Economic Value of Improving Feed Efficiency of Beef Cows on Pasture

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Abstract. Dry matter intake of beef cows is based on a percentage of body weight, so as mature cow size increases, intake increases. Feed efficiency, or the amount of feed required to produce gain or maintain production, has a direct impact to the producer. That is, as mature cow weight increases, yearly maintenance costs increases due to higher feed costs. However, variation in feed efficiency exists within population. Some large cows consume the same or less dry matter as a smaller cow, but produce a larger calf. Conversly, some smaller cows consume the same or more as a large cow but produce a smaller calf. Cows identified to have improved feed efficiency should have an economic advantage to producers, primarily due to improvements in stocking rates. To determine this value, we utilized data reflecting individual animal measures of cow body weight, feed intake and calf weaning weights from a trial using multiparous Angus mature cows ranging in initial weight from 513 kg to 731 kg. An economic benefit-cost model was used to determine net returns of feed efficiency for six cow-calf production systems reflecting combinations of three levels of intake efficiencies and two forage species. Production systems grazing either bermudagrass or native prairie grass pastures with 50 and 75 percent improvements in dry matter intake realized 17 and 28 percent higher stocking rates (hd ha^{-1}) relative to conventional systems with an average mix of dry matter intake. Due to higher stocking rates, costs associated with pasture maintenance, feed, healthcare, breeding and operating interest were greater for the more efficient systems. However, the additional revenue from marketing additional kilograms of weaned calves was greater than the increase in costs. Net returns for improved herd feed efficiency ranged from \$32-195 ha^{-1}. Selection for feed efficiency in beef cows has positive net returns to producers.

Introduction

Over the last fifty years the United States (U.S.) beef cowherd population has decreased while beef production per cow has increased. The selection for growth traits for increased calf weaning and yearling weights has led to an increase in carcass weights and total beef production. The selection for growth traits has also had an effect on mature cow body weight because selection for replacement females is often based on growth, leading to an increase in mature cow weights. As a result, it is a common perception that these heavier, larger cows do not convert feed into pounds of beef as efficiently as smaller, lighter cattle do. Walker et al. (2015) revealed from a study of cows in Louisiana using individual animal measurement technology to measure feed efficiency via individual measurements of dry matter intake (DMI) that there were as many smaller, lighter weight cattle that had below average DMI as there were larger, heavy cattle. These results were the first to challenge the popular opinion that only large, heavy cattle do not efficiently convert feed into pounds of beef. As a result, innovations that would allow producers to easily identify inefficient animals in their herds early in the production process are thought to have a great deal of value, but would require substantial investment in research and development from both the private and public sectors. Would the value of more efficient herds outweight the cost of these investments? Would there be positive net economic benefits to agricultural producers that could identify and cull out inefficient animals from their herds? An economic study was conducted to address these questions. The objectives of the study were to determine the stocking rates (head/ha) and economic net returns (\$/ha) for six alternative cow-calf production systems with three alternative levels of feed efficiency for two alternative pasture types.

Data and Methods

Animal Management. Procedures and protocols used in this study were approved by Oklahoma State University (OSU) Animal Care and Use Committee (#AG-19-1). Data were collected from a completely randomized design (CRD) feeding trial (replicated twice) initiated in September 2019 at the Noble Research Institute's individual animal measurement [GrowSafe® (Vvtelle, Edmonton, Alberta)] drylot facility located near the community of Oswalt, OK (33°59'02.4"N 97°15'16.7"W). Using genomic panel scores for relative feed intake (RFI) produced by the Neogen Igenity Beef platform, 48 non-lactating, spring-calving, commercial Angus cows (708 ± 52 kg; 7.0 ± 0.75 yrs old) were chosen from a pool of 90 contemporaries to participate in the study. Prior to trial initiation, spring calves were weaned and cows were managed as a group for 14-d while transitioning from lactating to non-lactating. Following the post-weaning adjustment period, cows were stratified by RFI genomic score, initial body weight, age, and days pregnant at trial inititation and randomly assigned, 12 cows per pen, to one of four pens each equipped with four GrowSafe® intake units. Three cows were eliminated from the study due to incomplete data, leaving 45 cows. The study was set up with a single hay treatment (HAY) consisting of 100% bermudagrass hay (10% crude protein (CP), 53% total digestible nutrients (TDN)). The HAY treatment had 10% water added to reduce dust and improve ease of delivery. Note, the HAY treatment was designed to represent a proxy for a pasture-only diet representing the typical quality associated with well managed pastures commonly used by cow-calf producers in the Southern Great Plains (SGP). Feed was delivered three times daily to provide adequate access to the diet for all cows. Prior to the start of data collection, a 14-d feed transition period was conducted to allow cows to adapt to the HAY treatment, feeders and cohorts. Following the adaptation period, daily feed intake data was collected for 50-d. Initial, midpoint, and ending measures of cow BW and average individual daily measures of DMI of HAY diets were collected in the trial. The spring-calving calves born to the dams used in the trial were weaned in the fall of 2020 and their weights were adjusted to a 205-d weight to minimize variation surrounding birth date. Two additional herds comprised of cows from two subsets of the original 45 cows were used, including the 22 cows from the original 45 that represent the upper 50% of DMI, and 12 of the orginal 45 cows that represent the upper 25% of DMI. Two pasture types common to the SGP (i.e., introduced bermudagrass (BG) and native prairie grass (NG)) were superimposed on the three alterantive herds, providing for six alternative cow-calf production systems. The six alternative production systems are designated henceforth as AvgBG, AvgNG, 50%BG, 50%NG, 25%BG, and 25%NG.

Statistical analysis. Mixed effects regression models were estimated using the Mixed Procedure in SAS (Little, 1996) and number of hypothesis tests were conducting to justify using individual cow measurement (Growsafe®) data for the economic analysis. Following Walker et al. (2017), data were first sorted into two BW groups (small and large) based on those below and above the 50th percentile of BW. Then, cows in each weight class were further separated into two more groups (i.e., efficient and inefficient), also based on those above and below the 50th percentile of DMI of the HAY diets. Data and results of hypothesis tests for the four different weight-efficiency groups of cows are reported in Table 1. Based on the test results associated with DMI between the four size-efficiency groups, the data was pooled into two groups of cows (efficient and inefficient). Economic modeling was conducted using the data pooled data.

Table 1. The effects of cow size-efficiency treatment group on cow BW and DMI

	Size-efficiency treatment group				
Animal performance measure:	Small, efficient	Small, inefficient	Large, efficient	Large, inefficient	P-value*
Number of dry cows	10	12	12	11	-
Cow age (years)	6.53	6.9	6.95	7.09	0.6702
Cow body weight (kg/hd)	602.72^{b}	627.66^{b}	710.20^{a}	700.23^{a}	<0.0001
DMI of grass hay (kg/day)	11.57^{b}	15.25^{a}	11.97^{b}	15.41^{a}	<0.0001

* Letters that differ between columns are considered statstically different for p-values less than 0.05.

Economic Analysis. Enterprise budgeting techniques were used to calculate expected revenues, production costs, and net returns for six representiative cow-calf production systems (AAEA, 2000). Revenues were calculated as the product of 10-yr (2010-2020) average calf (average steer prices for steers, and average heifer prices for heifers) price times the 205-d adjusted weaning weight (WW) (kg hd^{-1}) times the stocking rate SR (hd ha^{-1}). To calculate SR, the National Research Council's approach was used to estimate forage availability for BG and NG pastures common to the SGP region of the United States (NRC, 1996). Well-managed Bermudagrass and NG pastures have similar nutritive value but differ in forage mass. For this analysis we assume that BG and NG pastures would produce 2268 and 2094 kg ha^{-1}, respectively, and assume producers would, on average, utilize 70% and 35% of BG and NG, respectively (NRC, 1996). This leaves 1587 and 733 kg ha^{-1} of forage available for annual grazing for each pasture type. Stocking rates were calculated for each of the six cow production systems using mean DMI values measured in the study. For the three alternative levels of herd efficiency (average, 50% improvement, and 75% improvement) the mean DMI for nonlactating cows were 13.64, 11.66, and 10.65 kg ha^{-1}, respectively. However, because cows spend more of the year lactating than not, consuming more than a non-lactating cow, it is more economical for producers to determine initial SR for lactating cows. To convert mean DMI of non-lactating cows to a DMI for lactating cows, multiply the mean DMI for the average cow-calf systems (Avg50%BG and Avg50%NG) and systems with 50% and 75% improvements in feed efficiency (50%BG, 50%NG, 25%BG and 25%NG) by 7.25%, 7.60% and 8.80%, respectively (NRC, 1996).

Costs of production included a pasture rental rate, annual pasture maintenance costs, feed during the winter, veterinary/healthcare, breeding expenses, and interest on operating capital. Pasture rental rates for BG and NG were $57.64and $38.17 ha^{-1}, respectively (OCES, 2020). For BG pastures, maintenance costs included the annual applications of fertlizers N, P_2O_5, K_2O and lime, and herbicides for controlling broadleaf weeds. For NG pastures, maintenance costs included the cost of prescribed fire of $24.57 ha^{-1} (Gee and Biermacher, 2007) every third year and a cost of $6.00 ha^{-1} for spot spraying herbicides to control pockets of weeds (e.g., Johnsongrass) on a third of a ha $year^{-1}$ basis. We assume that medium quality hay was fed for all three representative BG production systems for 90 days (mid-Dec – mid-Mar) and 45 days (mid-Jan – Mar 1) for all three NG production systems. Hay was fed at rates of 12.70, 10.84, and 9.80 kg hd^{-1} for all six production systems. Range cubes (CP=32%) were fed for 60 days for BG systems (Nov 1 – Jan 1) and 130 days for NG systems (Nov 1 – Mar 10). Cubes were fed each day at a rate of 0.91 and 1.59 kg hd^{-1} for all six production systems. Mineral was assumed to be fed daily at a rate of 0.11 kg hd^{-1} for all six systems. Ten-year (2010-2020) prices of hay were obtained from the Agricultural Marketing Service's Direct Hay Report (USDA-AMS). Prices for medium quality grass hay, 32% range cubes, and loose mineral used in the analysis were $76, $273, and $569 MT^{-1}, respectively, and were obtained from local input supply dealers in 2020. Fertilizers in the form of N, P_2O_5, and K_2O were applied at a rate of 112, 34, and 34 kg ha^{-1}. Lime (100% ECCE) was assumed to be applied every fifth year at a rate of 0.91 MT ha^{-1}. A custom rate of $15 ha^{-1} was used to account for the cost of applying N, P_2O_5, and K_2O fertilizers each spring. Prices of $0.16, $0.23, $0.23 kg^{-1} for N, P_2O_5, and K_2O and lime (100% ECCE) equal to $36.28 MT^{-1} (including application) were used in the analysis and obtained from local input supply dealers. Veterinary/healthcare costs of $35.77 hd^{-1} and breeding expenses equal to $36.20 hd^{-1} were calculated using prices paid for medicine and supplies administered for the trial. Operating interest was calculated as the product of the total cash operating expenses and an interest rate of 5.5%. The summation of these operating costs were then multiplied by the SR for each of the six production systems to get their respective system's total cost.

Results and Discussion

Production and economic results by cow-calf production system is reported in Table 2. A key result of importance is the increase in SR associated with cow-calf production systems with improvements in DMI for BG and NG pastures. For systems on BG, SR increased by 16.83 and 27.57 percent for the 50%BG and 25%BG production systems, respectively, compared to the AvgBG system. Similar percent increases were found for the more efficient production systems on NG. Increases in SR resulted in an increase in total gross weaning weight per hectare by 10.72 and 19.58 percent for the 50%BG and 25%BG cow-calf systems compared to the conventional BG systems. Costs for all four of the more efficient production systems increased by a range of 4.46 percent for the 50%BG system to a 13.34 percent increase for the 25%NG system. Overall, net return for the four more-efficient systems increased by a range of 12.06 percent for the 50%NG system to 31.71 percent for the 25%BG system. Overall, the results of this study suggest that the economic value that can be expected from improving overall efficiency is not trival and ranges between $32 and $195 ha^{-1}, depending on the forage type and level of DMI. The results suggest that improvements in herd efficiency will likely be a primary driver of livestock development over time.

Conclusions and/or Implications

The development of individual animal measurement technologies has made it possible for researchers to better understand factors that effect the ability of specific animals in the herd to efficiently convert forage into pounds of beef, providing for economic efficiencies at the farm level, providing benefits to producers across the entire supply chain and to consumers. And, because of these benefits, investments for devolping innovations that will allow producers to easily identify inefficient animals (large or small) early in the production process will likely pay off. This is the first study that we know of that uses individual animal measurement technology to determine the economic value of improvements in herd efficiency. Other studies that are conducted in different regions with different pasture species might find different results. Also, this study is limited to a relatively small sample of cows that have individual daily measures of feed intake. Replication of the study with a greater number of cows over time and space would be valuable.

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Table 1. Measures of production and costs, revenues, and net returns of alterantive cow-calf production systems

	Cow-calf production systems*					
Production/economic variable:	AvgBG	50%BG	25%BG	AvgNG	50%NG	25%NG
Number of cows	45	22	12	45	22	12
Annual forage production (kg/ha)	2268	2268	2268	2094	2094	2094
Ulitization rate (%)	0.70	0.70	0.70	0.35	0.35	0.35
Annual forage available (kg/ha)	1587	1587	1587	733	733	733
Average cow weight (kg/hd)	662	662	644	662	662	644
Average weaning weight (kg/hd)	276	262	263	276	262	263
Average dry matter intake (kg/hd/day)	13.64	11.66	10.65	13.64	11.66	10.65
Stocking rate (hd/ha)	1.06	1.23	1.35	0.42	0.49	0.54
Total cost ($/ha)	549	573	587	160	174	181
Gross weaning weight (kg/ha)	291	323	354	116	128	141
Average price of steers and heifers ($/kg)	3.68	3.68	3.68	3.68	3.68	3.68
Gross revenue ($/ha)	1072.45	1187.42	1304.99	425.38	471.24	519.19
Net return ($/ha)	523.63	614.10	718.37	265.64	297.68	338.14
Relative value of efficiency ($/ha)	Base	90.47	194.73	Base	32.04	72.50

* AvgBG and AvgNG systems reflect cows from the original 45 cows with an average combination of DMI for large and small efficient and inefficient cows on bermudagrass (BG) and native prairie grass (NG) pastures, respectively; 50%BG, 25%BG and 50%NG and 25%NG represent the upper 50% (N=22) and upper 25% (N=12) of large and small efficient cows on bermudagrass (BG) and native prairie grass (NG) pastures, respectively.