Investigating Optimal Bull:Heifer Ratios Required for Estrus-Synchronized Heifers

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ABSTRACT: The objectives of this study were to determine 1) the effect of bull:heifer ratio on reproductive performance and associated costs and returns on heifers in synchronized estrus and 2) the effect of estrus synchronization on reproductive performance and economic variables, in a multiple-sire, pasture breeding situation. Eight hundred yearling beef heifers and 28 mature, sexually experienced beef bulls were allotted to four treatments (two replicates per treatment) at bull:heifer ratios of 2 per 100 (1:50; Treatment 1), 2 per 100 (1:50; Treatment 2), 4 per 100 (1:25; Treatment 3), and 6 per 100 (1:16; Treatment 4). Treatment 1 (control) used nonsynchronized heifers, whereas heifers in Treatments 2, 3, and 4 were synchronized using the 33-d melengestrol acetate (MGA)-prostaglandin F₂α (PGF₂α) program. Pregnancy results after a 28-d breeding season indicate that there may be a limit to how many estrus-synchronized heifers bulls can impregnate. Treatment 2 showed a 6% decrease (P < .10) in pregnancy rate (77%) compared with Treatment 3 (83%), indicating that the bulls probably were not able to service all the synchronized heifers. Treatments 3 and 4 had similar pregnancy rates (83 and 84%, respectively). Treatment 4 had a 3-d advantage (P < .01) over Treatment 3 in average day of conception. However, based on economic analysis, Treatment 3 exhibited greater returns. Estrus synchronization failed to provide any advantage in pregnancy rate or day of conception. For unknown reasons, the control, nonsynchronized heifers cycled and conceived as if they were synchronized. Treatment 2 had a 5% decrease in pregnancy rate compared with Treatment 1 (77 vs 82%; P < .10) with no difference in average day of conception. Consequently, Treatment 1 (nonsynchronized) exhibited greater economic returns. Results of this study indicated that the optimal bull:heifer ratio for estrus-synchronized heifers was 1:25. In this study, estrus synchronization failed to provide an advantage in terms of reproductive performance or economic efficiency.

Key Words: Fertility, Estrus Synchronization, Economics

Introduction

Beef producers in the United States are becoming increasingly aware of the need to lower costs of production to compete with less expensive protein sources, such as poultry and pork. One possible strategy for lowering costs of production is to improve the production efficiency of the cow herd. A key area to focus on is the reproductive function of the beef bull, because natural mating accounts for more than 95% of the pregnancies achieved each year in the 33.7 million beef cows in the United States. A majority of beef bulls today are still being mated at traditional ratios of 1:25 to 1:30 (Taylor, 1984). However, it has been reported that many herd bulls may be underused (Rupp et al., 1977; Neville et al., 1979; Price, 1987). Therefore, increasing bulls' mating loads offers potential for lowering operating and investment costs. Using bulls to their optimal breeding potential will allow many producers to decrease their bull numbers, thus lowering annual operating and investment costs per cow or heifer in the breeding herd.

Estrus synchronization has proven to be a valuable tool for enhancing reproductive efficiency by allowing for a shortened breeding and calving season. Based on an average estrous cycle length of 21 d, synchronized heifers have two opportunities to conceive during a
Materials and Methods

Heifer Selection. Nine hundred yearling heifers of mixed English and Continental breeding were developed at Noffsinger Feedlot near Ault, CO during the winter of 1989-1990. Approximately one-half of the heifers had been raised by Noffsinger Ranches and half had been purchased. Forty-five days before the breeding season, heifers underwent a reproductive soundness evaluation, which included body condition score, reproductive tract score, and pelvic area measurement. Because expression and measurement of bull fertility is primarily dependent on the availability of animals in estrus, 800 heifers were selected based on reproductive tract score. Eighty-eight percent of the 800 heifers were estimated to be cycling at the time of palpation (reproductive tract score 3 of 5); 12% were estimated to be close to cycling (reproductive tract score 3). Heifers were randomly allotted to treatment (Table 1); however, we did ensure that the heifers with a reproductive tract score of 3 were evenly distributed among treatments and replicates.

Bull Selection. Twelve days before the breeding season, 44 mature bulls belonging to Noffsinger Ranches underwent a breeding soundness examination and were weighed. Twenty-eight bulls were selected based on their acceptable semen quality (> 80% normal spermatozoa), scrotal circumference (> 34 cm), and structural soundness. Bulls ranged in age from 2 to 5 yr old, but were mostly 2- and 3-yr-olds, and all had prior breeding experience. Number and breeds of bulls included 16 Salers or Salers crosses, five Black Angus or Angus crosses, five Gelbvieh or Gelbvieh crosses, and two Red Angus or Red Angus crosses. Bulls were stratified to treatment by age, weight, semen quality, scrotal circumference, and breed (Table 2).

Experimental Design. Four treatments (two replicates per treatment) were used to investigate the optimal use of bull fertilizing ability on synchronized and nonsynchronized heifers. Treatment 1 (control) consisted of two breeding pastures (replicates), each containing 100 nonsynchronized heifers and two bulls (bull:heifer ratio of 1:50). Treatment 2 was identical, except that the heifers were synchronized. Treatments 3 and 4 also contained synchronized heifers, with four bulls per 100 heifers (bull:heifer ratio of 1:25) and six bulls per 100 heifers (bull:heifer ratio of 1:16), respectively.

Method of Estrus Synchronization. Heifers in Treatments 2, 3, and 4 were synchronized with the 33-d MGA-PGF2α synchronization program. The MGA was combined with rice hulls and calcium carbonate, pelleted, and fed at the rate of 5 mg/(animal·d) for 14 d. Because of limited bunk space, pellets were mixed...
## Table 2. Prebreeding season bull characteristics

<table>
<thead>
<tr>
<th>Item</th>
<th>Trt 1</th>
<th></th>
<th>Trt 2</th>
<th></th>
<th>Trt 3</th>
<th></th>
<th>Trt 4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of bulls</td>
<td>Avg</td>
<td>Range</td>
<td>Avg</td>
<td>Range</td>
<td>Avg</td>
<td>Range</td>
<td>Avg</td>
<td>Range</td>
</tr>
<tr>
<td>Age, yr</td>
<td>2.5</td>
<td>2-3</td>
<td>2.5</td>
<td>2-3</td>
<td>3.0</td>
<td>2-4</td>
<td>2.8</td>
<td>2-5</td>
</tr>
<tr>
<td>Body condition score&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.8</td>
<td>4-5</td>
<td>4.8</td>
<td>4-5</td>
<td>5.0</td>
<td>4-6</td>
<td>5.0</td>
<td>4-6</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>567</td>
<td>464-648</td>
<td>581</td>
<td>486-680</td>
<td>569</td>
<td>446-671</td>
<td>571</td>
<td>473-698</td>
</tr>
<tr>
<td>Scrotal circumference, cm</td>
<td>35.4</td>
<td>34.5-36</td>
<td>35.8</td>
<td>35-36</td>
<td>35.6</td>
<td>34-40</td>
<td>36.6</td>
<td>34.5-39</td>
</tr>
<tr>
<td>Normal spermatozoa, %</td>
<td>93.3</td>
<td>89-97</td>
<td>90.3</td>
<td>86-95</td>
<td>89.9</td>
<td>82-95</td>
<td>92.5</td>
<td>81-98</td>
</tr>
<tr>
<td>Primary abnormalities, %</td>
<td>4.0</td>
<td>2-8</td>
<td>5.0</td>
<td>4-8</td>
<td>6.3</td>
<td>3-14</td>
<td>4.0</td>
<td>0-12</td>
</tr>
<tr>
<td>Secondary abnormalities, %</td>
<td>2.8</td>
<td>1-6</td>
<td>4.8</td>
<td>1-9</td>
<td>3.9</td>
<td>1-9</td>
<td>3.5</td>
<td>0-8</td>
</tr>
<tr>
<td>Progressively motile, %</td>
<td>75.0</td>
<td>60-80</td>
<td>75.0</td>
<td>60-80</td>
<td>70.0</td>
<td>50-80</td>
<td>70.0</td>
<td>30-80</td>
</tr>
<tr>
<td>Score&lt;sup&gt;d&lt;/sup&gt;</td>
<td>80.0</td>
<td>76-84</td>
<td>84.0</td>
<td>84-84</td>
<td>84.0</td>
<td>68-100</td>
<td>81.8</td>
<td>60-100</td>
</tr>
</tbody>
</table>

<sup>a</sup>Measurements taken 12 d before beginning of breeding season.

<sup>b</sup>Range 1-9; 1 = very thin, 5 = moderate, 9 = obese.

<sup>c</sup>BSE = breeding soundness examination.

<sup>d</sup>Scoring system is recommended by Society for Theriogenology (Ball et al., 1983). Maximum of 40 points for scrotal circumference, 40 points for semen morphology, and 20 points for semen motility.

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in with the total ration and fed twice a day. Feed consumption was monitored and heifers were observed for signs of behavioral estrus. At the conclusion of MGA feeding, heifers in Treatments 2, 3, and 4 were transported 240 km from the feedlot to the Lone Pine Ranch division of Noffsinger Ranches near Walden, CO. Treatment 1 heifers were transported 10 d earlier. Seventeen days after the final day of MGA feeding, heifers in Treatments 2, 3, and 4 were injected i.m. with 25 mg of PGF2α. Heifers in all treatments were group-weighted on the same day.

**Breeding Season.** Breeding season began on the same day for all treatments, at time of injection of PGF2α. Cattle were placed in eight different intermountain pastures ranging in size from 80 to 120 ha. Terrain in each pasture varied from meadows to steep hills; vegetation included partially irrigated meadow grasses, sagebrush, willow thickets, and aspen groves. Total length of the breeding season was 28 d. Cattle were observed daily to ensure that they remained in their allotted pasture. Observations for health, structural and reproductive soundness, and behavior of the bulls were also made; however, due to the extensive nature of this study, constant observations were not possible. Consequently, this did not allow ranking of social hierarchies. From limited daily observation, however, no health, structural, or reproductive soundness problems were observed among bulls, nor were there any apparent atypical behaviors or social interactions that could have been interpreted as compromising the bulls’ performance.

**Postbreeding Season Measurements.** Bulls underwent another breeding soundness examination and were weighed at the end of the breeding season.

Because the primary variable being studied was bull fertility we chose to use heifer pregnancy rate and average day of conception rather than calving date as the main measurement criteria because calving date is influenced by those factors influencing gestation length, including breed, sire, nutrition, environment, cow age, and twinning (Odde et al., 1987). Odde et al. (1987) reported a large variation in gestation length and, therefore, calving distribution of estrus-synchronized cows. Calving data on 229 Angus cows and 105 Hereford cows that conceived at a synchronized estrus revealed that 62.4% of the Angus and 55.2% of the Hereford cows calved during the peak week (Odde et al., 1987). Therefore, in this study, palpation data were considered more accurate in estimating the day of conception than were calving data (Ball, 1983). Pregnancy status and estimated day of conception were determined by rectal palpation 30 d after the end of the breeding season. To minimize bias, pregnancy testing was performed by two experienced palpators, neither having knowledge of either the other’s diagnosis or to which treatment the heifer was assigned. For pregnant heifers, the official estimate of day of conception was an average of the two estimates. Ultrasound was used for heifers of questionable pregnancy status.

**Analysis of Results.** Pregnancy rate data were analyzed by the chi-square method (Steele and Torrie, 1980). The day of conception was analyzed by analysis of variance (SAS, 1985).

Economic analysis was performed to determine the different costs and returns associated with different bull:heifer ratios and estrus synchronization.

### Results and Discussion

Reproductive tract score, body condition score, or source of heifers (ranch-raised vs purchased) were not found to be significant sources of variation ($P > .20$); therefore, data were pooled and examined for differences among treatments.
Table 3. Effect of bull:heifer ratio on estimated pregnancy rate and estimated day of conception of nonsynchronized and synchronized heifers

<table>
<thead>
<tr>
<th>Item</th>
<th>Bull:heifer ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1:50</td>
</tr>
<tr>
<td>Pregnancy status</td>
<td></td>
</tr>
<tr>
<td>6-d pregnancy rate, %</td>
<td>40</td>
</tr>
<tr>
<td>28-d pregnancy rate, %</td>
<td>82</td>
</tr>
<tr>
<td>Estimated day of conceptiona</td>
<td>10b</td>
</tr>
</tbody>
</table>

a Estimated day of conception is average day of the breeding season that heifers become pregnant. Start of the breeding season is
bMeans within rows with different superscripts differ (P < .05).
cMeans within rows with different superscripts differ (P < .01).

**Effect of Bull:Heifer Ratio with Estrus-Synchronized Heifers**

**Reproductive Evaluation.** Pregnancy rates after a 28-d breeding season indicate that there may be a limit to how far bulls can be extended when using estrus synchronization. Treatment 2 showed a 6% decrease (P < .10) in pregnancy rate (77%) compared with Treatment 3 (83%) (Table 3). Although this only suggests a trend toward lowered pregnancy rates, further evidence of the potential risk associated with this bull:heifer ratio is provided by replicate pregnancy rates. Considerable variation was found between replicates within Treatment 2 (68 and 85%) compared with Treatments 3 (82 and 87%) and 4 (82 and 84%). Pregnancy rates within Treatment 2 illustrate the dilemma of the variation often found with single-sire mating (Lunstra and Laster, 1982). Rupp et al. (1977) suggested that multiple-sire mating may allow some bulls to compensate for others less fertile or able. This would concur with findings by Lunstra and Laster (1982), which suggested that multiple-sire mating should result in higher average pregnancy rates and less variation than could be achieved with single-sire mating. Treatments 3 and 4 had similar pregnancy rates (83 and 84%, respectively), however, Treatment 4 had a 3-d advantage (P < .01) in average day of conception over Treatment 3 (Table 3). This advantage in average day of conception reflects the difference in pregnancy rates between Treatments 3 and 4 in the first 6 d of the breeding season (41 vs 53%, respectively). This may be a function of an increased number of services per heifer by different sires, which has been shown to result in higher pregnancy rates than a single service by one sire or multiple services by one sire (Farin et al., 1982; Lunstra and Laster, 1982).

The advantage in average day of conception should result in earlier calving dates and heavier weaning weights. The remaining question is whether the return from heavier weaning weights will offset the costs of the two additional bulls in Treatment 4.

**Economic Evaluation.** In order to determine the “optimal” bull:heifer ratio, it becomes necessary to quantify both costs and revenue associated with the four treatments. Differences in cost are directly related to differences in bull:heifer ratio and whether or not heifers were synchronized. Assume a yearling bull costs $1,750 and is sold after four breeding seasons for $907 (salvage value based on average price in Colorado over the period 1986 through 1990 [Cattle-Fax Market News Service, Englewood, CO] for a 720-kg bull), resulting in an annual depreciation of $210.75. Other fixed costs include interest (8%; $106.28), insurance (1%; $13.29), and death loss (.5%; $6.64), calculated on the average of the purchase price and salvage value. Variable costs include feed at $200 and veterinary and medical costs of $35. Feed costs for bulls can vary considerably from one operation to another, depending on available feedstuffs and management strategy. The use of $200 in this example is representative of average feed costs for Colorado Integrated Resource Management cooperators. Thus, total annual bull costs is calculated as $572 per head.

Additional costs to be considered for Treatments 2, 3, and 4 include the synchronization program. The MGA carrier pellets cost $153.00 per metric ton, or $1.46 per heifer for 14 d. The PGF2α cost was $2.00 per heifer, and labor for administration of MGA and PGF2α cost $.24 per heifer, for a total of $3.70 per heifer. Bull costs and synchronization costs are combined into the breeding cost, attributed appropriately to each treatment, and expressed as the breeding cost per heifer exposed (dollar; $15.14, $26.58, and $39.45 for Treatments 2, 3, and 4, respectively; Table 4).

Table 4 reports the economic value and differences of the four treatments at three phases in the heifer's production (breeding, pregnancy check, and first calf heifer). A gross revenue or base market value approach was used to determine the change in revenues between treatments for each production period, on both a per-head and total basis. The base value is a market value of the heifers, both individually and in total, at the end of each production period. It is important to recognize that the analysis reported in Table 4 measures the change in base value or revenue of heifers (i.e., whether pregnant or nonpregnant) as they move through each production period. The change in base value per animal is added to the base market value of heifers at the beginning of trial to determine the total gross revenue by treatment.

The per head gross revenue value provides an indication of the difference in revenue between treatments. The net change in revenue by treatment is calculated by subtracting breeding costs from total revenue. The resulting figure, whether on a per animal or total basis provides the best measure of the economic impact of the various treatments.

Expected gross revenues in the following evaluation (Table 4) is mainly a function of pregnancy rates, calf
weaning rate, and market value of the heifer (whether pregnant or nonpregnant) and its calf. Revenues are based on the following assumptions: 85% of pregnant heifers wean a calf; steer calves average 214-kg weaning weight and sell for $1.95/kg; and heifer calves average 203-kg weaning weight and sell for $1.78/kg. Production figures are typical of those found in Colorado; prices are based on average price in Colorado over the period 1986 through 1990 (CattleFax Market News Service).

Net revenue (gross revenue less breeding costs) on a per heifer basis, has been estimated for each treatment (Table 4), which reveals the expected advantages or disadvantages of the different bull: heifer ratios and synchronization. Based on these figures, Treatment 3, with a bull:heifer ratio of 1:25,

Table 4. Estimated effect of bull:heifer ratio on costs and revenues for heifers not synchronized and synchronized for estrus

<table>
<thead>
<tr>
<th>Line no.</th>
<th>Production period</th>
<th>Treatment a</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breeding/yearling (approx. 15 mo)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Bull:heifer ratio</td>
<td></td>
<td>1.50</td>
<td>1.50</td>
<td>1.25</td>
<td>1.16</td>
</tr>
<tr>
<td>2</td>
<td>Heifer/treatment, no.</td>
<td></td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>Average market value, $/animal</td>
<td></td>
<td>$552.77</td>
<td>$552.77</td>
<td>$552.77</td>
<td>$552.77</td>
</tr>
<tr>
<td>4</td>
<td>Total value of heifers</td>
<td></td>
<td>$110,554</td>
<td>$110,554</td>
<td>$110,554</td>
<td>$110,554</td>
</tr>
<tr>
<td></td>
<td>Pregnancy check (approx. 18 mo)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Estimated percentage pregnant</td>
<td></td>
<td>82%</td>
<td>77%</td>
<td>83%</td>
<td>84%</td>
</tr>
<tr>
<td>6</td>
<td>No. pregnant</td>
<td></td>
<td>164</td>
<td>154</td>
<td>166</td>
<td>168</td>
</tr>
<tr>
<td>7</td>
<td>Average market value, $/animal</td>
<td></td>
<td>$723.11</td>
<td>$715.64</td>
<td>$724.60</td>
<td>$726.10</td>
</tr>
<tr>
<td>8</td>
<td>Total value of heifers, $</td>
<td></td>
<td>$144,622</td>
<td>$143,128</td>
<td>$144,920</td>
<td>$145,220</td>
</tr>
<tr>
<td>9</td>
<td>Change from breeding, $/animal</td>
<td></td>
<td>$170.34</td>
<td>$162.87</td>
<td>$171.83</td>
<td>$173.33</td>
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<tr>
<td>10</td>
<td>Total change from breeding, $</td>
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<td>$34,068</td>
<td>$32,574</td>
<td>$34,366</td>
<td>$34,666</td>
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<tr>
<td></td>
<td>First-calf heifer (approx. 30 mo)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Weaning rate, %</td>
<td></td>
<td>69.70</td>
<td>65.46</td>
<td>70.55</td>
<td>71.40</td>
</tr>
<tr>
<td>12</td>
<td>No. weaning a calf</td>
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<td>139.4</td>
<td>130.9</td>
<td>141.1</td>
<td>142.8</td>
</tr>
<tr>
<td>13</td>
<td>Avg. market value per calf, $/animal</td>
<td></td>
<td>$389.32</td>
<td>$389.32</td>
<td>$389.32</td>
<td>$389.32</td>
</tr>
<tr>
<td>14</td>
<td>Total value of calf prod, $</td>
<td></td>
<td>$54,271</td>
<td>$50,982</td>
<td>$54,933</td>
<td>$55,595</td>
</tr>
<tr>
<td>15</td>
<td>Value of calf prod/heifer exposed, $/animal</td>
<td></td>
<td>$271.36</td>
<td>$254.81</td>
<td>$274.67</td>
<td>$277.97</td>
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<tr>
<td></td>
<td>Estimated gross revenue</td>
<td></td>
<td>$994.46</td>
<td>$970.45</td>
<td>$999.27</td>
<td>$1,004.1</td>
</tr>
<tr>
<td>16</td>
<td>Revenue per heifer exposed</td>
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<td>$198,893</td>
<td>$194,090</td>
<td>$199,853</td>
<td>$200,815</td>
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<tr>
<td>17</td>
<td>Total revenue</td>
<td></td>
<td>$196,605</td>
<td>$191,062</td>
<td>$194,537</td>
<td>$192,924</td>
</tr>
<tr>
<td></td>
<td>Breeding cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Per heifer exposed</td>
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<td>$11.44</td>
<td>$15.14</td>
<td>$26.58</td>
<td>$39.45</td>
</tr>
<tr>
<td>19</td>
<td>Total breeding costs</td>
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<td>$3,028</td>
<td>$5,316</td>
<td>$7,890</td>
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<tr>
<td></td>
<td>Net revenue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Per heifer exposed</td>
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<td>$963</td>
<td>$955</td>
<td>$973</td>
<td>$965</td>
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<td>21</td>
<td>Total</td>
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<td>$196,605</td>
<td>$191,062</td>
<td>$194,537</td>
<td>$192,924</td>
</tr>
</tbody>
</table>

aTreatment 1 heifers were not synchronized; heifers in other treatments were synchronized.

bAssumption: yearling heifers market value was based on 331 kg/animal @ $1.67/kg.

cTotal value of heifers at breeding equals (line 2)(line 3).
dNumber of heifers pregnant equals (line 2)(line 5).
eAverage market value per heifer (preg check) equals the weighted average value of pregnant and nonpregnant heifers this phase, where pregnant and nonpregnant heifers were assumed to have a market value of $750/animal and $601/animal (385 x 1.56 = $590.80), respectively.

fTotal value of heifers at preg check equals (line 2)(line 7).
gChange in revenue per head from breeding period-to-preg check equals, (line 7 - line 3).
hChange in total revenue from breeding period-to-preg check equals, (line 8 - line 4).
iWeaning rate is assumed to be 85% of estimated percentage pregnant, (i.e., 85 x line 5).
jEstimated number of first calf heifers weaning a calf equals, (line 11)(line 2).
kAssumption: a 50:50 sex ratio at weaning; weaning weight of steer calves avg. 214 kg @ $1.78/kg; i.e., [(214 kg)($1.95) + (203 kg)($1.78)]/2 = $389.32.
l(line 13)(line 12).
m(line 14)(line 2).
n(line 3 + line 9 + line 15).
o(line 16 x line 2) or (line 4 + line 10 + line 14).
pBreeding cost/heifer is based on annual bull cost of $572, divided by the average number of heifers/bull plus synchronization cost of $3.70/ heifer.
q(line 18)(line 2).
r(line 16 - line 18).
s(line 17 - line 19).
has an advantage over both Treatments 2 and 4 ($973 per heifer vs $955 and $965, respectively). Even though Treatment 4 had a 3-d advantage in average day of conception compared with Treatment 3, the expected returns from the older, heavier calves (approximately $4.42/heifer) would not be enough to justify the extra bulls. Therefore, considering both biological and economic variables, the optimal bull: heifer ratio for synchronized heifers would be 1:25.

If bull investment cost was lower, for example, with a purchase price of $1,000, there would be little cost difference between the treatments. However, when bull investment costs are greater than in the example discussed, the advantages of heavier mating loads become more apparent.

Effect of Estrus Synchronization

Reproductive Evaluation. In this study, estrus synchronization failed to provide any advantage in pregnancy rate or day of conception. Treatment 2 had a 5% decrease in pregnancy rate compared with Treatment 1 (77 vs 82%; P < .10) and no difference in average day of conception (Table 3). Normally, one would expect synchronized heifers to have an advantage in average day of conception, due to a higher percentage of heifers showing estrus and conceiving in the first 6 d of the breeding season. However, no advantage was found in this study. Palpation data indicated that the nonsynchronized heifers cycled and conceived as if they were synchronized; 40% of the nonsynchronized heifers conceived during the first 6 d of the breeding season, compared with 38% of the synchronized heifers in Treatment 2 (Table 3). These results are unusual, because the nonsynchronized heifers were located ≥ 1 km from synchronized heifers, and, therefore, not subject to any visual, olfactory, or otherwise unknown environmental influence. At least 88% of the heifers in Treatment 1 were cycling 45 d before the breeding season, thus any effect of bull exposure on induction of cycling would provide little advantage.

Pregnancy rates between replicates within Treatments 1 and 2 varied considerably (77 and 87%; 68 and 85%, respectively), indicating that the bull:heifer ratio of 1:50, or 2:100, may have put too much breeding pressure on some of the bulls.

Economic Evaluation. Applying the same assumptions for costs and revenues as discussed earlier, Treatment 1 offers a greater return than Treatment 2 ($983 vs $955 per heifer, respectively; Table 4), due to a higher pregnancy rate and no cost of synchronization.

Calving Data

Using a 280-d gestation length, average expected and actual calving dates did not differ by more than 2 d within treatment.

The pregnancy loss percentage, defined as the number of heifers diagnosed as pregnant that failed to calve, divided by the number of heifers diagnosed as pregnant, multiplied by 100, was 8.7%, which compared to previous years in which heifers were palpated at a similar time, was higher than normal (previous pregnancy loss averages 2 to 5%). The difference is attributed to a change in management to winter feeding of heifers in very large groups, which was observed to result in more competition for feed, some slipping on frozen ground, and thus additional stress.

Other Postbreeding Season Measurements

All bulls passed the postbreeding season breeding soundness examination with the exception of one bull in Treatment 3, which had < 80% normal sperm. Surprisingly, bulls actually gained weight during the 42-d period (length of time from pre- to postbreeding season weights) at an average of 1.14 kg/d. In support of these findings is an experiment reported by Boyd et al. (1989), which found that mating activity had no effect on grazing activity. Grazing time for bulls mated to estrus-synchronized cows was similar to bulls mated to nonsynchronized cows.

Heifers gained an average of .95 kg/d during the 57-d period (length of time from prebreeding season weight until weight at time of palpation); thus, it seems that nutrition was not a limiting factor in their ability to conceive.

Implications

Analysis of these findings reveals that the optimal bull:heifer ratio for synchronized heifers was 1:25, considering both biologic and economic response to treatments. Extrapolation of these results to naturally cycling heifers or cows indicates that there may be opportunity to lower production costs simply by increasing bulls’ mating loads. From this study, it seems that mature, experienced bulls are capable of heavier mating loads than the traditional 1:25 to 1:30. Additional research is needed to determine the optimal bull:heifer ratio for naturally cycling heifers and cows and what effect, if any, pasture size and terrain may have on mating loads.

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