PREGNANCY RATES OF BEEF HEIFERS BRED EITHER ON PUBERAL OR THIRD ESTRUS

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ABSTRACT

The objective of this study was to determine if pregnancy rates (PR) differed between beef heifers bred to fertile bulls on either their puberal (E1; n = 89) or third (E3; n = 67) estrus. Heifers were obtained from two lactations (Manhattan, L1; and Miles City, L2), and the experiment was conducted at Miles City. Heifers were assigned randomly within location to either E1 or E3. Heifers were fed to gain .56 kg·head⁻¹·d⁻¹ and observed twice daily for estrus. After exhibiting first estrus (puberty) and breeding, each heifer in E1 was palpated rectally on d 6, 9 and 12 ± 1 d (estrus = d 0) for the presence of a corpus luteum, and a venous blood sample was collected for assay of progesterone by radioimmunoassay. Heifers in E3 were palpated and bled on the same schedule as heifers in E1 after first estrus and after being bred to a fertile bull at third estrus. Pregnancy rates were determined by rectal palpation at approximately 38 d post-breeding. Location of origin did not affect (P>.10) weight at puberty or weight at breeding; however, heifers from L1 were younger (P<.05) than heifers from L2 at puberty and breeding. Pregnancy rates were 57 and 78% for heifers in E1 and E3, respectively (P<.05). Weight at breeding did not influence (P>.10) pregnancy rates. The probability of heifers in E1 becoming pregnant increased (P<.05) with increasing age, while age was not a factor (P>.10) for heifers in E3. These results indicated that fertility of puberal estrus in beef heifers is lower than third estrus. Higher fertility of third estrus may be related to maturational changes associated with cycling activity.

(Key Words: Heifers, Puberty, Pregnancy, Fertility, Estrus.)

Introduction

Beef heifers that calve at 2 yr of age produce more calves in their lifetime than heifers that calve first at 3 yr of age or older (Donaldson, 1968). Heifers that conceive early in their first breeding season calve earlier and wean heavier calves than those that conceive late in their first breeding season (Short and Bellows, 1971; Lesmeister et al., 1973). Furthermore, Lesmeister et al. (1973) indicated that heifers which conceived early in the breeding season maintained this production advantage throughout their lifetime. These data, and others, have led to the current management recommendation that beef heifers be bred as early as possible in their first breeding season. However, this may result in heifers being bred at puberal estrus.

Litter size has been reported to be lower when breeding occurred at puberty compared with breeding at subsequent estrous periods in gilts (Robertson et al., 1951) and rats (Evans, 1985). In addition, pregnancy rates associated with breeding ewe lambs at puberal estrus were lower than pregnancy rates of ewe lambs bred at a subsequent estrus (Hare and Bryant, 1985). Therefore, fertility associated with puberal estrus may be lower in some mammals. If this phenomenon occurs in beef heifers then current...
management recommendations may result in lower reproductive efficiency. Thus, the objective of this study was to determine if pregnancy rates of heifers bred at puberal estrus differed from heifers bred at third estrus.

Materials and Methods

The study was conducted at the Fort Keogh Livestock and Range Research Laboratory, Miles City, Montana. Beef heifers were obtained at weaning from Manhattan, Montana (L1; n = 102) and Miles City (L2; n = 54). Crossbred heifers from L1 were Angus (50%), Brown Swiss (12.5 to 25%) and Hereford (25 to 37.5%). Heifers from L2 were crossbred types derived by using Angus, Brahman, Charolais, Shorthorn and Jersey sires on composite Hereford, Angus and Simmental crossbred dams. At the beginning of the experiment, heifers from L1 were older (253 ± 3 vs 222 ± 2 d; P< .05) and heavier (264 ± 3 vs 230 ± 5 kg; P< .05) than heifers from L2. During the experiment, heifers were fed to gain approximately .56 kg·head⁻¹·d⁻¹ and body weights were obtained every 28 d for recalculation of the diet to meet this rate of gain. This diet was formulated in accordance with requirements of growing beef heifers (NRC, 1984), and consisted of corn silage, chopped hay, rolled barley, soybean meal and trace minerals. Water was provided ad libitum. Weights at first estrus and breeding were obtained by linear interpolation between two consecutive weighing periods.

Heifers in L2 were stratified by breed, then heifers from each location were assigned randomly, before the start of the experiment, to one of two treatments: 1) bred by a fertile bull on first (puberal) estrus (E1; n = 89) or 2) bred by a fertile bull on third estrus (E3; n = 67). Animals were housed in two sets of four adjacent pens of similar size. Four pens contained intact mature bulls (one bull per pen) that had been given a breeding soundness evaluation (Simons, 1976). The other four pens contained vasectomized bulls (one bull per pen) that were confirmed sterile by semen examination. Each bull was fitted with a marking harness to aid in detecting estrus. All bulls had previous breeding experience.

Heifers in E1 were equally distributed among four pens containing the fertile bulls with approximately one bull per 20 heifers. When a heifer was detected in estrus (first estrus) and mating had occurred, she was moved into one of the four pens containing a vasectomized bull. The heifer remained in this pen for observation of estrus and was pregnancy-tested by rectal palpation at a minimum of 38 d after breeding. Heifers in E1 were removed from the experiment after being pregnancy tested.

Heifers in E3 were equally distributed among pens containing one vasectomized bull per 20 heifers. When a heifer's first estrus was detected, she was moved into an adjacent pen containing a vasectomized bull until after her second estrus was detected. Then, she was moved into a pen containing a fertile bull until breeding at third estrus and subsequently moved back into a pen containing a vasectomized bull until she was either detected in estrus or pregnancy-tested and removed from the experiment. A heifer was randomly assigned to a pen each time a move occurred and bulls were either added or removed to maintain the male-to-female ratios of the pens.

Heifers were observed twice daily (morning, evening) for estrous detection from November 19, 1984 to August 1, 1985. Ovaries of each heifer were examined rectally for the presence of a corpus luteum, and a 10-ml blood sample for assay of progesterone was collected by venipuncture of the tail or jugular vein on d 6 ± 1, 9 ± 1 and 12 ± 1 post-estrus (estrus = d 0) and breeding.

Blood samples were allowed to clot at 22 °C for 4 h and centrifuged at 1,000 x g at 4 °C for 30 min. Serum was decanted and stored at -25 °C until assayed for progesterone. Serum (2.0 ml) samples were extracted with 5 ml of methylene chloride and assayed by a double antibody procedure developed and validated by Staigmiller et al. (1979). Sensitivity of this assay was 16 pg; intra- and inter-assay coefficients of variation were 9.7 and 12.8%, respectively, for a sample with a mean concentration of 4.46 ng/ml.

The following criteria were used to characterize normal cycling activity: 1) display of behavioral estrus, 2) presence of a palpable corpus luteum on d 6 ± 1, 9 ± 1 and 12 ± 1 post-estrus and 3) an increase in progesterone concentration to greater than 1 ng/ml on d 9 and 12. Only heifers that met all three criteria were used in the statistical analyses.

Statistical Analyses. Weight and age at puberty, weight and age at breeding and estrous cycle lengths of heifers postbreeding (return cycle lengths) were dependent variables. Treatment, location and the treatment x location interaction were the independent variables.
TABLE 1. LEAST-SQUARES MEANS ± SE FOR AGE AND WEIGHT AT PUBERTY AND AGE AND WEIGHT AT BREEDING FOR HEIFERS BRED AT PUBERAL (E1) OR THIRD ESTRUS (E3) FROM MANHATTAN (L1) OR MILES CITY (L2)

<table>
<thead>
<tr>
<th>Classification</th>
<th>n</th>
<th>Age at puberty, d</th>
<th>Wt at puberty, kg</th>
<th>Age at breeding, d</th>
<th>Wt at breeding, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E1</td>
<td>63</td>
<td>322 ± 6</td>
<td>295 ± 4</td>
<td>322 ± 6</td>
<td>295 ± 4</td>
</tr>
<tr>
<td>E3</td>
<td>45</td>
<td>339 ± 7</td>
<td>306 ± 5</td>
<td>375 ± 7</td>
<td>326 ± 5</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>64</td>
<td>316 ± 6</td>
<td>298 ± 4</td>
<td>330 ± 6</td>
<td>305 ± 4</td>
</tr>
<tr>
<td>L2</td>
<td>44</td>
<td>349 ± 7</td>
<td>301 ± 5</td>
<td>363 ± 7</td>
<td>309 ± 5</td>
</tr>
</tbody>
</table>

*Effect of treatment or location (P<.05).

These data were analyzed by the General Linear Model procedure of SAS (1985). Pre-breeding estrous cycle lengths of heifers in E3, i.e., first and second cycles, were compared by using a paired t-test. Return cycle lengths for E1 and E3 heifers were compared with prebreeding estrous cycle lengths for heifers in E3 using a grouped t-test (Steel and Torrie, 1980). Pregnancy rates were analyzed using the Categorical Data Modeling (CATMOD) procedure of SAS (1985). This procedure allowed the derivation and testing of a model for pregnancy rates that included continuous variables as covariates. Initially, the model included effects of treatment, location and the treatment x location interaction. The two-factor interaction was not significant, therefore, it was removed from the model. Data were re-analyzed using weight at puberty, age at puberty, weight at breeding and age at breeding separately as covariates in models for pregnancy rates. Logistic regression equations were developed for examining the influence of these covariates on pregnancy rate.

Results

Four heifers were removed from the data set because they did not reach puberty or third estrus by the end of the experiment and seven other heifers were removed because of sickness or injury. Additionally, 27 heifers from E1 and 10 heifers from E3 were deleted due to low progesterone concentrations and lack of a palpable corpus luteum following estrus. These animals were classified as having exhibited non-puberal estrus (Nelsen et al., 1985).

Age and weight at puberty did not differ (P>.10) between heifers in E1 and E3 (table 1). However, heifers in E3 were older (P<.05) and heavier (P<.05) at breeding than heifers in E1 (table 1). Location did not affect (P<.10) weight at puberty and breeding (table 1). However, heifers from L1 were younger (P<.05) at puberty and breeding than heifers from L2, (table 1). There was no interaction (P>.10) between location and treatment for age and weight at puberty or age and weight at breeding.

Overall pregnancy rate for heifers bred during this experiment was 66% (table 2). A greater percentage of heifers in E3 than E1 became pregnant (P<.05; table 2). Likewise, a greater percentage of heifers from L2 than from L1 became pregnant (P<.05; table 2). There was no interaction (P>.10) between location and treatment for pregnancy rates. Neither weight at breeding nor age and weight at puberty influenced (P>.10) pregnancy rates when used as within-treatment covariates. However, age at breeding affected (P<.05) pregnancy rates for heifers in E1, but not for heifers in E3 (P>.10; table 3). The age at breeding, within-treatment
TABLE 3. CATMOD\textsuperscript{a} ANALYSIS OF INDIVIDUAL PARAMETERS FOR THEIR EFFECT OF PREGNANCY RATES IN BEEF HEIFERS BRED ON THEIR PUBERAL (E1) OR THIRD ESTRUS (E3)

<table>
<thead>
<tr>
<th>Effect</th>
<th>Estimates of regression\textsuperscript{b}</th>
<th>SE</th>
<th>$\chi^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment intercept</td>
<td>-1.64318</td>
<td>1.56049</td>
<td>1.11</td>
<td>.2923</td>
</tr>
<tr>
<td>E1</td>
<td>-4.62977</td>
<td>1.56049</td>
<td>8.80</td>
<td>.0030</td>
</tr>
<tr>
<td>E3</td>
<td>4.62977</td>
<td>1.56049</td>
<td>8.80</td>
<td>.0030</td>
</tr>
<tr>
<td>Age bred within treatment:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E1</td>
<td>-.020633</td>
<td>.0061878</td>
<td>11.12</td>
<td>.0009</td>
</tr>
<tr>
<td>E3</td>
<td>-.0048213</td>
<td>.0062011</td>
<td>.60</td>
<td>.4369</td>
</tr>
</tbody>
</table>

\textsuperscript{a}CATMOD; Categorical Data Modeling procedure (SAS, 1985).

\textsuperscript{b}Use of estimates: $\ell = \ln \left( \frac{p}{1 - p} \right) = \text{intercept} + \text{treatment effect} + (b \times \text{age bred})$ and $\ell$ is converted to percentage by the formula, $100/1 + e^{-\ell}$.

The regression coefficient for heifers in E1 indicated that as age of breeding increased the probability of a heifer becoming pregnant increased (table 3).

Proportions of heifers that returned to estrus after being bred to a fertile bull differed (P<.05) between E1 (43%) and E3 (22%). Estrous cycle lengths for heifers in E3 were 24.5 ± 1.5 and 20.7 ± 1.0 d for their first and second cycles, respectively (P>.10; table 4). Return estrous cycle lengths for E1 and E3 did not differ (P>.10; table 4) and were similar (P>.10) to estrous cycle lengths for heifers bred to vasectomized bulls.

Discussion

Nelsen et al. (1985) and Rutter and Randel (1986) described the phenomenon of non-puber al estrus (NPE) in beef heifers. It is characterized by expression of estrus without luteal function. Its occurrence may be due to environmental and genetic factors (Nelsen et al., 1985), but physiological processes involved in NPE are unknown. Rate of occurrence of NPE in the present study was 25.5% (37/145), which is lower than that reported by Rutter and Randel (1986) but similar to rates (12 to 24%) observed by Nelsen et al. (1985). Environmental and management conditions and breed-types were similar between our study and the study of Nelsen et al. (1985).

None of 27 heifers in E1 classified as having exhibited NPE became pregnant after breeding by fertile bulls. Thus, the potential for conception is apparently absent in heifers that show NPE, and should be considered a characteristic in the description of this phenomenon. This observation, plus those of Nelsen et al. (1985) and Rutter and Randel (1986) support the notion that investigators emphasize and employ specific, well-defined criteria when studying puberty in beef heifers.

Heifers from L1 were younger at puberty than heifers from L2, but weights at puberty

TABLE 4. ESTROUS CYCLE LENGTHS FOR HEIFERS BRED AT THIRD ESTRUS (E3) AND RETURN ESTROUS CYCLE LENGTHS FOR HEIFERS BRED AT PUBERAL (E1) OR THIRD ESTRUS (E3)

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estrous cycle length, d</td>
<td>E1</td>
</tr>
<tr>
<td>1st cycle</td>
<td>24.5 ± 1.5 (n=45)\textsuperscript{a}</td>
</tr>
<tr>
<td>2nd cycle</td>
<td>20.7 ± 1.0 (n=45)</td>
</tr>
<tr>
<td>Return estrous cycle lengths, d</td>
<td>22.8 ± 1.2</td>
</tr>
</tbody>
</table>

\textsuperscript{a}1st vs 2nd estrous cycle lengths (P>.10).

\textsuperscript{b}E1 vs E3 (P>.10).
were similar. This was not unexpected, because heifers from L1 were 12.5 to 25% Brown Swiss. Laster et al. (1972, 1979) found that heifers from dairy crosses attained puberty at younger ages relative to their body weight than heifers from beef crosses.

The difference in pregnancy rates between heifers from L1 and L2 may have been due to breed-type. Gregory et al. (1979) reported differences in pregnancy rates between groups of different crossbred heifers. Also, season may have been a factor for the difference in pregnancy rates between heifers from L1 and L2 because heifers from L1 were bred 1 mo earlier than heifers from L2. In areas where seasonal changes in temperature and photoperiod are large, fertility is lowest in winter and early spring (de Kruif and Brand, 1978; Salisbury et al., 1978; Montgomery, 1985).

Pregnancy rates were higher for heifers in E3 compared with heifers in E1. This result is similar to those observed in gilts (Robertson et al., 1951), rats (Evans, 1985) and ewe lambs (Hare and Bryant, 1985). The physiological basis of sub-optimal fertility at puberal estrus in beef heifers or other species is not clear. Ovulation rate has been implicated in smaller litter size in gilts bred at puberty (Andersson and Einersson, 1980). Evidence for normal cycling activity, i.e., increasing concentrations of progesterone from d 6 to 12 and associated palpable corpus luteum leads us to conclude that ovulation rate was not a factor for the difference in pregnancy rates between treatments. The lower pregnancy rate of heifers in E1 may have been due to either early (d 1 to 15) or late (d 15 to 19) embryonic mortality. However, return estrous cycle lengths did not differ between heifers bred to either fertile or sterile bulls. If late embryonic mortality occurred in either treatment, then one would expect an extension in return cycle lengths since Northey and French (1980) reported that removal of embryonic tissue between d 15 and 19 post-breeding resulted in extending the inter-estrus interval. Nevertheless, early embryonic mortality could have occurred differentially in E1 and E3 heifers. McMillan and McDonald (1985) reported that embryos collected after breeding at first estrus in ewe lambs had lower survivability scores than embryos from adult ewes when transferred to adult ewes. Thus sub-optimal fertility associated with breeding at first estrus may be a general phenomenon in female mammals.

Pregnancy rate was a positive logistic function of age at breeding (puberty) for heifers in E1, but not for heifers in E3. The reasons for this are not clear. It may be that maturational changes associated with age at breeding for heifers in E3 had been overcome by physiological changes that occurred as a result of recurrent estrous cyclicity. The effect of season cannot be excluded as a factor for the effect of age at puberty on pregnancy rates. Heifers in E1 that were younger at puberty were bred earlier in the year than heifers in E1 that attained puberty at older ages.

In conclusion, breeding beef heifers at puberal estrus reduced pregnancy rates compared with breeding at third estrus. Increased age at breeding (puberty) may improve pregnancy rates associated with breeding at puberty, but not above rates associated with breeding at third estrus. Further research is necessary to elucidate the physiological bases of lower fertility in beef heifers bred at puberty and the maturational relationships between age at puberty and increasing fertility.

Literature Cited
Hare, L. and M. J. Bryant. 1985. Ovulation rate and embryo survival in young ewes mated either at puberty or at the second or third oestrus. Anim. Reprod. Sci. 8:41.


