Impact of supplemental protein source offered to primiparous heifers during gestation on I. Average daily gain, feed intake, calf birth body weight, and rebreeding in pregnant beef heifers

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ABSTRACT: A 3-yr study was conducted to determine the effect of supplemental protein source on ADG, feed intake, calf birth BW, and subsequent pregnancy rate in pregnant beef heifers. Crossbred, Angus-based, AI-pregnant heifers (yr 1, n = 38; yr 2, n = 40; and yr 3, n = 36) were stratified by BW (450 ± 10 kg) and placed in a Calan Broadbent individual feeding system at approximately d 142 of gestation. Following a 25-d adaptation period, an 84-d feeding trial was conducted. Heifers were offered ad libitum grass hay (8 to 11% CP, DM basis) and no supplement (CON), 0.83 kg/d distillers-based supplement (HI), or 0.83 kg/d dried corn gluten–based supplement (LO). Supplements were formulated to be isocaloric, isonitrogenous (28% CP, DM basis), and equal in lipid content but differed in RUP, with HI (59% RUP) having greater levels of RUP than LO (34% RUP). Dry matter intake was also calculated based on feed NE values to account for different energy levels of the supplement compared with the control diet. Control heifers tended (P = 0.09) to consume less total DM than either supplement treatment. However, forage-only DMI was greater (P < 0.01) for CON heifers (9.94 ± 0.12 kg) compared with HI or LO heifers (8.50 and 8.34 ± 0.12 kg, respectively). Net energy DMI was less (P < 0.01) for CON heifers compared with HI or LO heifers (4.98 ± 0.12 kg) compared with HI or LO heifers (5.43 and 5.35 ± 0.23 kg, respectively). Control heifers gained less (P < 0.01; 0.59 ± 0.14 kg/d) than either HI (0.82 ± 0.14 kg/d) or LO heifers (0.78 ± 0.14 kg/d), resulting in lower (501 ± 9 kg) BW (P < 0.01) than HI (519 ± 9 kg) heifers at the end of the feeding period. Calf birth BW was similar (P = 0.99) among treatments. At pre-breeding, CON heifers weighed less (P < 0.03) than LO heifers. Cow BW was similar (P = 0.48) among treatments at pregnancy diagnosis, and final pregnancy rate was also similar (87%; P = 0.22). Protein supplementation increased ADG in pregnant heifers; however, calf birth BW and subsequent pregnancy rates were similar.

Key words: feed intake, pregnant beef heifer, supplementation

INTRODUCTION

The relationship between prepartum nutrition and subsequent pregnancy rates is well established (Wiltbank, 1970; Bellows and Short, 1978; Short et al., 1990). This relationship is especially critical for primiparous heifers and young cows due to the added nutrient requirement of their own growth, resulting in a higher risk of reproductive failure compared with older cows (Meek et al., 1999). Patterson et al. (2003) reported a 6 percentage point increase in 2-yr-old pregnancy rates for pregnant heifers supplemented to meet MP requirements compared with heifers supplemented to meet CP requirements from mid September to mid to late February. Similarly, Engel et al. (2008) reported increased pregnancy rates (94 vs. 84%) for heifers fed a diet of grass hay and dried distillers grains with solubles (DDGS) compared with heifers fed grass hay and soybean hulls as a supplement. In that study, DDGS-supplemented heifers consumed diets containing RUP levels approximately 2 times greater than soybean hull–supplemented

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heifers. Therefore, it is hypothesized that using increased levels of RUP in late gestation heifer diets may improve subsequent pregnancy rates in young cows.

Providing supplemental protein to beef cattle grazing low-quality forages has been reported to increase forage intake and improve cow BW gain and may increase pregnancy rate (reviewed in DelCurto et al., 2000). However, results vary based on protein source, degradability, and physiological status (Wiley et al., 1991; Rusche et al., 1993; Triplett et al., 1995; Patterson et al., 2003). Therefore, objectives of the current study were to determine the effect of supplemental protein source on ADG, feed intake, calf birth BW, and subsequent pregnancy rate in pregnant beef heifers.

MATERIALS AND METHODS

The University of Nebraska-Lincoln Institutional Animal Care and Use Committee approved all procedures and facilities used in this experiment.

Pregnant Heifer Management

A 3-yr study was conducted at the West Central Research and Extension Center (WCREC), North Platte, NE. Crossbred, Angus-based, AI-pregnant heifers (yr 1, n = 38; yr 2, n = 40; and yr 3, n = 36) were stratified by BW (450 ± 10 kg) and placed in 1 of 4 pens (10 head gates each) within a Calan Broadbent (American Calan, Northwood, NH) individual feeding system at approximately d 142 of gestation. Heifers were allowed 25 d to adapt to the individual feeding system followed by an 84-d feeding trial. Heifers were offered an initial diet of 19% wet corn gluten feed and 81% grass hay (DM basis) ad libitum during the acclimation period. Wet corn gluten feed was slowly removed from the diet during the acclimation period until heifers received only grass hay prior to the initiation of the feeding trial. Following the acclimation period, heifers were stratified based on age, BW, AI sire, and pen and assigned to 1 of 3 treatments: ad libitum grass hay (DM basis) ad libitum during the acclimation period. Wet corn gluten feed was slowly removed from the diet during the acclimation period until heifers received only grass hay prior to the initiation of the feeding trial. Following the acclimation period, heifers were stratified based on age, BW, AI sire, and pen and assigned to 1 of 3 treatments: ad libitum grass hay (8 to 11% CP, DM basis) and no supplement (CON), 0.83 kg/d distillers-based supplement (HI), or 0.83 kg/d dried corn gluten-based supplement (LO; Table 1). Supplements were formulated to be isocaloric and isonitrogenous, and equal in lipid content but differed in RUP.

Hay and supplement were offered once daily at approximately 0800 h. Hay offered was recorded daily and estimated to allow for ad libitum intake with 0.10 to 0.23 kg refusals daily. Hay was measured and fed followed by 0.83 kg supplement offered on top of the hay for HI and LO heifers, respectively. Feed refusals were measured and recorded weekly and heifer BW measured every 14 d in yr 1 and every 21 d in yr 2 and 3. Nutrient balance for heifers based on late gestation nutrition was calculated using the NRC computer model (NRC, 1996; Table 2). Model considerations included the average day of gestation for the feeding period (220 d), age of heifer (22 mo), and average BW during the feeding period (CON = 476 kg, HI = 483 kg, and LO = 482 kg) with thermoneutral conditions. Dietary nutrient intake was based on nutrient analysis (Ward Laboratories, Kearney, NE) and heifer DMI. Residual feed intake (RFI) was calculated as the actual DMI minus predicted DMI, with DMI calculated from the feed

| Table 1. Composition of high and low RUP supplements offered to heifers during late gestation |
|---------------------------------|--------|--------|
| Item                            | HI1    | LO2   |
| DDGS3                          | 99.0   | –     |
| CGF4                           | –      | 72.4  |
| Corn germ                      | –      | 24.5  |
| Urea                           | –      | 2.1   |
| Trace minerals and vitamins     | 1.0    | 1.0   |
| Nutrient analysis               |        |       |
| CP, %                          | 28.2   | 28.0  |
| RUP, % CP                      | 59.0   | 34.0  |
| TDN                            | 78.9   | 78.8  |
| Crude fat, %                   | 11.9   | 11.9  |

1 HI = 0.83 kg/d distillers-based supplement.
2 LO = 0.83 kg/d dried corn gluten–based supplement.
3 DDGS = dried distillers grains with solubles.
4 CGF = dried corn gluten feed.
5 Wet chemistry; Ward Laboratories Inc., Kearney, NE; RUP based on the NRC (1996) estimated model.

| Table 2. Nutrient balance for primiparous heifers during late gestation1 |
|---------------------------------|--------|--------|--------|
| Item                            | CON    | HI     | LO     |
| Diet supplied3 NE, Mcal/d       | 11.4   | 12.5   | 12.3   |
| Required NE, Mcal/d             | 10.6   | 11.2   | 11.1   |
| Difference, Mcal/d              | 0.8    | 1.3    | 1.2    |
| Diet supplied3 MP, g/d          | 631    | 817    | 733    |
| Required MP, g/d                | 535    | 571    | 565    |
| MP from RUP, g/d                | 243    | 352    | 275    |
| Difference MP, g/d              | 96     | 247    | 168    |
| Diet supplied3 RDP, g/d         | 709    | 759    | 839    |
| Required RDP, g/d               | 606    | 727    | 716    |
| RDP balance, g/d                | 103    | 32     | 123    |

1 Based on NRC model application (NRC, 1996).
2 Primiparous heifers individually fed ad libitum grass hay (8 to 11% CP, DM basis) and no supplement (CON), 0.83 kg/d distillers-based supplement (HI), or 0.83 kg/d dried corn gluten–based supplement (LO) during late gestation.
3 Based on DMI.
Protein source and heifer performance

NE values to account for different energy levels of the supplement compared with the control diet.

Postcalving Management

After the individual feeding period, heifers were placed in a drylot for calving. Heifers remained in a single group and were offered 7.9 to 9.5 kg/d (DM basis) grass hay and 1.25 kg/d (DM basis) corn and wet corn gluten feed–based supplement until placed on summer pasture after the breeding season. Hay offered during postcalving management period differed based on nutrient content of the hay and increased physiological demands (lactation) of the heifers. Heifers were given a calving ease score (1 = no assistance; 2 = easy assist, 3 = difficult assist, 4 = caesarian section, and 5 = breech/abnormal presentation) and calves received a vigor score (1 = nursed immediately; 2 = nursed on own, took some time; 3 = required some assistance to suckle; 4 = died shortly after birth; and 5 = dead on arrival) at parturition.

Prior to the breeding season, blood samples were collected 10 d apart via coccygeal venipuncture to determine plasma progesterone concentration. Plasma progesterone concentration was determined through direct solid phase RIA (Coat-A-Count; Diagnostics Products Corp., Los Angeles, CA). Cows with plasma progesterone concentrations >1.0 ng/mL at either or both sampling time points were considered to have resumed estrous cyclicity. One month prior to the breeding season, cows were vaccinated against infectious bovine rhinotracheitis, bovine viral diarrhea type I and II, parainfluenza-3 virus, vibriosis, and leptospirosis (PregGaurd Gold FP10; Zoetis, Florham Park, NJ).

Estrus was synchronized using a controlled internal drug release (CIDR; Zoetis) protocol, with cows receiving 100 μg intramuscularly GnRH (Fertagyl; Intervet Inc., Millsboro, DE) and CIDR insert on d 0. Seven days later, the CIDR insert was removed and a single injection of PGF$_{2α}$ (25 mg intramuscularly; Lutalyse; Zoetis) was administered followed by GnRH and AI approximately 60 h later. Five days following AI, cows and calves were transported 43 km to a commercial ranch in the Nebraska Sandhills for summer grazing. A single bull was placed with heifers 10 d after AI for 60 d. Cows and calves were returned to WCREC prior to weaning for final pregnancy diagnosis. Following weaning, all pregnant 2-yr-old cows grazed corn residue and received 0.45 kg/d (32% CP, DM basis) distillers-based supplement.

Statistical Analysis

Heifers were offered hay and supplement on an individual basis during the experimental period; therefore, heifer was considered the experimental unit and diet the treatment. The statistical model included treatment as the fixed effect with pen and year as random effects. Calf sex was included in the model as a fixed effect and sire was included as a random variable in the model for calving data. There was no interaction for calf sex and maternal diet; therefore, the interaction was removed from the model. Data were analyzed using PROC MIXED and PROC GLIMMIX of SAS (SAS Inst. Inc., Cary, NC) for categorical and binomial data, respectively. Regression analysis using PROC REG of SAS was used to determine the relationship between DMI, diet, and week of gestation. There was no intake × diet interaction ($P = 0.62$); therefore, regression was used to determine the relationship of DMI and week of gestation resulting in the following regression equation: intake = 25.756 – 0.1531wk. Intake per week of gestation was then analyzed in PROC MIXED of SAS with treatment and week as the main effects and year as a random effect. Data were considered significant if $P ≤ 0.05$ and tendency was considered if $P < 0.1$ but $P > 0.05$.

RESULTS AND DISCUSSION

Individual Feeding Results

Heifer BW, DMI, and feed efficiency are reported in Table 3. Heifers not receiving supplement tended ($P = 0.09$) to consume less total DM than either supplement treatment. Similarly, NE DMI was less ($P < 0.01$) for CON heifers (4.98 ± 0.23 kg) compared with HI or LO heifers (5.43 and 5.35 ± 0.23 kg, respectively). However, forage-only DMI was greater ($P < 0.01$) for CON heifers (9.94 ± 0.12 kg) compared with HI or LO heifers (9.49 and 9.33 ± 0.12 kg, respectively).

Forage intake declines when CP values are below 7% (Mathis, 2000). Providing supplemental protein when cattle are grazing or consuming low-quality forage may increase forage DMI (DelCurto et al., 2000). In the present study, forage CP content was greater than 7% and subsequently protein supplement replaced forage intake in HI and LO heifers. These data agree with Olson (1998) reporting decreased total OM intake in heifers supplemented with increased RUP levels during the last 15 wk of gestation. Similarly, Loy et al. (2007) reported heifers provided chopped grass hay (8.2% CP) and 0.4% BW/d of either dry-rolled corn or dried distillers grain supplement had reduced ($P < 0.01$) hay DMI compared to nonsupplemented heifers. Furthermore, forage DMI was similar ($P = 0.45$).
regardless of supplement type, comparable to findings in the current study. However, Strauch et al. (2001) reported heifers offered stockpiled tall fescue forage (11.7% CP) had increased prepartum forage DMI when heifers were supplemented with an additional 84 g/d (106 vs. 190 g/d) RUP for 64 d prior to calving compared with control heifers.

Control heifers had reduced ADG (0.59 ± 0.14 kg/d) than either HI (0.82 ± 0.14 kg/d) or LO (0.78 ± 0.14 kg/d; \( P < 0.01 \)) heifers, resulting in reduced \( P < 0.01 \) final BW (501 ± 9 kg) compared with HI heifers (519 ± 9 kg). However, final BW did not differ between CON and LO heifers \( P = 0.98 \). The differences in diet nutrient density resulted in a greater \( P < 0.01 \) NE intake for the HI and LO heifers compared with the CON heifers. Although DMI tended to be greater for HI compared with CON heifers (10.16 vs. 9.94 ± 0.12 kg), G:F was greater \( P < 0.01 \) for HI compared with CON heifers. The increase in G:F can be attributed to improved ADG for HI heifers, which was approximately 1.5 times greater than CON heifers. There was no difference in DMI between LO and CON heifers; however, similar to HI heifers, LO heifers exhibited increased G:F compared with CON heifers \( P < 0.01 \). Although heifer efficiency as indicated by G:F was improved in the supplemented groups, CON heifers had increased RFI based on diet NE \( P < 0.01 \) compared with HI and LO heifers, whereas RFI between supplement groups was similar \( P = 0.97 \). Differences in birth weight due to calf sex is likely the cause of increased calving difficulty in those heifers giving birth to bull compared with heifer calves and has been noted previously in the literature (Burfinen et al., 1978; Berger et al., 1992; Eriksson et al., 2004). Subsequent postnatal calf performance through slaughter is reported elsewhere (Summers et al., 2015).

**Calving and Subsequent Pregnancy Results**

Data for calving performance are reported in Table 4. Julian birth date and gestation length were similar among treatments \( P \geq 0.23 \). Calf birth BW, calving ease, and calf vigor did not differ \( P \geq 0.12 \) among treatments. However, bull calves were 3 kg (±1) heavier \( P < 0.01 \) than heifer calves. Furthermore, calving difficulty, based on calving ease score, was increased in male calves compared to female calves \( P < 0.01 \). Differences in birth weight due to calf sex is likely the cause of increased calving difficulty in those heifers giving birth to bull compared with heifer calves and has been noted previously in the literature (Burfinen et al., 1978; Berger et al., 1992; Eriksson et al., 2004). Subsequent postnatal calf performance through slaughter is reported elsewhere (Summers et al., 2015).

At prebreeding, CON heifers had decreased \( P < 0.03 \) BW compared with LO heifers. However, prepartum supplementation did not \( P = 0.51 \) influence the proportion of heifers resuming luteal activity prior to the breeding season. Cow BW was similar \( P = 0.48 \) among treatments at pregnancy diagnosis. The
Proportion of cows pregnant to AI and final pregnancy rate was similar ($P \geq 0.22$) among treatments.

At prebreeding, CON heifers had decreased ($P < 0.03$) BW compared with LO heifers. However, prepertum supplementation did not ($P = 0.51$) influence the proportion of heifers resuming estrual activity prior to the breeding season. Cow BW was similar ($P = 0.48$) among treatments at pregnancy diagnosis. The proportion of cows pregnant to AI and final pregnancy rate was similar ($P \geq 0.22$) among treatments (Table 5).

Cows were synchronized using a CIDR estrus synchronization protocol. Lucy et al. (2001) reported CIDR use increased the proportion of anestrous cows detected in estrus within the first 3 d of the breeding season compared with PGF$_{2\alpha}$-treated or control cows. It is possible the synchronization protocol used in the current study increased synchronization response and subsequent pregnancy rates to AI given the relatively low percentage of cows resuming estrus prior to synchronization. Regardless, prepertum supplement treatment did not affect resumption of estrus prior to synchronization.

The impact of late gestation nutrition on subsequent pregnancy rate has been inconclusive (reviewed by DelCurto et al., 2000). Rusche et al. (1993) reported that conception rate was similar for primiparous heifers supplied either 100 or 150% of the NRC recommendation (NRC, 1989) for CP in diets containing either low or high RUP. Patterson et al. (2003) reported increased pregnancy rates for heifers supplemented with RUP during late gestation to balance MP requirements compared with heifers supplemented to balance CP requirements. Also, Engel et al. (2008) reported providing heifers a diet of hay and distillers grains with solubles during late gestation improved pregnancy rate 10 percentage points ($P = 0.06$) compared with heifers offered hay and soybean hulls. In both studies (Patterson et al., 2003; Engel et al., 2008), pregnancy rates were decreased in heifers offered diets deficient in MP during late gestation. Nichols (2010) reported similar pregnancy rates for heifers supplied either 102 or 119% of MP requirements, suggesting that excess MP does not improve pregnancy rates. Similarly, in the present study, all diets supplied excess MP (Table 2), which may explain the lack of treatment effects on pregnancy rates.

Previous reports have indicated the importance of prepartum nutrition on subsequent pregnancy rates and longevity. In the current experiment, protein supplementation increased ADG in pregnant heifers; however, calf birth BW, resumption of estrus, and subsequent pregnancy rates were similar, regardless of supplementation or supplemental protein source. All diets in the current study were balanced for or exceeded MP requirements, which may explain the lack of treatment effects. Future studies restricting heifer MP intake during mid to late gestation are warranted to determine the impact RUP source and level may have on feed intake, ADG, and reproductive efficiency.

### Table 4. Impact of supplemental protein source on calving performance and first calf characteristics

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>SEM</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Julian birth date, d</td>
<td>CON$^1$</td>
<td>60</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>HI$^2$</td>
<td>60</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>LO$^3$</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>Gestation length, d</td>
<td>CON$^1$</td>
<td>276</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>HI$^2$</td>
<td>276</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>LO$^3$</td>
<td>277</td>
<td></td>
</tr>
<tr>
<td>First calf birth BW, kg</td>
<td>CON$^1$</td>
<td>33</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>HI$^2$</td>
<td>34</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>LO$^3$</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Calving ease$^4$</td>
<td>CON$^1$</td>
<td>1.43</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>HI$^2$</td>
<td>1.44</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>LO$^3$</td>
<td>1.56</td>
<td></td>
</tr>
<tr>
<td>Calf vigor$^5$</td>
<td>CON$^1$</td>
<td>1.42</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>HI$^2$</td>
<td>1.48</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>LO$^3$</td>
<td>1.92</td>
<td></td>
</tr>
</tbody>
</table>

$^a$Within each row, means without common superscripts differ ($P < 0.05$).
$^1$CON = ad libitum grass hay (8 to 11% CP, DM basis) and no supplement.
$^2$HI = 0.83 kg/d distillers-based supplement.
$^3$LO = 0.83 kg/d dried corn gluten–based supplement.

### Table 5. Impact of supplemental protein source on subsequent cow reproductive performance

<table>
<thead>
<tr>
<th>Item</th>
<th>CON$^1$</th>
<th>HI$^2$</th>
<th>LO$^3$</th>
<th>SEM</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resumption of estrus, %</td>
<td>25</td>
<td>27</td>
<td>37</td>
<td></td>
<td>0.51</td>
</tr>
<tr>
<td>Prebreeding BW, kg</td>
<td>445$^a$</td>
<td>458$^b$</td>
<td>460$^b$</td>
<td>13</td>
<td>0.03</td>
</tr>
<tr>
<td>Pregnancy diagnosis BW, kg</td>
<td>483</td>
<td>488</td>
<td>493</td>
<td>12</td>
<td>0.48</td>
</tr>
<tr>
<td>Retention rate, %</td>
<td>92</td>
<td>90</td>
<td>82</td>
<td>82</td>
<td>0.35</td>
</tr>
<tr>
<td>AI pregnancy rate, %</td>
<td>59</td>
<td>56</td>
<td>64</td>
<td>64</td>
<td>0.80</td>
</tr>
<tr>
<td>Overall pregnancy rate, %</td>
<td>90</td>
<td>91</td>
<td>79</td>
<td>79</td>
<td>0.22</td>
</tr>
<tr>
<td>Second calf Julian birth date, d</td>
<td>68</td>
<td>72</td>
<td>64</td>
<td>64</td>
<td>0.19</td>
</tr>
<tr>
<td>AI to parturition, d</td>
<td>290</td>
<td>294</td>
<td>286</td>
<td>286</td>
<td>0.20</td>
</tr>
<tr>
<td>Calved first 21 d, %</td>
<td>73</td>
<td>65</td>
<td>87</td>
<td>87</td>
<td>0.20</td>
</tr>
</tbody>
</table>

$^a$Within each row, means without common superscripts differ ($P < 0.05$).
$^1$CON = ad libitum grass hay (8 to 11% CP, DM basis) and no supplement.
$^2$HI = 0.83 kg/d distillers-based supplement.
$^3$LO = 0.83 kg/d dried corn gluten–based supplement.
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