The influence of beef cow weaning weight ratio and cow size on feed intake behavior, milk production, and milk composition[1]

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INTRODUCTION

Techniques that identify which beef cows in a production setting will produce more calf weight weaned per kilogram of feed consumed, often termed cow efficiency, has long been sought after in both beef cattle production settings and research (Dinkel and Brown, 1978; Scasta et al., 2015; Beck et al., 2016). Previous research and applied practice has suggested the ratio of calf weight weaned to cow weight, or weaning weight ratio (**WWR**), is a potential metric to estimate cow efficiency (Dinkel and Brown, 1978; Kress et al., 2001; Scasta et al., 2015). However, previous research either considered the direct ratio of calf weight weaned to cow weight or considered the additional effect of cow intake but utilized individual feed bunks with limited feeding times or fecal markers to estimate cow intake (Davis et al., 1983; Kirkpatrick et al., 1985; Kress et al., 2001). With modern technology (e.g., automated feed bunks and EID tags), it is easier to acquire accurate, individual feed intake data that may include feed intake behavior attributes (e.g., time spent feeding, number of feeding visits per day, and intake per visit), not previously reported in the literature. Milk yield and milk constituents have also been attributed to influence calf preweaning ADG but have not been revisited in recent years (Totusek et al., 1973; Mondragon et al., 1983; Beal et al., 1990). Furthermore, as defined by WWR, the effects milk production has on preweaning calf growth and the influence of cow feed intake on cow efficiency has not been jointly considered. Therefore, the purpose of this study was to evaluate cow–calf WWR, and within WWR, cow size influences on feed intake, milk production and composition, and subsequent calf preweaning performance.

MATERIALS AND METHODS

Protocols for this research were approved by the Montana State University Agricultural Animal Care and Use Committee (#2018-AA02). Lifetime production records from cows with a minimum of three calf crops and bred for the forth calf from the Montana State University Northern Agriculture Research Center Angus and Angus cross cow herd were used to identify high and low WWR groups. All calf data were corrected for age of dam, sex of calf and equalized to a 205-d adjusted weaning weight. Likewise, cow weights were adjusted to a standardized body condition before calculating WWR. All of the multiparous (minimum of three weaned calves), Angus cow–calf pairs (cow initial BW = 598 ± 55.7 kg) were stratified by WWR and randomly allotted to high and low WWR (whole plot; ± 0.75 SD from herd mean) and, within WWR classification groups, allotted to light and heavy weight groups. Because WWR was

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correlated to cow size with smaller cows typically having higher WWR, cow size was evaluated within WWR groups. This resulted in a randomized split-plot design with the following four classification groups: 1) high WWR–light BW (**HL**; 57% ± 3% WWR; 509 ± 8.6 kg), 2) high WWR–heavy BW (**HH**; 54% ± 1% WWR; 544 ± 16 kg), 3) low WWR–light BW (**LL**; 42% ± 4% WWR; 591 ± 9 kg), and 4) low WWR–heavy BW (**LH**; 43% ± 2% WWR; 632 ± 12 kg). Cow–calf pairs were contained in a dry-lot and fed ad libitum a commercially available pelleted grass/alfalfa diet designed to meet NRC requirements when consumed at 2.5% of BW (Table 1; CHS Nutrition, Sioux Falls, SD). Diets were provided in eight SmartFeedPro feeders, which were fully contained within two portable trailers (C-Lock Inc., Rapid City, SD). Cow–calf pairs had continuous access to water throughout the study period. BW were recorded for the cows and calves, and BCS were taken following a 16-h shrink prior to the start of the trial (Table 2). The trial consisted of a 14-d adaption period followed by a 7-d data collection period. Only cows that had calved within the first 3-wk of calving were used and mean calf age at trial initiation was 66.2 ± 2.8 d post partum (Table 2). As fed, individual cow average daily feed consumption (**DFC**), average daily feeding bout duration (**FBD**), number of visits per day (**NOV**), and time of day (**TOD**) feeding bouts occurred were collected. On the last day of the feed trial, a weigh-suckle-weigh procedure was conducted following the procedures suggested by Williams et al. (1979). In addition to the weigh-suckle-weigh protocol, 100 mL milk samples were collected from each cow, immediately placed on ice, and transported to the Montana Central Milk Laboratory (Montana Veterinary Diagnostic Laboratory, Montana Department of Livestock, Bozeman, MT) where the samples were analyzed for fat, solids not fat (**SNF**), total solids (**TS**), protein,

Table 1. Ingredient and nutrient composition (DM basis) of the fully fortified, alfalfa pellets fed

Item	%
Ingredients	
Alfalfa, hay	79.3
Corn, ground	20.0
Trace mineral mix*	0.2
Nutrient composition	
DM	91.1
CP	14.7
NDF	34.4
ADF	26.3
Ash	7.8

*Trace mineral mix: 1.4% Ca, 0.28% P, 0.07% Na, 2.0% K, 0.3% Mg, 52.3 ppm Mn, 331.0 ppm Fe, 27.4 ppm Cu, 73.4 ppm Zn, 0.4 ppm Co, 1.6 ppm I, 0.4 ppm Se, 8.4 ppm organic Mn, 6.3 ppm organic Cu, 18.75 ppm organic Zn, 1.0 IU/kg vitamin A, 0.1 IU/kg vitamin D, 1.7 IU/kg vitamin E.

Table 2. Cow BW, cow BCS, cow age, calf BW, calf birth weight, and weight ratio (**WR**) between calf and cow weight pre and post adaption and feed trial period

	High*		Low†			WP‡	SP§	WP * SP¶
Item	Light	Heavy	Light	Heavy	SE	*P* value	*P* value	*P* value
Start trial								
Cow BW, kg	536.4[a]	586.6[b]	627.7[c]	645.1[cd]	11.9	<0.01	<0.01	0.18
Cow BCS	4.8	5	5.2	5.2	0.2	<0.06	0.53	0.75
Cow age, yr	7	7	8	9	0.6	<0.03	0.87	0.52
Calf wt, kg	104.1	104.7	96.6	99.1	4.1	0.11	0.70	0.82
Calf birth wt, kg	42.3	45.2	47.2	42.4	1.6	0.53	0.54	<0.03
Calf age, d	69.3	65.5	66.6	63.4	2.8	0.40	0.22	0.92
WR,‖ %	19.4[a]	18	15.4[b]	15.5[bc]	0.8	<0.01	0.44	0.38
October, 2017								
Weaning wt, kg	278.5	289.1[a]	257.1[b]	280.7	7.6	<0.09	<0.04	0.40
WWR,& %	51.6[a]	49.3[ab]	41.1[c]	43.9[bcd]	12.7	<0.01	0.87	0.14

*High = high WWR cows.
†Low = low WWR cows.
‡Whole plot = cow WWR.
§Split-plot = cow BW.
¶Whole-split-plot interaction was the interaction between WWR and cow BW.
‖WR = weight ratio at start of trial, calf weight/cow weight.
&WWR = calf 205-d weaning wt/cow wt at weaning.
P values were considered significant at ≤0.05 and were considered as a trend toward significance at ≤0.1.
[a–d]Means within a row with different superscripts differ ($P \le 0.05$).

and lactose content. Milk yield was calculated using calf weights from the weigh-suckle-weigh protocol.

Statistical Analysis

Individual cow was the experimental unit. Feed trial data were analyzed as a randomized split-plot design using the PROC MIXED procedure in SAS (v. 9.4; SAS Inst. Inc., Cary, NC). Dependent variables were DFC, FBD, NOV, TFC, and TSE. The PROC FREQ procedure in SAS was used to determine TOD of feeding bouts. Three cows were removed from this analysis due to either EID tag failure and/or unacceptable feed intake variation (>30%). Milk data were analyzed as a randomized split-plot design using the PROC MIXED procedure in SAS. Fat, SNF, TS, protein, and lactose were set as dependent variables. When WWR interacted with cow size, means were separated using the LSMEANS procedure of SAS and a Tukey–Kramer test was included in both MIXED procedures. *P* values ≤0.05 were considered significant and *P* values >0.05 and ≤0.10 were considered a tendency.

RESULTS AND DISCUSSION

As expected, cow BWs at the beginning (HL 536.4 ± 25.3 kg; HH 586.6 ± 49.9 kg; LL 627.7 ± 29.2 kg; LH 645.1 ± 33.6 kg) of the trial were significantly affected by WWR ($P < 0.01$) and BW ($P < 0.01$) classification groups (Table 2). Additionally, there was a significant difference ($P < 0.01$) in cow–calf weight ratio between high WWR (18.7%) and low WWR (15.5%) cows at the initiation of the study (Table 2), suggesting cow classification protocols, based on previous years WWR, were effective in predicting future performance. Calf birth weight (44.3 ± 1.6 kg), calf age (66.2 ± 2.8 d) and calf weight start of trial (101.1 ± 4.1 kg) were not different between cow classification groups (P > 0.10; Table 2). Calf 205-d, adjusted weaning weights, taken October 2017, were significantly affected by cow BW classification group (276.4 ± 7.6 kg; $P < 0.04$); however, cow WWR classification tended to effect calf weaning weight ($P < 0.09$; Table 2). Cow WWR classification had a significant effect on 2017 cow–calf WWR ($P < 0.01$), with high WWR classified cows weaning 50.5% and low WWR classified cows weaning 42.5% (Table 2). This suggests that cows with higher WWR may be able to transfer feed nutrients more efficiently to their calves from birth to weaning.

Although cow WWR did not affect feed intake expressed as kg per day, cow weight influenced DFC ($P < 0.01$) with heavy cows within WWR groups consuming an average of 6.1 kg more than light cows (Table 3). Similar results of heavy cows consuming considerably more feed than light cows while lactating were reported by Walker et al. (2015) and in nonlactating heifers by Waghorn et al. (2012). When expressed as g feed/kg cow BW, however, cow WWR had a significant effect and BW tended to effect feed intake ($P < 0.02$ and $P < 0.06$, respectively). High WWR cows consumed 34.9 g of feed per kg of BW, whereas low WWR cows consumed 30.4 g of feed per kg BW. Heavy cows consumed 34.2 g and light cows consumed 31.0 g of feed per kg BW (Table 3). Although high WWR cows and heavy cows consumed more feed per kg of BW than low WWR and light cows, these two groups also had calves that gained more. Possibly suggesting

Table 3. Cow feed intake and feeding behavior from 16 to 23 May 2017 trial

	High*		Low†			WP‡	SP§	WP * SP¶
Item	Light	Heavy	Light	Heavy	SE	*P* value	*P* value	*P* value
Intake								
Daily, kg	18.2	20.8	17.6	21.1	0.97	0.98	<0.01	0.69
g/kg cow BW	33.9	35.8	28.1	32.6	1.6	<0.02	<0.06	0.41
Feeding bouts								
Number/day	31.5	35.1	29.8	31.3	3.3	0.41	0.44	0.76
Duration, min	2.4	2.5	2.65	2.1	0.01	0.11	<0.02	0.39
Total time eating, min	617.6	614.7	452.2	547.1	68	0.08	0.51	0.48

*High = high WWR group.

†Low = low WWR group.

‡Whole plot = cow WWR.

§Split-plot = cow BW.

¶Whole-split-plot interaction was the interaction between WWR and cow BW.

P values were considered significant at ≤0.05 and were considered as a trend toward significance at ≤0.1.

that cows classified as high WWR transfer the additional feed energy to the calf.

Cow BW had a significant effect on average FBD ($P < 0.02$) with light cows eating an average of 29 s longer per feeding bout than heavy cows (Table 3). Hafla et al. (2013) reported that low RFI heifers spent less time feeding than high RFI heifers, although no significant difference was reported in heifer BW. The highest number of feeding bouts, when day was broken into six, 4-h periods, occurred in the evening (1700 to 2000 h; Table 4). However, the single hour with the highest number of visits was 0800 to 0900 h. This was most likely caused by the stimulus of the feeders being filled, as feeding occurred between 0800 and 0900 h, daily.

The interaction between cow WWR and cow BW was observed in respect to milk lactose content ($P < 0.01$). High WWR–heavy BW cows had 0.4% more milk lactose than LH cows ($P < 0.05$) and LL cows tended to have 0.3% more milk lactose than LH cows ($P = 0.093$; Table 5). Percent milk lactose (mean 4.9 ± 0.2) and percent fat (3.7 ± 0.1) were comparable to percent milk lactose and milk fat reported by Mondragon et al. (1983). Total solids (10.6 ± 0.3) and SNF (9.3 ± 0.2) were comparable to results reported by

Table 4. Time of day feeding events occurred, categorized by six, 4-h periods: early morning (0100–0400 h), morning (0500–0800 h), late morning (0900–1200 h), afternoon (1300–1600 h), evening (1700–2000 h), and night (2100–0000 h)

	High*		Low†			WP‡	SP§	WP * SP¶
Item	Light	Heavy	Light	Heavy	SE	P value	P value	P value
Time of day								
Early morning	95	116	66	81	6.0	0.18	0.45	0.90
Morning	408	461	321	382	31.3	0.49	0.66	0.98
Late morning	517	475	325	377	12.6	<0.01	0.92	0.37
Afternoon	426	480	336	417	13.0	0.16	0.22	0.80
Evening	549	639	447	530	17.0	0.14	0.23	0.96
Night	207	280	173	176	23.5	0.45	0.70	0.72

*High = high WWR group.
†Low = low WWR group.
‡Whole plot = cow WWR.
§Split-plot = cow BW.
¶Whole-split-plot interaction was the interaction between WWR and cow BW.
P values were considered significant at ≤0.05 and were considered as a trend toward significance at ≤0.1.

Table 5. Milk analysis results

	High*		Low†			WP‡	SP§	WP * SP¶
Item	Light	Heavy	Light	Heavy	SE	P value	P value	P value
Milk yield								
Yield, kg	2.1	2.4	1.4	2	0.28	<0.08	0.11	0.45
g/kg cow BW	3.92	4.09	2.14	3.18	0.5	<0.02	0.23	0.39
Milk constituents								
Fat, %	1.8	1.1	1.2	1.3	0.3	0.46	0.34	0.25
SNF, %	9.3	9.4	9.3	9.1	0.14	0.28	0.84	0.35
TS, %	11	10.6	10.5	10.4	0.29	0.21	0.39	0.49
Protein, %	3.8	3.7	3.6	3.7	0.11	0.34	0.72	0.19
Lactose, %	4.8	5.1[a]	5	4.7[b]	0.1	0.57	0.83	<0.01

*High = high WWR group.
†Low = low WWR group.
‡Whole plot = cow WWR.
§Split-plot = cow BW.
¶Whole-split-plot interaction was the interaction between WWR and cow BW.
P values were considered significant at ≤0.05 and were considered as a trend toward significance at ≤0.1.
a,bMeans within a row with different superscripts differ ($P \le 0.05$).

Melton et al. (1967). However, previous studies have reported that milk constituents were not correlated to calf ADG or preweaning growth (Jeffery and Berg, 1971; Totusek et al., 1973; Mondragon et al., 1983). Results from this research indicated a WWR and cow BW interaction (P < 0.05) in respect to milk lactose content, suggesting that lactose content could influence calf preweaning growth. Additionally, previous studies examining milk production in beef cows attribute milk yield as an important factor in calf preweaning growth (Williams et al., 1979; Mondragon et al., 1983; Beal et al., 1990). Results from this research suggest that high cow WWR tended (P = 0.08) to be higher in milk production and were higher in milk production (P < 0.05) when expressed on a BW basis. In contrast, cow BW did not influence milk yield within WWR cow groups (P > 0.10; Table 5). Milk yield reported in this research was consistently lower than milk yield reported in other studies using weigh-suckle-weigh or machine milking techniques at comparable days post partum (Totusek et al., 1973; Mondragon et al., 1983; Walker et al., 2015).

IMPLICATIONS

Results from this research provide additional information on how cow size, cow–calf WWR, and milk production affect cow and production efficiency. Overall, these results indicated that cows classified as high WWR consumed more feed on a g/kg BW bases. Also, cow WWR classification only had a tendency to affect calf weight at weaning whereas cow body size, when considered within WWR classifications, had a significant effect. Milk lactose content was effected by the interaction between cow weight and WWR classification, suggesting that heavy cows classified as high WWR tend to produce more milk lactose, which could effect preweaning calf growth. In conclusion, the use of cow–calf WWR as a metric of cow efficiency needs to be used with caution because of potential increases in intake, milk production, and a potential bias to cow age and size.

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