	34.5	27.9	494	41 8	35.5	496	590	759	45 5	42 2	41.0	750	672	46.0	44.0
3	132	32179	68	183	360	428	40.0	38 0	32 8	571	45 0	40 2	582	658	849	46 8	45.3	43.8	863	.	48.8	46.5
4	149	40779	74	164	375	412	40 5	36.4	32.8	573	44.6	39.6	573	687	844	47 3	45 3	44.5	842	763	48.0	47.0
5	154	32079	78	184	410	475	40.9	38 0	32 5	600	45 4	38 9	596	719	876	47 0	45 6	43.0	899	784	48.9	45.4
6	324	31979	68	185	350	396	40 2	35.7	31 8	563	43.4	38.7	571	666	822	46 8	43.5	44.3	790	807	48.8	44.1
7	433	32279	72	182	335	379	39.3	36 1	30.5	480	43.2	36 0	.		.	.	.	.	.	.	.	.
8	503	40279	80	171	360	396	39.5	36.8	32.0	511	42.3	37 3	527	647	821	45 4	44.8	39.4	823	646	47.0	43.5
9	513	31479	60	190	360	392	39.8	38.0	30.5	513	44.1	37.4	513	600	749	46 0	43 8	41.3	743	657	47.4	44 1
10	523	30979	68	195	400	403	40.5	38.1	30 7	525	44.2	36.2	531	655	817	47.7	45 3	43.2	816	748	47.1	46.1
11	529	50179	76	142	345	396	39 3	36 5	31 2	536	43 4	38.4	549	665	817	47.1	44.2	43.7	820	723	48.5	46.6
12	601	31579	64	189	385	416	40 0	37 0	30.2	561	43 9	38.6	569	682	862	47 0	44 2	42 8	896	746	47.7	45.7
13	4024	32579	76	179	350	412	39 7	36.7	31.2	585	44.6	40 1	586	710	901	46.8	44.5	44.0	906	792	48.8	45.1
14	4026	22679	58	206	385	401	39 5	46 1	32 0	521	42.9	38 2	526	621	785	45 4	42 7	42.2	776	676	46.7	44.8
15	4040	42179	82	152	350	390	39 8	36.9	30.7	526	44 0	36.8	536	655	797	46.6	43.8	41 0	825	724	47.9	45.5
16	4046	41479	82	159	350	389	39.8	35.9	30.0	534	43.1	37.6	532	636	771	45 1	44.0	38.0	800	.	48.0	44.5
17	4048	32679	78	178	385	445	39.6	37.3	31.8	553	44 2	39.4	570	680	854	46 1	44 0	45.6	845	.	47.0	44.4
18	4070	41079	90	163	350	373	39.7	37.0	30 7	513	42 9	37.0	523	660	837	47.1	44.1	40.0	842	752	48.0	45.5
19	4078	41379	62	160	340	378	39.5	36 5	30.7	510	44.0	37 8	524	651	801	46.9	44.8	44.2	828	708	48.5	45.3
20	4131	.	.	175	.	.	38.8	36.0	12.6	559	43.0	38.1	550	646	798	45.8	42 4	43.0	797	688	46.9	43.0

OBS	HOOO7	PCWT	DPCWT	BGRP	LD	CS	CBWT	PVW	PVD	PVA	WTO8	WTO9	WT10	CWTWN	CAWTWN	JCD1	JCD2	CSEX	DTC1	DTC2	CNS1	CNS2	CNS3	CNS4	PPI
1	44 0	665	22781	1	2	4	99	94	137	129	.		1050	.	.	52	.	1	132	.	.	.	.	.	.
2	44.2	672	41481	1	2	4	75	95	125	119	.	.	1009		.	59	58	1	139	138	.	.	.	.	79
3	48.8	755	42781	1	1	3	81	110	125	138	774	898	970	343	399	109	.	2	189	.	.	.	.	.	.
4	47 0	645	22781	2	2	1	72	125	150	188	.	.	1106	.	.	52	.	2	132	176	.	.	.	.	124
5	47 5	784	41481	2	1	1	78	105	135	142	842	939	1008	379	397	83	88	2	163	168	.	.	.	.	85
6	46 9	810	30281	1	.	.		105	140	.			1150	.	.	.	73	.		153	.	.	.	.	.
7	.	.	.	1	.	.	.	110	120	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8	45 2	646	41481	2	2	4	82	100	125	125	.	.	1045	.		84	60	2	164	140	.	.	.	.	56
9	44 1	635	22781	1	2	4	88	95	137	130		.	945		.	55		1	135	.	.	.	.	.	.
10	45 0	725	30281	2	2	4	81	105	135	142	.	.	1092	.	.	59	.	2	139	166	.	.	.	.	107
11	45.5	830	31981	1	2	1	.	117	140	164		.	1084	.	.	78	65	.	158	145	.	.	.	.	67
12	42 6	775	22781	2	1	4	75	110	139	153	774	937	977	497	452	45	80	2	125	160	.	.	.	.	115
13	49.0	845	30481	2	1	2	72	105	140	147	918	1024	1076	310	301	62	55	2	142	135	.	.	.	.	73
14	46 0	765	30281	1	2	4	79	115	130	150	.		982	.		49	57	2	129	137	.	.	.	.	88
15	45 8	725	30981	2	2	4	82	110	132	145	.		1099	.	.	66	67	2	146	147	.	.	.	.	81
16	47 1	710	42781	1	1	4	72	115	137	158	729	871	925	358	411	113	112	1	193	192	.	.	.	.	79
17	47 0	780	41681	2	1	1	78	110	125	138	819	947	1030	327	374	105	98	2	185	178	.	.	.	.	73
18	46.0	760	30281	1	1	1	70	110	130	143	810	916	970	423	405	59	81	2	139	161	.	.	.		102
19	47 6	745	40781	2	1	3	80	105	125	131	750	862	907	412	456	96	110	2	176	190	.	.	.	.	94
20	46.0	728	22581	2	1	3	70	95	122	116	720	826	876	440	413	54	.	2	134	169	.	.	.	.	115

TABLE XXII

DATA: HEIFERS TO CALVE AT 30 MO. (TREATMENT 2, TRIAL 1)

OBS	HFR	BRDT	BRWT	AGWN	WTWN	WTO1	HIPO1	WITO1	HOOO1	WTO2	HIPO2	HOOO2	WTO3	WTO4	WTO5	HIPO5	WITO5	HOOO5	WTO6	WTO7	HIPO7	WITO7
51	825	92178	.	293	450	480	42.3	39 8	34 8	541	44 3	39.3	557	680	851	47.1	45.1	44.0	858	750	48.0	46.9
52	826	92078	61	294	430	494	41 9	39 0	36.8	599	44 5	41.2	570	739	956	47.6	45.4	47.6	956	776	49.0	46.0
53	827	92378	73	291	470	497	41 4	37 9	37.8	602	43.3	42.0	589	693	897	46.4	44.0	45.6	904	744	47.4	44.3
54	828	92478	.	290	480	495	42.8	39.0	33.8	617	46.0	41 1	590	741	947	48.4	45.1	47.5	990	822	49.2	46.6
55	829	92478	78	290	475	543	43.5	40.8	33.8	659	45.3	39.6	617	748	911	49.1	45.3	42.3	958	.	50.0	46.0
56	831	100178	.	283	425	485	42.0	39.4	35.6	570	44.2	39.5	599	710	895	47.3	45 4	44.3	888	719	48.0	45.9
57	832	100178	.	283	540	586	44.9	40.3	37.6	666	48.8	40.7	643	790	1008	49.3	46.0	46.3	1036	899	51.3	46.9
58	835	100178	.	283	470	528	43 0	39 5	36.3	598	45.1	39.3	571	743	906	47.5	44.6	44.3	933	771	48.5	45.7
59	836	100878	.	276	495	498	42 7	40.0	37.1	598	44.6	40.6	591	740	931	48.0	45.3	47.6	921	763	48.8	45.0
60	837	100978	62	275	470	491	41.1	40.0	33.8	573	43.5	38.9	585	682	881	46.3	44.7	40.2	856	693	47.0	45.6
61	838	101078	60	274	410	470	42 4	38.4	33 0	587	45.3	39.1	594	698	910	47.9	45.6	43.5	927	786	48.5	45.4
62	839	101278	72	272	435	443	39.7	37.5	34.0	567	42.6	38.9	573	710	887	45.3	43.0	42.4	865	729	47.0	43.0
63	840	101378	76	271	480	482	42.5	40 3	35.3	610	46.0	39.9	607	723	942	47.9	46.0	47.0	943	763	48.5	46.0
64	841	101478	70	270	460	528	41.5	39 3	36.3	609	44.9	40.0	593	731	901	46.6	44.6	44.5	914	735	47.6	45.1
65	842	101778	62	267	485	531	42 0	39 8	36 6	612	45 9	39.6	580	705	945	48 3	44.8	46.2	943	816	48.2	46.5
66	843	101778	64	267	465	516	41 0	38 5	36.8	606	44 0	40.9	591	730	901	46.3	44.0	46.1	904	794	47.0	44.5
67	844	101978	76	265	420	435	40 0	38.6	33.3	573	43.8	38 9	599	724	918	48 0	45.2	44.1	940	771	48.2	45.5
68	9848	91678	.	279		571	43 8	38 8	39.1	650	45.7	40.4	614	788	949	47.5	43.5	47.8	981	886	48.5	45.5
69	9852	92178	.	279	.	562	43.0	40 0	37.1	668	45 0	41.1	630	774	980	48.0	44.0	46.8	972	878	47.8	45.5
70	9876	101378		279	.	530	43.5	39 5	38.4	589	47.3	40 5	574	759	970	48.0	45.9	46.4	969	766	49.2	46.0

OBS	HOOO7	PCWT	DPCWT	BGRP	LD	CS	CBWT	PVW	PVD	PVA	WTO8	WTO9	WT10	CWTWN	CAWTWN	JCD1	JCD2	CSEX	DTC1	DTC2	CNS1	CNS2	CNS3	CNS4	PPI
51	48 0	.	.	2	2	4	80	110	152	167	816	949	1105	.	.	46	57	2	126	137	.	.	.	.	91
52	50.8	.	.	2	1	1	71	118	155	183	844	920	985	443	449	84	.	1	164	.	.	.	.	.	.
53	49.2	820	22781	1 ·	1	1	75	130	155	202	820	852	934	525	447	38	83	1	118	163	.	.	.	.	125
54	50.0	.	.	1	2	3	92	110	160	176	880	1034	1160	.		60	65	1	140	145	.	.	.	.	85
55	47.8	820	42781	1	1	1	80	115	145	167	870	963	1070	342	412	116	61	2	196	141	.	.	.	.	25
56	47.3	780	22781	1	1	1	74	115	150	173	758	834	927	465	424	57	70	1	137	150	.	.	.	.	93
57	49 2	930	22581	2	1	3	82	117	152	178	914	1009	1046	485	440	55	77	1	135	157	.	.	.	.	102
58	47.4	805	30281	2	2	.	.	112	157	.	.	.	.	.	.	59	.	1	139	.	.	.	.	.	.
59	49.2	815	22781	1	1	1	73	107	155	166	819	914	1003	481	429	51	62	1	131	142	.	.	.	.	91
60	45 5	845	22781	1	1	3	70	130	140	182	.	.	.	397	349	46	.	1	126	.	.	.	.	.	.
61	48.4	785	30281	1	2	3	81	115	140	161	831	1027	1160	.	.	51	68	1	131	148	.	.	.	.	97
62	47.0	.	.	2	2	.	.	110	122	134	796	992	1093	.	.	90	72	1	170	152	.	.	.	.	62
63	49.2	860	22781	1	1	4	93	125	155	194	805	935	1002	474	433	56	81	1	136	161	.	.	.	.	105
64	47.0	800	30281	2	1	1	79	122	137	167	808	926	974	464	428	60	80	1	140	160	.	.	.	.	100
65	48.0	860	22781	1	1	1	72	115	150	173	804	936	973	470	418	50	116	1	130	196	.	.	.	.	146
66	49.5	930	31981	2	2	1	72	130	145	189	856	1010	1131	.	.	77	84	2	157	164	.	.	.	.	87
67	47.5	810	40781	2	1	3	72	115	135	155	835	967	1071	407	435	97	59	1	177	139	.	.	.	.	42
68	50.0	930	30281	2	1	1	71	125	135	169	917	1070	1091	467	432	61	.	1	141	.	.	.	.	.	.
69	50.5	930	31181	1	1	3	84	120	145	174	932	1111	1207	.	.	70	.	1	150	151	.	.	.	.	81
70	48.0	805	22781	2	1	4	90	122	147	179	840	981	1063	515	458	49	.	1	129	161	.	.	.	.	112

TABLE XXIII

DATA: HEIFERS TO CALVE AT 24 MO. (TREATMENT 1, REP. 1, TRIAL 2)

OBS	HFR	BRDT	BRWT	AGWN	WTWN	WTO1	HIPO1	WITO1	HOOO1	WTO2	HIPO2	HOOO2	WTO3	WTO4	WTO5	HIPO5	WITO5	HOOO5	WTO6	WTO7	HIPO7	WITO7
21	134	22980	64	215	385	389	40.0	36.7	32.1	480	43.3	37.0	523	638	757	44 5	43.0	41.0	747	601	46.3	43.8
22	152	.	.	210	.	381				477	43.6	30.5	525	581	777	47.0	43.5	41.5	773	683	47.1	44.1
23	184	.	.	210	.	431	39 8	37.0	33 3	511	42.5	37.0	552	668	804	45.5	46.5	41.8	809	758	46.3	42.5
24	379	.	.	210	.	426	40.6	36.8	32.3	506	42 8	36.8	544	638	774	44.0	43 8	40.0	760	605	45.4	44.0
25	383	31780	64	198	330	352	39.0	35 4	29.0	463	42.0	35.0	517	632	.	.	.	.	.	.	.	.
26	403		.	210		445	40.8	37.6	33.0	537	44.0	38.4	582	697	836	47.0	44.5	43.5	829	713	46.8	43.8
27	429	.	.	210	.	380	39.8	36 5	31 4	501	42.5	38 6	542	681	798	45.3	44 3	43.0	813	763	47.3	45.5
28	506			210	.	398	.			491	43.0	38.0	538	644	771	46.0	43.0	44.0	778	769	46.3	43.3
29	509	.	.	210	.	416			.	512	43.5	35.5	567	706	836	46.8	44.0	42.0	837	773	47.0	44.3
30	512	21180	64	223	410	418	40.9	36.4	33.0	542	44.0	35.2	599	714	883	47.0	·45.0	45.0	878	758	49.1	46.1
31	518		.	210	.	373	.	.	.	459	43.4	36.0	503	646	730	46.8	42.8	41.5	738	694	47.3	43.8
32	519	.	.	210	.	391	39.3	37 3	30 5	495	43.4	35.0	542	658	808	47.5	44.0	43.0	776	679	47.8	43.8
33	4009	.	.	210	.	398	39 4	36.6	30.6	463	42.5	32 5	517	608	770	46 5	43.3	39.0	748	653	46.3	44.0
34	4071	30880	80	207	370	402	40.8	38 8	30 5	523	44.6	37.0	576	672	816	47 0	44.3	42 5	832	740	48.8	45.5
35	6600	31180	63	204	360	370	39.1	36.6	29 3	457	42.4	34.5	511	612	780	46.0	44.0	39.0	807	655	46.8	42.5
36	6602	22980	78	215	345	349	39.9	35.9	31.2	463	43.5	37.0	505	609	778	46.3	44.0	43.0	723	640	47.0	44.9

OBS	HOOO7	PCWT	DPCWT	BGRP	LD	CS	CBWT	PVW	PVD	PVA	WTO8	WTO9	WT10	CWTWN	CAWTWN	JCD1	JCD2	CSEX	DTC1	DTC2	CNS1	CNS2	CNS3	CNS4	PPI
21	40.5	650		3	1	3	70	95	120	114	598	682	705	400	382	61		1	141	.	7	6	5.0	5	.
22	45 0	765	.	4	1	3	82	115	135	155	635	752	775	357	357	73	.	1	153	.	6	6	5.0	5	.
23	41.7	750		5	1	4	75	110	120	132	729	835	906	385	370	52	55	2	132	135	7	6	5.5	6	83
24	41.4	645	.	5	1	3	66	105	130	137	597	746	820	335	331	59	64	2	139	144	7	6	4.0	6	85
25	.	.	.	5	.	.	.	98	110	108	.		.	.	.	.	.	.	.	.	.	.	.	.	.
26	44 0	690	.	4	1	3	71	110	140	154	723	781	793	415	379	49	.	1	129	188	7	6	5.0	5	139
27	44 8	750	.	5	1	3	80	118	125	148	719	852	903	347	376	93	67	1	173	147	6	6	5.0	6	54
28	46 8	775	.	3	2	1	70	105	125	131	.			.	.	66	55	1	146	135	6	6	.	.	69
29	44 3	745		3	1	4	75	115	125	144	712	831	889	424	397	56	64	1	136	144	7	6	5.0	5	88
30	46 0	780		5	1	3	80	108	135	146	740	806	869	462	443	62	.	1	142	.	6	6	5.0	5	.
31	42.5	680		4	1	1	70	100	130	130	664	750	773	370	346	55	70	1	135	150	6	6	5.0	5	95
32	41 6	695	.	4	1	4	70	100	135	135	649	769	802	416	396	49	.	2	129	.	7	6	4.5	6	.
33	41 9	675		4	1	3	70	93	120	112	596	693	729	332	313	57	87	1	137	167	7	6	4.0	5	110
34	42.0	830	.	3	1	1	72	110	140	154	717	813	814	422	413	57	64	2	137	144	6	6	5.0	5	87
35	41 2	710	.	3	1	1	70	100	135	135	647	762	805	339	354	84	.	1	164	.	7	6	5.0	6	.
36	41 5	650	.	3	1	1	64	105	125	131	634	722	755	423	399	58	102	1	138	182	7	6	5.0	5	124

TABLE XXIV

DATA: HEIF·ERS TO CALVE AT 30 MO. 273 KG-MAINT. (TREATMENT 2, REP. 1, TRIAL 2)

OBS	HFR	BRDT	BRWT	AGWN	WTWN	WTO1	HIPO1	WITO1	HOOO1	WTO2	HIPO2	HOOO2	WTO3	WTO4	WTO5	HIPO5	WITO5	HOOO5	WTO6	WTO7	HIPO7	WITO7
71	107	92179	57	264	361	514	41.0	39 0	35.1	601	44.3	40 0	677	807	943	46.5	44.8	46.5	921	837	47.3	44.3
72	129	102979	72	226	395	516	42.4	40 4	36.6	569	45.0	41.2	645	743	900	46 8	45.0	45.0	908	836	47.8	45.5
73	947	90579	.	280	354	530	44.0	40.3	35.9	622	47.5	41.0	680	858	1029	50.5	47 0	50.0	994	939	50.6	47.4
74	954	92679	62	259	346	490	40 8	38 0	36 8	573	43.8	41.7	632	715	926	46.5	43 5	45.5	897	751	45.3	43.3
75	955	92679	90	259	455	603	43.6	42 5	35 1	646	46.8	42 0	729	912	1023	49.3	47.0	47.5	1016	1105	49.8	48.3
76	956	92879	69	257	438	541	42.0	39 2	36.5	621	45.4	38.1	700	845	985	47.0	45 0	43.5	983	866	48.4	45.5
77	959	101479	84	241	360	488	42.0	38.2	35 6	567	44.3	37.4	629	755	939	47.3	45.0	44.5	921	743	48.5	44.0
78	964	111079	85	214	377	452	41.5	38.2	33 8	557	44.0	40.0	620	717	862	46.5	45.0	44.5	853	786	47.3	45.5
79	965	111079	70	214	384	527	41.2	38.2	33.3	631	45.9	39.0	703	870	1041	47 8	44.8	46.5	1025	882	49.0	44.5
80	966	111179	70	213	308	416	40.5	39.2	32.7	553	44.6	39.0	626	741	924	47.3	44.3	45.0	907	782	48.0	46.6
81	967	92579	.	260	358	558	43 5	40.0	36.5	601	46.0	42.2	665	830	1023	48.5	46.0	48.0	1029	.	48.0	45.3
82	969	111779	65	207	301	405	41 4	37.7	32.5	504	43.4	36.0	553	.	787	46 0	44.3	42.0	791	696	46.8	45.3
83	972	112079	78	204	353	470	41.4	38.2	34 5	544	44.5	38.5	613	764	888	47.0	44.5	45.0	871	751	48.0	46.0
84	976	100779	.	248	339	503	43 5	39 5	35.8	593	46 8	40.2	840	849	1015	49.5	46 8	45.0	1009	1010	50.8	47.5
85	977	101079	.	245	401	553	45 0	41 2	37.5	631	48 0	42.5	879	990	1044	50.5	47 0	50.0	1033	863	50.8	46.0
86	987	111279	.	212	351	502	42 9	39 5	34 9	590	45 4	39 5	796	934	973	48.3	45 0	45.5	993	883	49.8	46.3
87	9700	111879	65	206	337	481	42.2	37.5	36 0		44.5	.		.	.	.	.	.	.	.	.	.

OBS	HOOO7	PCWT	DPCWT	BGRP	LD	CS	CBWT	PVW	PVD	PVA	WTO8	WTO9	WT10	CWTWN	CAWTWN	JCD1	JCD2	CSEX	DTC1	DTC2	CNS1	CNS2	CNS3	CNS4	PPI
71	45 3	900	.	4	1	1	64	113	150	170	774	877	941	425	411	54	72	2	134	152	7	6.0	5.0	5.5	98
72	49.3	.	.	5	1	1	72	105	115	121	827	953	1060	.	.	46	.	2	126	158	7	6.0	5.5	6.5	112
73	48.3	960	.	3	1	1	80		.	.	877	973	969	448	420	56	54	1	136	134	7	6.0	5.0	5.5	78
74	45 2	720	.	5	1	4	80	120	140	168	788	927	995	.	.	60	.	1	140	.	7	7.0	6.0	7.0	.
75	51 8	.	.	3	.	.	.	120	150	.	.		.	.	.	.	74	.	.	154	7	6.0	.	.	.
76	46 4	910	.	3	1	3	86	130	150	195	809	938	960	460	492	80		2	160	.	7	6.0	5.0	5.5	.
77	44.7	785		5	1	4	82	110	140	154	722	837	849	448	456	67	.	2	147	.	7	7.0	5.0	5.5	.
78	45 7	785	.	5	1	1	70	110	140	154	744	833	876	365	406	89	77	2	169	157	7	6.0	5.0	5.0	68
79	45 5	945	.	4	1	1	76	120	150	180	841	960	1015	508	482	60	.	1	140	.	7	7.0	6.0	6.5	.
80	45 8	875	.	5	1	2	80	125	125	156	744	870	896	496	492	71	.	1	151	.	7	7.0	5.0	5.0	.
81	47.3	955		4	1	1	80	125	145	181	855	958	1016	520	469	46	57	1	126	137	7	6.3	5.5	6.0	91
82	42 1	745	.	5	1	1	64	105	135	142	641	722	756	470	458	67	87	1	147	167	7	6.0	5.0	5.0	100
83	44.4	785	.	5	1	1	66	115	140	161	714	841	910	423	419	60	81	2	140	161	7	6.0	5.0	6.0	101
84	48.2	1025	.	3	1	1	90	120	160	192	913	1054	1019	423	476	101	76	1	181	156	7	7.0	5.5	6.0	55
85	48.3	870	.	3	1	1	62	130	140	182	829	966	986	475	454	51	55	2	131	135	7	6.0	5.0	5.0	84
86	46.8	885	.	4	1	1	80	120	150	180	808	930	970	.	.	79	60	2	159	140	7	6.0	5.0	5.0	61
87	.			.			.	.	.	.		.	.	.	.	.	.	.		.	.	.	.	.	.

TABLE XXV

DATA: HEIFERS TO CALVE AT 30 MO. 273 KG-GAIN (TREATMENT 3, REP. 1, TRIAL 2)

OBS	HFR	BRDT	BRWT	AGWN	WTWN	WTO1	HIPO1	WITO1	HOOO1	WTO2	HIPO2	HOOO2	WTO3	WTO4	WTO5	HIPO5	WITO5	HOOO5	WTO6	WTO7	HIPO7	WITO7
102	951	91879	59	267	417	518	42 6	39.8	35 3	575	44.0	39 0	640	759	886	46 0	44.5	44.0	853	716	45.0	43.3
103	953	92479	50	261	395	522	42.0	40.2	35 5	558	44 6	40.3	627	718	883	47.5	44 3	42.5	877	846	48.0	45.5
104	958	100879	81	247	415	547	43.0	40 2	37 4	634	46.5	39.5	726	873	1029	49.0	46.5	47.0	1005	996	50.3	47.3
105	960	101879	75	237	333	479	42 2	40.0	35.5	582	45.6	38.4	635	783	922	48.8	46.8	46.0	947	803	48.8	45.8
106	961	101879	80	237	348	499	42.0	38.6	36 2	598	45.1	39.5	658	815	959	48.0	44.8	46.0	967	831	48.5	44.0
107	962	102179	72	234	399	532	42 2	41 0	36.6	625	45.9	40.5	705	859	1036	48 0	46 0	47.5	1005	873	48.0	46.3
108	963	102579	65	230	382	492	42.2	40 2	34 0	596	46.0	41 2	652	779	946	47.0	46.5	46.5	936	761	48.0	46.5
109	968	111779	70	207	420	540	42 5	40 2	34 1	608	45.5	39 0	667	761	938	48.0	45 5	45.0	926	736	47.0	45.4
110	970	92879		257	365	472	43 4	40.1	36 3	571	45 5	37.1	635	830	1014	49.3	46.3	47.5	1002	804	48.8	46.3
111	971	112079	80	204	330	489	41 4	39 5	35 2	614	44.4	40 1	675	806	980	48 0	45 0	44.0	1001	937	47.5	45.8
112	979	101979		236	352	514	42.0	39.2	35.0	611	45 5	39.5	865	950	1002	48.0	46 3	46.5	972	1052	48.8	46.4
113	980	102179	.	234	386	562	43 9	40 5	36.5	655	47 5	40 0	919	1056	1103	49 0	46 5	48.0	1084	1017	49.8	46.8
114	981	102479		231	443	603	45 5	40.5	40 0	705	48 0	43 1	886	1090	1127	50.5	46.5	50.0	1105	861	51.3	46.3
115	990	120379	.	191	365	507	43 5	39.5	36.4	636	47 0	39.2	889	1055	1077	50.5	46.5	48.0	1077	932	49.8	46.8
116	9676	111579	68	209	392	451	40 2	38 4	35 5	554	44.3	38 9	619	761	904	46.8	43.8	45.0	894	709	47.5	44.8

OBS	HOOO7	PCWT	DFCWT	BGRP	LD	CS	CBWT	PVW	PVD	PVA	WTO8	WTO9	WT10	CWTWN	CAWTWN	JCD1	JCD2	CSEX	DTC1	DTC2	CNS1	CNS2	CNS3	CNS4	PPI
102	42.8	730		5	1	1	82	123	133	164	671	786	778	505	474	57	.	1	137	.	7	6.0	4.5	5.0	.
103	46 1	885		5	1	3	85	130	140	182	779	867	913	377	438	100	79	2	180	159	6	6.0	5.0	5.0	59
104	47.8	980	.	3	1	1	90	120	140	168	972	1057	1195	.	.	84	69	2	164	149	7	7.0	6.0	6.0	65
105	45.7	885		4	1	1	72	110	155	171	739	855	900	468	474	66	.	2	146	128	7	6.0	5.0	5.0	62
106	46 0	925		3	1	3	90	120	155	186	801	899	956	413	410	61	59	2	141	139	7	6.0	5.0	6.0	78
107	47 7	865	.	3	1	1	71	120	155	186	840	952	999	500	447	44	66	1	124	146	7	6.2	5.0	6.0	102
108	45.5	815		3	1	3	74	115	140	161	763	867	923	534	486	49	97	1	129	177	7	6.0	5.5	6.0	128
109	44 4	750	.	4	1	1	80	120	145	174	718	796	859	392	378	53	.	2	133	.	7	6.0	5.0	5.0	.
110	47 2	885		5	1	1	80	120	140	168	774	913	940	505	471	55	.	1	135	158	7	6.0	5.0	5.0	103
111	47 4	970		4	1	.	70	118	135	159	923	997	1106	.	.	81	68	2	161	148	7	7.0	7.0	7.0	67
112	48 2	945		4	1	3	96	110	140	154	913	1014	1049	389	478	113	101	2	193	181	7	6.0	6.0	6.0	68
113	48 1	1040		4	1	3	82	110	140	154	946	1061	1075	495	514	82	55	1	162	135	7	6.0	5.0	6.0	53
114	49.8	905		3	1	4	90	120	150	180	873	1043	1076	496	453	49	77	1	129	157	8	6.2	5.0	5.5	108
115	49 0	930	.	4	1	4	105	120	120	144	872	976	1056	526	494	56	60	1	136	140	7	6.0	4.5	6.0	84
116	43.3	800	.	5	1	3	60	115	150	173	689	828	823	421	407	54	.	2	134	158	6	6.0	4.5	5.0	104

TABLE XXVI

DATA: HEIFERS TO CALVE AT 24 MO. (TREATMENT 1, REP. 2, TRIAL 2)

OBS	HFR	BRDT	BRWT	AGWN	WTWN	WTO1	HIPO1	WITO1	HOOO1	WTO2	HIPO2	HOOO2	WTO3	WTO4	WTO5	HIPO5	WITO5	HOOO5	WTO6	WTO7	HIPO7	WITO7
37	8	.				401	40 5	37 3	31 5	538	44.0	36 1	539	640	758	46.8	43 8	42.0	726	700	47.0	44.0
38	102	.	.	.	.	449	40.0	37 0	33.0	599	43.8	36 1	633	739	850	45.5	41.8	44.0	863	755	47.0	42.3
39	217	30280	88	220	382	380	40 8	37 5	32.0	482	43 1	35.0	508	660	756	47 6	44.9	42 5	753	727	48.0	45.5
40	315	.	.			381	42 0	39.5	32 0	556	44 8	37.8	605	725	825	48 9	45.8	43.7	788	735	49.3	47.0
41	517	30580	72	217	440	430	41 3	38.8	33 0	635	45.5	39 7	665	788	884	49 8	45.0	44.8	885	780	49.3	46.3
42	524	22580	79	225	395	378	41 0	38.0	31.0	535	44.3	36 3	558	674	755	47.6	45 3	41.2	767	668	48.0	46.3
43	605		.	.	.	447	42.0	38 5	34 0	574	44.0	36.3	602	708	820	47.8	45.3	43.8	778	706	48.3	44.8
44	637	31780	68	205	374	381	41.2	37 6	32 0	606	46 6	37 0	629	733	809	48 0	45 0	40.5	812	748	48.3	44.8
45	4090	30680	88	216	444	433	42.5	40 5	34.5	620	45 9	37 9	656	726	882	49 3	47 2	45.2	887	824	50.0	48.5
46	6601	32280	85	200	352	348	40.5	38 0	29 5	498	44 6	32 8	531	644	736	47.0	45 0	40.0	744	690	47.5	55.5
47	6604	33080	82	192	340	314	39.5	36.0	31 5	489	43.6	34.5	517	598	721	47 2	42 8	44.0	728	630	46.3	44.3
48	6605	30180	86	221	400	399	42.0	39 8	34 0	594	45.3	38.8	611	778	848	47 5	46 3	44.0	860	751	49.0	47.0
49	6606	41080	90	181	367	363	40.0	36 5	32 0	531	43 8	35.1	533	640	739	46.2	43.0	43 9	763	708	47.0	38.8
50	6607	32080	90	202	437	419	40.8	37 5	33.0	591	44 9	39.2	620	740	824	47.2	45 5	44.1	854	793	48.8	46.0

OBS	HOOO7	PCWT	DPCWT	BGRP	LD	CS	CBWT	PVW	PVD	PVA	WTO8	WTO9	WT10	CWTWN	CAWTWN	JCD1	JCD2	CSEX	DTC1	DTC2	CNS1	CNS2	CNS3	CNS4	PPI
37	42.5	695	.	6	1	3	64	105	120	126	700	806	919	318	324	59		2	139	182	6	5.0	5.5	6.5	123
38	43 0	840		7	1	5	80	98	105	103	799	870	931	426	426	64	.	1	144	147	6	5.5	5.5	6.0	83
39	44 0	750		6	1	1	72	100	115	115	738	858	921	398	447	82		2	162	142	6	5.5	5.5	6.0	60
40	45 0	775		6	1	3	74	103	120	124	721	801	886	480	474	61	.	1	141	163	5	5.5	5.0	5.0	102
41	45 5	800		6	1	3	80	110	130	143	792	928	990	483	469	46	.	2	126	142	6	5.5	5.5	6.0	96
42	41 5	670		6	1	3	80	108	130	140	671	760	852	456	445	58	.	1	138	131	6	5.0	5.0	5.5	73
43	45 0	715		6	1	3	72	110	125	138	717	781	875	424	417	60		1	140	171	6	5.0	5.0	5.5	111
44	44 0	765		7	1	1	66	105	125	131	745	842	928	456	439	44	.	2	124	150	6	5.0	5.0	5.5	106
45	47 0	800		6	1	3	76	108	135	146	826	975	1035	440	460	65		2	145	165	6	5.5	5.0	5.5	100
46	40.0	675	.	7	1	4	72	90	118	106	686	788	891	350	384	77	.	2	157	132	6	5.5	5.0	6.0	55
47	42 5			7	2	4	72	95	125	119	.	.	.	.		61	.	1	141	137	6	5.5	.	7.0	76
48	46.5	790		6	1	3	82	105	138	145	785	890	956	452	428	50		1	130	142	6	5.5	5.5	6.0	92
49	44 0	720		7	1	3	64	100	115	115	696	777	847	422	449	69	.	2	149		6	5.5	5.0	6.0	.
50	47.5	775	.	7	1	1	70	105	110	116	798	939	1017	358	375	66		2	146	.	6	5.5	5.0	6.5	.

TABLE XXVII

DATA: HEIFERS TO CALVE AT 30 MO. 273 KG-MAINT. (TREATMENT 2, REP. 2, TRIAL 2)

OBS	HFR	BRDT	BRWT	AGWN	WTWN	WT01	HIP01	WIT01	H0001	WT02	HIP02	H0002	WT03	WT04	WT05	HIP05	WIT05	H0005	WT06	WT07	HIP07	WIT07
88	121	100980	70	201	280	487	41 0	38 0	36.0	606	43.5	39 2	616 000	703	800	46 3	43 3	43 5	812	858	47.3	44.5
89	157	101780	60	193	292	485	43 5	40 6	35 0	594	46 3	39 3	620 000	735	838	49 0	44.8	45.1	873	708	49.8	46.5
90	410	100780	82	203	345	512	43 5	39 5	37.0	632	45.4	40 4	662 000	790	875	48.3	43.5	43 9	870	796	48.0	45.0
91	419	92580	60	215	379	586	45.0	42 0	38.5	650	46.5	41.3	684.000	791	929	48.5	44.9	45.8	961	885	49.5	46.8
92	432	92280	58	218	351	549	43.5	40.0	38.0	586	45.1	38 8	0.613	766	902	48.0	44 5	45.9	916	793	48.8	45.3
93	522	101080	74	200	331	507	44 0	41 0	37.0	605	45 9	40.5	629 000	753	855	48 5	44.9	45.1	885	764	48.0	45.5
94	624	102580	81	185	315	523	42 0	37 5	37 0	565	43.8	38.1	612 000	758	852	46 5	43.3	44.2	879	736	46.8	42.8
95	641	.	.	.		585	44 3	41 0	38.0	623	46 6	40 5	660 000	812	977	49 3	46.2	46.1	995	825	49.0	46.5
96	664	91780	64	223	381	602	45.0	41 5	37 0	610	47 8	40 3	638.000	774	922	49 2	44 0	46.7	966	887	49.8	46.0
97	708	92980	63	211	300	524	42 8	40 5	36.5	609	44 6	38 9	635.000	776	894	46.8	45.5	46.3	895	754	49.3	45.5
98	743	.	.			535	43.3	39 8	37 5	633	44 6	41 8	637 000	804	887	48 3	44.5	45.6	905	822	47.8	44.3
99	750	.		.		532	43.6	40.5	37 0	618	45.1	40 2	626 000	782	906	49 3	46 3	45.6	911	813	49.5	45.8
100	5034	103080	80	180	272	421	42 0	38 3	33.0	603	44 5	38.3	623 000	752	893	48 5	46 3	44.5	902	781	49.0	45.3
101	6201					550	44 0	40 5	38 0	609	44 9	41 0	642 000	778	888	48.0	64 3	44.8	905	836	48.8	45 3

OBS	H0007	PCWT	DPCWT	BGRP	LD	CS	CBWT	PVW	PVD	PVA	WT08	WT09	WT10	CWTWN	CAWTWN	JCD1	JCD2	CSEX	DTC1	DTC2	CNS1	CNS2	CNS3	CNS4	PPI
88	44.5	.	.	6				108	143	154			.	.		.	.	.		156	6	6.0	.	7.5	.
89	44 0	785	.	7	1	3	80	115	155	178	725	787	860	510	488	53	.	1	133	157	6	5.0	5.0	6.0	104
90	44 0	815	.	7	1	3	74	118	130	153	819	913	992	468	465	52		2	132	168	6	5.0	5.5	6.5	116
91	46.0	910		6	1	1	80	115	135	155	874	965	983	390	468	97	.	2	177	.	7	6.0	5.5	6.0	.
92	46 5	840		6	1	3	78	110	150	165	810	898	956	431	443	61	.	2	141	145	6	6.0	5 5	6.5	84
93	47 5	830	.	7	1	3	82	110	138	152	793	891	947	499	489	59	.	1	139	.	6	5.0	5.0	6.0	.
94	44 0	805		7	1	4	78	118	120	142	742	857	949	434	431	62	.	1	142	177	6	6.0	5.5	6.5	115
95	46.5	875		6	2	3	82	125	148	185	877	1024	1178	.	.	71	.	1	151	157	7	6.0	.	7 5	86
96	44 5	900		6	1	3	62	120	143	172	868	932	1028	430	512	93	.	2	173	157	7	6.0	5.5	6 0	64
97	42.0	800	.	7	1	4	84	105	145	152	760	860	944	477	469	60	.	1	140	170	6	5.5	5.0	6.0	110
98	47.0	835		7	1	4	82	128	150	192	833	952	1043	499	489	59	.	1	139	163	6	5.5	5.5	6.5	104
99	46.0	845	.	6	1	4	82	105	140	147	848	939	1037	433	418	55		1	135	139	6	5.5	5.0	6.5	84
100	45.0	805		6	1	4	80	108	133	144	817	920	1003	449	427	51	.	1	131	132	6	5.5	5.5	6.5	81
101	44 5	860		7	1	1	66	113	135	153	848	953	996	423	408	55		1	135	147	6	5.5	5.5	6.0	92

TABLE XXVIII

DATA: HEIFERS TO CALVE AT 30 MO. 273. KG-GAIN (TREATMENT 3, REP. 2, TRIAL 2)

OBS	HFR	BRDT	BRWT	AGWN	WTWN	WTO1	HIPO1	WITO1	HOOO1	WTO2	HIPO2	HOOO2	WTO3	WTO4	WTO5	HIPO5	WITO5	HOOO5	WTO6	WTO7	HIPO7	WITO7
117	150	91580	68	225	402	626	46 0	42 8	41.0	699	48.1	43 8	723	880	1031	50.3	48 0	49.3	1026	930	51.0	48.8
118	384	91780	72	223	373	586	45 8	42 5	38 5	695	47 5	40 7	743	858	981	49 8	48.5	47.6	1007	912	51.3	48.3
119	414	102480	76	186	262	417	41.8	39.5	33 5	562	44 5	38 0	577	680	786	49 0	45.5	44.9	789	690	48.3	46.8
120	421	92680	77	214	363	548	43 5	42 3	38 0	678	46 8	41 6	736	842	970	48 5	45 6	46.8	994	890	49.0	46.5
121	427	92380	71	217	324	507	42 8	39 8	37 5	643	45 3	41 1	674	780	883	48 0	44.0	46.1	893	814	48.0	45.0
122	504	102180	67	189	332	504	44 5	41 8	37 0	586	46.3	38.4	647	755	830	49.3	46 0	44.4	853	729	49.5	46 5
123	521	91280	70	228	392	597	44 5	42.3	41 0	655	46.4	41 7	703	810	929	47 8	45.0	48.5	958	757	49.3	45.8
124	662	91680	76	224	265	439	42 8	39 0	32.0	594	45.5	35.3	625	743	879	49 3	46 0	45.3	902	771	50.0	46.3
125	706	.		.		529	43 8	40.0	37.0	678	45.5	39.8	713	840	946	46 8	45 3	46.8	960	825	49.5	46 0
126	734		.	.		567	43 0	39 5	38 0	695	45 5	40 2	748	850	998	47.5	45.5	45.4	1027	938	49.3	46.3
127	736			.	.	537	43 5	41.3	38.0	653	46.3	42.5	696	833	939	47 8	45 0	47.8	981	890	48.3	46.3
128	749	.		.		524	44 0	39.0	38 0	639	45.5	42.3	681	799	980	49.5	45 0	46.6	983	904	50.4	45.5
129	4107	91080	48	230	307	519	43.5	40 8	37 0	615	46.3	39.4	649	744	822	46 3	43.8	43.5	839	711	47.8	45.5

OBS	HOOO7	PCWT	DPCWT	BGRP	LD	CS	CBWT	PVW	PVD	PVA	WTO8	WTO9	WT10	CWTWN	CAWTWN	JCD1	JCD2	CSEX	DTC1	DTC2	CNS1	CNS2	CNS3	CNS4	PPI
117	48 5	950	.	7	1	1	80	125	145	181	933	1024	1087	438	428	58	.	1	138	135	6.0	5.5	5.5	6.0	77
118	47 5	945		6	1	1	68	115	145	167	890	980	1030	471	468	52		2	132	132	6.0	6.0	5.5	6.0	80
119	46 0	725		7	1	1	60	105	145	152	689	781	871	443	470	68		2	148	158	5.5	5.0	5.0	5.5	90
120	48 5	890		6	1	3	80	115	135	155	899	970	1066	455	457	55	.	2	135	167	6.0	5.5	5.0	6.5	112
121	47 5	840		7	1	1	78	115	135	155	811	911	968	421	461	76	.	2	156	145	6.0	5.5	5.5	5.5	69
122	45.5	800	.	6	1	3	74	115	143	164	744	810	856	460	456	62		1	142	.	5.5	5.5	5.0	5.5	.
123	48 5	850	.	7	1	1	84	120	138	166	778	878	966	416	440	78	.	1	158	154	7.0	6.0	5.0	6.0	76
124	45 0	825	.	6	1	2	70	118	130	153	768	858	937	489	482	50		2	130	134	6.0	5.5	5.0	6.0	84
125	48.0	875	.	7	1	3	82	130	140	182	813	903	989	467	495	78		1	158	139	7.0	6.0	5.5	6.0	61
126	46.5	950		6	1	3	76	120	150	180	940	1034	1135	448	467	64		2	144	140	7.0	6 0	6.0	6.5	76
127	49 0	895	.	7	1	3	82	115	135	155	892	1011	1095	349	354	68		1	148	166	6.0	6.0	6.0	6.5	98
128	47 5	935		6	1	1	92	120	140	168	879	979	1042	444	460	63		2	143	134	6.0	6.5	5.5	6.0	71
129	44.5	780		7	1	1	74	110	155	171	706	784	845	485	470	46	.	2	126	143	5.5	5.0	5.0	6.0	97

TABLE XXIX

AVERAGE WINTER FEED CONSUMPTION PER HEIFER (TRIALS 1 AND 2)

	CALVE AT 24 MO. (TREATMENT 1)	CALVE AT 30 MO (TREATMENT 2)	
TRIAL 1			
First Wintering Period (11/29 until 4/17)			
Cottonseed Meal	352 lbs (160 kg)	371 lbs. (169 kg)	
Ground Milo	736 lbs. (335 kg)	462 lbs. (210 kg)	
TRIAL 2, REPLICATION 1	CALVE AT 24 MO. (TREATMENT 1)	CALVE AT 30 MO. 273 kg - MAINT. (TREATMENT 2)	273 kg - GAIN (TREATMENT 3)
First Wintering Period (11/13 UNTIL 5/5)			
Cottonseed meal	522 lbs. (237 kg)	499 lbs. (227 kg)	514 lbs. (234 kg)
Ground Corn	277 lbs. (126 kg)	175 lbs. (80 kg)	205 lbs (93 kg)
Second Wintering period (11/2 until calving or 4/15)			
Cottonseed meal	272 lbs. (124 kg)	294 lbs. (133 kg)	
TRIAL 2, REPLICATION 2			
First Wintering Period (11/12 until 5/5)			
Cottonseed meal	444 lbs. (202 kg)	327 lbs. (149 kg)	406 lbs. (185 kg)
Ground corn	587 lbs. (267 kg)	226 lbs. (103 kg)	297 lbs. (135 kg)
Second Wintering Period (11/12 until calving or 4/15)			
Cottonseed meal	312 lbs. (145 kg)	334 lbs. (152 kg)	

VITA 2

James Edward Goodrich

Candidate for the Degree of

Master of Science

Thesis : GROWTH, REPRODUCTIVE DEVELOPMENT AND PERFORMANCE OF HEREFORD HEIFERS CALVING AT 24 OR 30 MONTHS OF AGE.

Major Field : Animal Science

Biographical:

Personal Data : Born in Wheatland, Wyoming, July 21, 1959, the son of William W. and Viola Goodrich.

Education: Graduated from Wheatland High School, Wheatland, Wyoming, May, 1977; received Bachelor of Science degree from University of Wyoming, December 1981, with a major in Animal Science; completed the requirements for the degree of Master of Science degree at Oklahoma State University in December, 1984.

Experience: Raised and worked on a livestock ranching operation, Albany County, Wyoming; Graduate Assistant, Animal Science Department, Oklahoma State University, 1982-1984.

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