Evaluation of Reproductive Traits in *Bos taurus* and *Bos indicus* Crossbred Heifers: Relationship of Age at Puberty to Length of the Postpartum Interval to Estrus

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ABSTRACT: Records of age at puberty (AAP) and duration of the postpartum interval to estrus (PPI) for heifers calving first at 2 yr of age were used to determine the relationship between the two reproductive traits. The study from which these records were obtained was designed in a $2 \times 2 \times 2$ factorial arrangement of treatments. Angus $\times$ Hereford (AH; $n=148$) and Brahman $\times$ Hereford (BH; $n=148$) heifers were allotted within breed after weaning by weight into light (LW) and heavy (HW) weight blocks. Heifers were assigned by age to different levels of energy (low or high) in diets calculated to reach a target weight of 55% (LE) or 65% (HE) of their projected mature weight by the onset of the breeding period. Data were analyzed within breed and included only records for which both AAP and PPI were available. Pearson correlation coefficients for AAP to PPI were $r = -0.12$ ($P = 0.20$) and $r = 0.05$ ($P = 0.71$) for AH and BH, respectively. Eliminating animals that experienced dystocia from the analyses yielded correlations of $r = -0.27$ ($P = 0.02$) and $r = 0.06$ ($P = 0.65$) for AH ($n=69$) and BH ($n=51$), respectively. When energy level, weight block, and energy level $\times$ weight block were included in the model for PPI, analyses of variance indicated that PPI among AH heifers was influenced most by the weight at which heifers began the trial after weaning ($P = 0.01$) but not by energy level ($P = 0.23$) or the interaction of energy level $\times$ weight block ($P = 0.48$). There seemed to be a negative relationship between AAP and PPI among AH, but no such relationship between the two reproductive traits in BH. Although heifers that were heavier at weaning reached puberty at younger ages, these same heifers experienced longer intervals to estrus after parturition than did their lighter-weight contemporaries.

Key Words: Puberty, Postpartum Interval, Beef Cows, Heifers, Reproductive Performance, Management


Introduction

Age at puberty in heifers is determined by an array of identifiable genetic and environmental variables (Menge et al., 1960; Cundiff, 1986; Kinder et al., 1987). Factors that influence length of the postpartum interval to estrus (PPI) in the cow are equally numerous (Christenson, 1980; Dunn and Kaltenbach, 1980; Edgerton, 1980; Kiracofe, 1980; Wettemann, 1980; Randel, 1990; Short et al., 1990;
Williams, 1990). Lauderdale (1986) described distinct physiological similarities between puberty in the heifer and resumption of estrous cycles in the cow after parturition. Studies designed to evaluate the relationship between these reproductive traits are lacking, despite physiological similarities and the large body of information pertaining to them.

The objective of our study was to determine the relationship between these two important reproductive traits by using records of age at puberty (AAP) and duration of the PPI for heifers calving first at 2 yr of age.

### Experimental Procedures

**Experimental Design.** The study from which these records were obtained was designed in a $2 \times 2 \times 2$ factorial arrangement of treatments (Patterson et al., 1991). Angus × Hereford (AH; $n = 148$) and Brahman × Hereford (BH; $n = 148$) heifers were allotted within breed by body weight after weaning into light (LW) and heavy (HW) weight blocks. Heifers were assigned by age to different levels of energy (low vs high) in diets calculated (NRC, 1984) to reach a target weight of 55% (LE) or 65% (HE) of their projected mature weights by the start of their first eligible breeding period. Frame measurements were used to predict mature weights (Fox et al., 1988).

Records for AAP and PPI were obtained from the research described by Patterson et al. (1989, 1990, 1991), which included a complete description of animals, management, and procedures involved in collection of these data. Puberty was defined by criteria described by Nelsen et al. (1985), including 1) behavioral estrus, 2) presence of a palpable corpus luteum 6 to 10 d after behavioral estrus (estrus = d 0), and 3) increased progesterone in serum to concentrations ≥ 1 ng/mL on the day of palpation. Duration of the postpartum interval to estrus was defined as the number of days to the first observed estrus. Records were considered complete and were included in the study only when both AAP and PPI were available.

**Statistical Analyses.** Data were analyzed within breed because of the different biological types and their differences in reproductive function (Plasse et al., 1988; Randel, 1984), using the GLM procedure of SAS (1982). Models included prebreeding level of energy (high vs low), weight block (heavy vs light), and the two-way interaction. The MANOVA (SAS, 1982) statements were used when model statements included more than one dependent variable (AAP and PPI). The MANOVA procedure was used also to obtain partial correlations of energy level, weight block, and the interaction of energy level × weight block with AAP and PPI. Pearson correlation coefficients were obtained for AAP with PPI (Snedecor and Cochran, 1980). Correlation coefficients between continuous variables were determined by SAS (1982).

### Results

**Relationships Among Angus × Hereford Heifers.** The Pearson correlation coefficient of AAP to PPI was $r = -0.12$ ($P = 0.20$). However, this correlation changed ($r = -0.27; P = 0.02$) after records were eliminated from the analyses for heifers that experienced problems at calving (calving difficulty score > 1; Doornbos et al., 1984). The number of heifers for which records were available is shown in Table 1. When energy level, weight block, and the interaction of energy level × weight block were included in the model for PPI, analyses of variance showed that PPI was influenced most by the weaning weight ($P = 0.01$) of the heifer but not by prebreeding level of energy ($P = 0.23$) or the interaction of energy level × weight block ($P = 0.48$). The correlation of AAP to PPI was $r = -0.19$ ($P = 0.11$) after weight block was accounted for. The regression equation used to predict PPI, given AAP and calving difficulty scores of 1, was as follows: $PPI = 135.363 + (-0.153) AAP (r^2 = 0.07; P = 0.02)$. Figure 1 illustrates, by use of least squares means, the relationship between AAP and PPI for LW and HW blocks. Ages at weaning of heifers in HW and LW blocks differed by 8 ± 1 d.

Figure 2 uses correlation coefficients to illustrate the various relationships involving AAP and PPI for AH heifers. Weight at weaning was correlated positively ($r = 0.25; P = 0.03$) with PPI. Heifer calves that were heavier at weaning reached puberty at younger ages ($r = -3; P = 0.003$) and were taller at the start of their first breeding
season \((r = .56; P = .01)\). Correlations of weight at weaning and prebreeding hip height with PPI were positive \((r = .25, P = .03; r = .21, P = .06; \text{respectively})\). These correlations support the negative relationship \((r = -.27; P = .02)\) between AAP and PPI. The correlation of weight at weaning with weight at calving is not presented in this figure because differences in weights were reflective of treatments imposed during the prebreeding development period (Patterson et al., 1991).

Figure 3 further illustrates some relationships described in Figure 2. Weight and body condition at calving and weight at the first postpartum estrus were correlated negatively with PPI. In other words, PPI increased with decreasing weight and body condition at calving. In addition, HW heifers weaned heavier calves \((P = .08; 184 \pm 2 \text{ kg HW vs } 174 \pm 2 \text{ kg LW})\) than LW heifers. Least squares means are presented for initial weight and height, AAP, body condition at calving, PPI, and calf weight at weaning for heifers assigned to HW and LW blocks (Table 2).

**Relationships Among Brahman × Hereford Heifers.** The Pearson correlation coefficient of AAP with PPI among BH heifers was \(r = .05 (P = .71)\). Eliminating animals that experienced dystocia from these analyses yielded a correlation of \(r = .06 (P = .65)\). These data fail to show a relationship between AAP and PPI in BH heifers. The Julian calendar date on which BH heifers returned to estrus after parturition was influenced \((P < .01)\) by their herd origin. Patterson et al. (1991) reported a similar influence on AAP among heifers included in this study. However, there seemed to be a prolonged influence of sire beyond attainment of puberty in the Brahman crossbred heifers. This theory is speculative because of the limited nature of the data and the lack of information pertaining to sires of the heifers that were involved. Although cattle are not seasonal breeders, seasonal variation in sexual activity of *Bos indicus* cattle has been observed (Anderson, 1944). Environmental changes affect the release of LH and progesterone in Brahman cattle (Harrison et al., 1982; Rhodes et al., 1982) and might have contributed to differences in the return to estrus after parturition that occurred in this study.

**Discussion**

Angus × Hereford heifers that were heavier at weaning reached puberty at younger ages. However, these heifers experienced longer intervals to estrus after parturition than lighter-weight con-

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**Figure 1.** Least squares means for age at puberty and length of postpartum interval to estrus for Angus × Hereford heifers in heavy and light weight blocks.

**Figure 2.** Correlations involving age at puberty and length of the postpartum interval to estrus for Angus × Hereford heifers.
Table 2. Comparison of weights, body condition, and reproductive traits of Angus x Hereford heifers

<table>
<thead>
<tr>
<th>Weight block</th>
<th>Initial wt, kg&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Initial height, cm&lt;sup&gt;b&lt;/sup&gt;</th>
<th>AAP, d&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Body condition at calving&lt;sup&gt;d&lt;/sup&gt;</th>
<th>PPI, d&lt;sup&gt;e&lt;/sup&gt;</th>
<th>Calf wt, kg&lt;sup&gt;f&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light wt</td>
<td>201 ± 2*</td>
<td>102 ± 2</td>
<td>372 ± 3*</td>
<td>5.0 ± .01*</td>
<td>79 ± 1*</td>
<td>174 ± 2*</td>
</tr>
<tr>
<td>Heavy wt</td>
<td>228 ± 3</td>
<td>107 ± 2</td>
<td>347 ± 3</td>
<td>4.7 ± .01</td>
<td>91 ± 1</td>
<td>184 ± 2</td>
</tr>
</tbody>
</table>

<sup>a</sup>Least squares means ± standard error.
<sup>b</sup>Weight and height measurements at weaning.
<sup>c</sup>Age at puberty.
<sup>d</sup>Body condition scale: 1 = emaciated, 9 = obese.
<sup>e</sup>Length of interval to estrus after parturition.
<sup>f</sup>Calf weight at weaning.
*Means within column differ (P < .05).
**Means within column differ (P < .10).

Longer PPI of HW heifers were associated with lower scores of body condition and higher levels of production. These conclusions are based on limited numbers but explain problems associated with reproductive management of first-calf heifers. Adequate nutrition during periods of development and growth was critical to their reproductive performance.

The relationship we observed between AAP and PPI is difficult to explain. Lauderdale (1986) described physiological similarities between puberty in the heifer and return to estrus after parturition in the cow. Puberty is characterized by the occurrence of two peaks in concentrations of LH. The preovulatory or pubertal peak is preceded by a second peak of similar magnitude and duration on d -11 to -9 (Gonzalez-Padilla et al., 1975). Increased concentrations of progesterone occur in two distinct periods between d -20 and 0 (Donaldson et al., 1970; Gonzalez-Padilla et al., 1975).

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*P=.09
<sup>b</sup>P=.01
<sup>c</sup>P=.001
<sup>d</sup>P=.0001

Figure 3. Correlations of weights and estimates of body condition to length of the postpartum interval to estrus in Angus x Hereford heifers.
Progesterone plays a major role in the establishment of peripubertal pulsatile patterns of gonadotropin secretion, which are needed for the development of the preovulatory surge (Schams et al., 1981). A transient increase in progesterone occurs also before resumption of normal ovarian cyclicity in postpartum beef cows (Prybil and Butler, 1978; Rawlings et al., 1980; Williams and Ray, 1980). The first corpus luteum after parturition is preceded generally by a small increase in progesterone in peripheral blood for a period of 3 to 10 d (Lauderdale, 1986). Perhaps if our study had encompassed timing of hormonal changes in the peripubertal heifer and those same changes in the postpartum cow reviewed by Lauderdale (1986), the correlation of these two reproductive traits would be explained more easily. From a management standpoint, however, the physiological similarities between the two reproductive events is perhaps not as significant a consideration as the influencing factor(s) that facilitates their onset.

Studies designed specifically to determine a relationship between AAP and PPI, despite physiological similarities, are not available. We know that earlier age at puberty is associated with earlier conception (Werre, 1980; Byerley et al., 1987), higher pregnancy rate (Ferrell, 1982), heavier weaning weights of calves (Werre, 1980), and higher lifetime production (Werre, 1980). Heifers that weigh more at weaning reach puberty at younger ages and heavier weights (Menge et al., 1960), and heavier weights at 6 mo lead subsequently to heavier weights at calving and higher 90-d milk production (Menge et al., 1960). Measurements of weight and height near 1 yr of age are related to pubertal age, weight, and height, and larger size near 1 yr of age is associated with younger, larger animals at puberty (Baker et al., 1988).

The increase in PPI among heifers that reached puberty at younger ages was associated with weight of the heifer at weaning. Heifers that weighed more at the time of weaning reached puberty at younger ages and heavier weights but experienced longer PPI after partition. Heifers assigned to HW blocks showed a tendency toward higher levels of production measured by calf weights at weaning. Heifers experienced longer PPI when both weight and condition at calving declined. Ferrell (1982) showed that large heifers were younger and heavier at puberty, produced more milk, and had lower condition scores than did small heifers. Large cows that produce more milk are expected to have higher feed requirements than small cows that produce less milk (Ferrell, 1982; Buttram and Willham, 1987). Lower condition scores suggest that large heifers are less able to meet their feed requirements during lactation than are small heifers (Ferrell, 1982; Buttram and Willham, 1987). Although these conclusions were based on comparisons among breeds, they tend to agree with findings we have reported within a breed cross. Large heifers in our study were more vulnerable to these same limitations than were small heifers.

Animals that are phenotypically heavier at maturity within a breed tend to require more time to mature in body weight (Taylor and Fitzhugh, 1971). This conclusion, the reports by Ferrell (1982) and Buttram and Willham (1987), and the findings of our study suggest that the relationship between AAP and PPI is accurate and influenced to a large extent by management-related factors. Although analyses of these data fail to provide an interpretation based on cause and effect, we know that the sequence of events leading from weaning to puberty and from puberty to first postpartum estrus is dictated largely by environmental influences, despite selection pressure placed on reproductive traits.

Implications

These findings collectively emphasize the need for adequate nutrition in reproductive management of the replacement beef heifer and support the role of body condition in reproductive performance. The day on which Brahman × Hereford heifers returned to estrus after parturition was influenced by origin or the source from which these heifers were obtained at weaning. These heifers represented a diverse genetic base, which may have resulted in differing responses to specific environmental cues. Increased genetic variability because of reduced selection pressure compared with Bos taurus breeds may explain our results in Brahman-derived breeds.

Literature Cited

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