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USING DNA TO DETERMINE PERFORMANCE AND ECONOMICS OF COMMERCIAL HERD BULLS IN MULTISIRE NATURAL SERVICE BREEDING GROUPS[1]

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Abstract

Sire contributions to ranch income as either total feeder calf value or total retained ownership value per sire were compared on 3 commercial cow/calf ranches in northern California. DNA testing was used for sire identification of calves conceived in multisire breeding groups in nine calf crops produced from both fall and spring calving herds. The number of calves born per sire per calf crop varied greatly, ranging from 0 to 54. Prolificacy was the main driver of total income per sire, irrespective of whether the calves were marketed as feeder or retained ownership. Feeder calf value and retained ownership values were similar but sires differed in their contribution to total income depending upon the marketing method. Scrotal circumference (SC) and cow energy value ($EN) EPDs were positively correlated with prolificacy (number of calves), and both total feeder calf and retained ownership value per sire. Day of calving categorized as four 21-d calving periods was significantly associated with carcass traits and income. Earlier calves were older, heavier, sold for less per pound but returned more dollars per head when sold as feeder calves and had superior WDA when adjusted for age. Earlier calves as retained ownership returned greater gross carcass value, with similar feed costs, feedlot ADG and grid price premiums resulting in greater net return. Early calves had superior carcass weight, marbling, ribeye area and yield grade score as compared to later calves, although the fat thickness was similar between the groups. Calves from the first 21d of calving returned about 40% of the total feeder calf or retained ownership value to the ranch, and those from periods 1 and 2 combined accounted for about 72% of the total income. These data suggest sire selection for increased SC and $EN EPDs and management to increase the proportion of calves born early in the calving season could increase total ranch income per sire and overall ranch efficiency.

Introduction

The "California commercial ranch project" has previously identified a large variation in prolificacy of bulls under commercial situations (Drake *et al.* 2011). The contribution of total weaning weight varied tremendously between bulls and was much more closely related to the number of calves sired than individual calf weaning weight or growth rates. Prolificacy and growth are important components of ranch efficiency, but it is ultimately income that determines profit and sustainability. In addition to sire effects, day of calving relative to the first date for a given calf crop is an important driver of income as it impacts calf age on a fixed sale age (due to a single day of sale) for feeder calf marketing, and feedlot entry in weights and age for retained

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ownership marketing (Minyard and Dinke 1965; Lesmeister *et al.* 1973). Day of calving has been reported to impact subsequent feedlot performance and carcass traits (Funston *et al.* 2012). Increasingly, calves are retained and sold on a grid basis instead of as feeder cattle. In this study we compared the projected income that would have been derived from targeting feeder and retained ownership marketing systems using the production data from the California commercial ranch project, and compared sire contributions to ranch income under these two marketing scenarios on 3 large commercial cow/calf ranches in northern California.

Materials and Methods

A total of nine calf crops from 3 commercial northern California cow/calf ranches involving 2,241 calves were evaluated. Ranches A and B ran both spring and fall breeding herds, whereas ranch C ran only a fall herd, and all used multisire breeding pastures made up predominantly of registered Angus bulls and Angus crossbred cows (calves approximately 75% Angus or more). A small number of South Devon, Hereford and Red Angus bulls were also used. The cow to bull ratio was approximately 25:1 and breeding took place in fenced pastures. Bulls underwent a breeding soundness exam prior to the breeding season and were then assigned to breeding groups. Bulls remained in the same breeding group unless they were injured or in inadequate condition based upon the judgment of experienced personnel working on the cooperating ranchers. Feedlot in weights were recorded on all of the calves that were shipped to the feedlot and carcass data was determined by the USDA. A sample of meat from all carcasses was collected for DNA confirmation of the animal's identity by comparing the genotype of the meat sample to that which was obtained from hair samples collected on all calves at weaning on each of the cow/calf ranches.

Feeder calf prices were calculated using feedlot in weights and market prices based on a single day (Green City, MO USDA/AMS reported prices, November 23, 2010), and may not be representative of general trends. Carcass values for retained ownership calf scenarios were based on actual USDA grader carcass data. USDA Marbling grades were converted to scores (Drake 2004). Marbling grades and corresponding marbling scores are: Slight:4.25; Slight+:4.5; Small-:5.0; Small:5.33; Small+:5.67; Modest-:6.0; Modest:6.33; Modest+:6.67; Moderate-:7.0; Moderate:7.33; Moderate+:7.67. Premiums and discounts for grid values were: Choice \$5.36; Prime \$16.75; Certified Angus Beef (CAB) \$4.04; Standard -\$8; Yield Grade (YG) 1 \$4; YG2 \$2; YG3 0; YG4 -\$12; YG5 -\$17 per 100 pounds (cwt) and correspond to the premiums and discounts available in June 2011 that allows for better comparison to feeder cattle sales in late 2010. Other costs that were considered including fixed marketing costs (checkoff, overhead charge) of \$31.90 per head and Age Source Verification bonus of \$35 per head. Feed costs were estimated as described in Funston *et al.* (2012) based on equations developed by Tedeschi *et al.* (2006) and Guiroy *et al.* (2001). These equations require measurements on live weight at slaughter and feedlot rate of gain, neither of which were available for this dataset. Feedlot gain was thereby calculated by estimating live slaughter weight by multiplying carcass weight by 0.63, and then using actual in weight as recorded at the feedlot, and total days on feed. Value of retained ownership (grid cattle) was calculated as individual carcass value minus estimated feed costs. Total sire contribution to income for each calf crop was calculated as the mean value of either feeder calf value or retained ownership value multiplied by the total number of progeny per sire. The total number of progeny per sire was greater than the number of progeny with feedlot data as some of the calves in each calf crop were not marketed through the feedlot. This was because some calves were too small to ship on the day of feedlot placement, others had been treated with antibiotics for pinkeye invalidating them from inclusion in the natural program, and in the case of heifers some of them were selected as replacement females. Due to the commercial nature of the ranches, this effect was not random: late calves were likely smaller and early-born heifer calves were more likely retained. As a result, sires with a disproportionately large number of early calves (i.e. prolific sires) would have been penalized and bulls with late calves would have been beneficially impacted by these missing data.

Statistical analysis included ANOVA or multiple regression using the General Linear Model procedures of Systat 11. Least square means adjusted for ranch, year, season, sex, sire and calving distribution period were included as appropriate and as indicator variables for regression. Differences were declared significant at P levels $\leq$ 0.05 unless specified differently. ANOVA least square means (LSM) were separated using Fisher's Protected LSD. EPDs and accuracies were obtained from the American Angus Association web site (http://www.angus.org/Nce/Definitions.aspx) in August 2012. The EPDs evaluated were:

BW: Birth Weight	**WW**: Weaning Weight	**YW**: Yearling Weight	**FAT**: Fat Thickness	**SC**: Scrotal Circumference
MILK: Maternal Milk	**CW**: Carcass Weight	**MARB**: Marbling	**RE**: Rib Eye Area	**CED**: Calving Ease Direct
CEM: Calving Ease Maternal	**$EN**: Cow Energy Value Index	**$W**: Weaned Calf Value Index	**$QG**: Quality Grade Index	**$YG**: Yield Grade Index
$B: Beef Value Index	**$G**: Grid Value Index	**$F**: Feedlot Value Index		

Other EPDs were not included due to their relative infrequency in genetic evaluations from young registered bulls. Non Angus bulls were excluded from analysis that included EPDs. Prolificacy evaluations or evaluations involving the complete calf crop were restricted to bulls that were present in the breeding group for the entire duration of the breeding season.

Calving distribution. Calving distribution was categorized into 4 periods based on day of calving: 1) days 1-21; 2) days 22-42; 3) days 43-64; 4) days past 64 with the first calf born in a calf crop being day 1. ANOVA consisted of ranch, year, season, sex and calving period. In addition, separate ANOVA included these variables plus sire. The weight per day of age (WDA) ANOVA included a covariate, calf age.

Quality grade percent. For Angus bulls, the weighted percentage of calves grading 1) "USDA Choice minus or better" and 2) "USDA Choice plus or better" for each sire for each calf crop was determined and sire effects were evaluated with ANOVA using ranch, year, season and sire as variables. Correlations between these values and EPDS (MARB, RE, FAT, G, QG, YG and B) and linear relationships were calculated. Linear relationships were evaluated with single EPDs and in a stepwise multiple regression manner.

Results

Feeder calf and retained ownership value of calves. Feedlot in weights averaged 706 pounds, and the average feeding period was 152 days. Average carcass traits were: carcass weight: 743 lb; Choice minus or better: 84.5%; Prime: 1.3%; YG: 3.2; fat thickness: 0.62 inches; and ribeye area: 12.8 sq. inches.

Feeder calf value ($/head) varied significantly between sires (Figure 1) after adjusting for ranch, year, season and sex of calf. A lot of this was driven by a small number of sires that had progeny with exceptionally high or low values. This range of about $300 occurred despite the missing data that resulted from sorting off low weight cattle on the day of feedlot placement. Gross carcass grid value ($/head) and estimated feedlot feed costs also varied significantly between sires, and showed a similar pattern with a handful of sires producing exceptionally high and low progeny, with the remaining bulls producing progeny of approximately equal value (Figure 1).

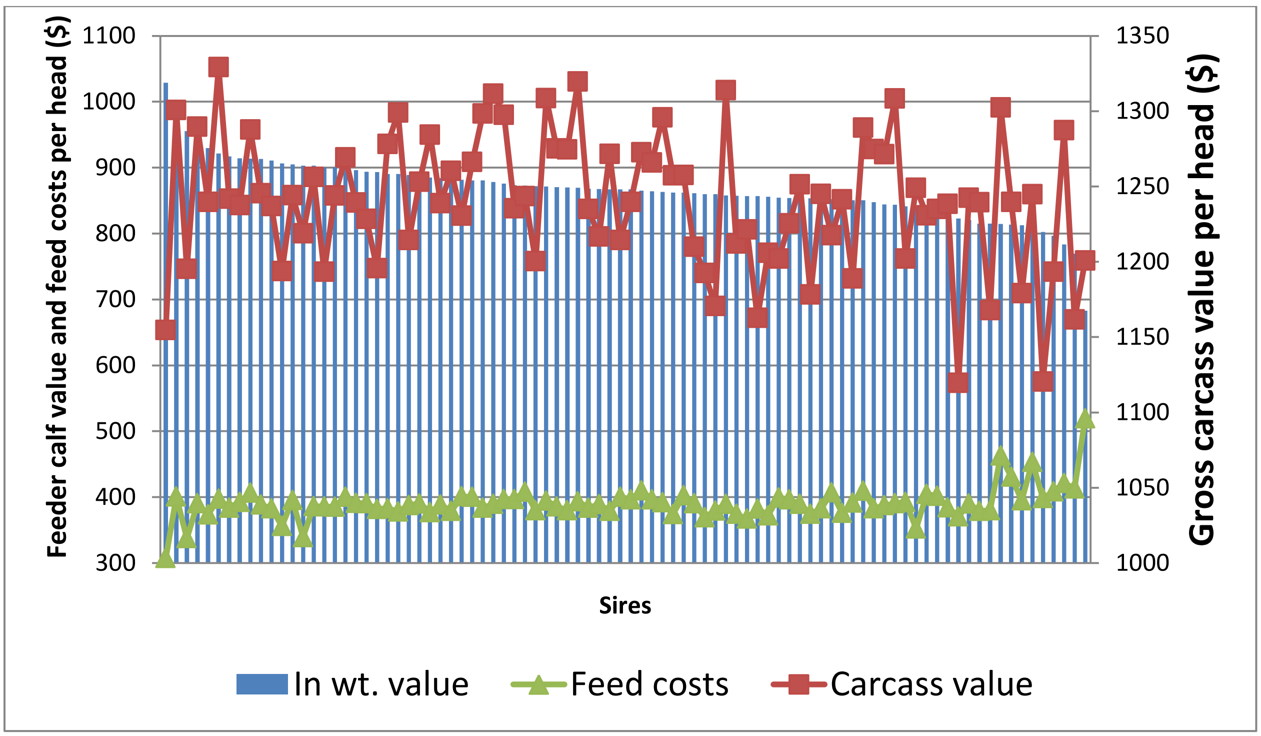


Figure 1. Feeder calf value (in wt. value; left axis) and feed costs at the feedlot ($/head; left axis), and gross carcass grid value ($/head; right axis). Both feeder and gross carcass value ($/head) were significantly different between sires.

The income derived from retained ownership can be grossly approximated by subtracting estimated feed costs from the carcass grid value. This "retained ownership value" varied by sire (Figure 2); and was compared with the same sire's feeder calf value (Figure 3). Under these conditions selling feeder cattle ($852 average individual value) was about $20 per head more profitable (Figure 2) than retaining ownership ($832 grid carcass value minus feed costs). But again statistically only the most extreme sires' progeny were different. These data should not be interpreted to mean that returns from retained ownership are less than selling calves at weaning as the economics associated with this decision will depend upon prevailing cattle and feed prices.

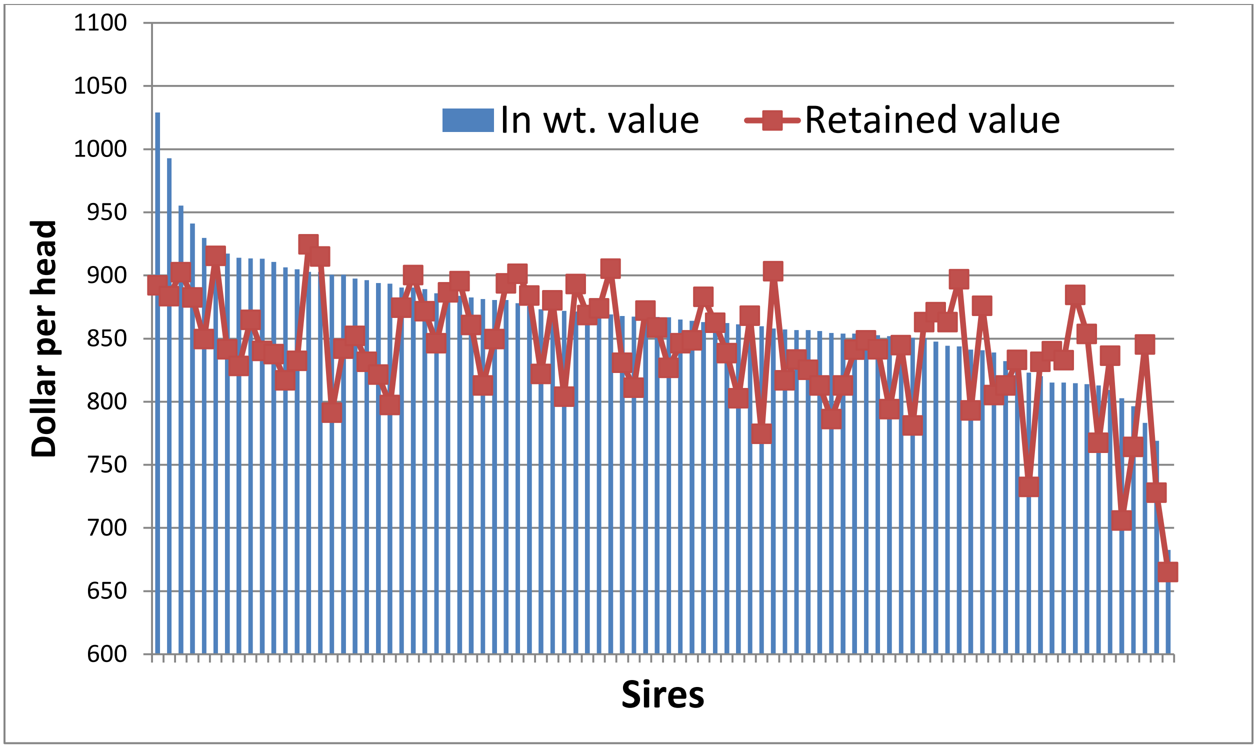


Figure 2. The average "retained value" (determined by subtracting carcass grid value by feed costs) and feeder value (in wt.value) of calves sired by commercial ranch bulls.

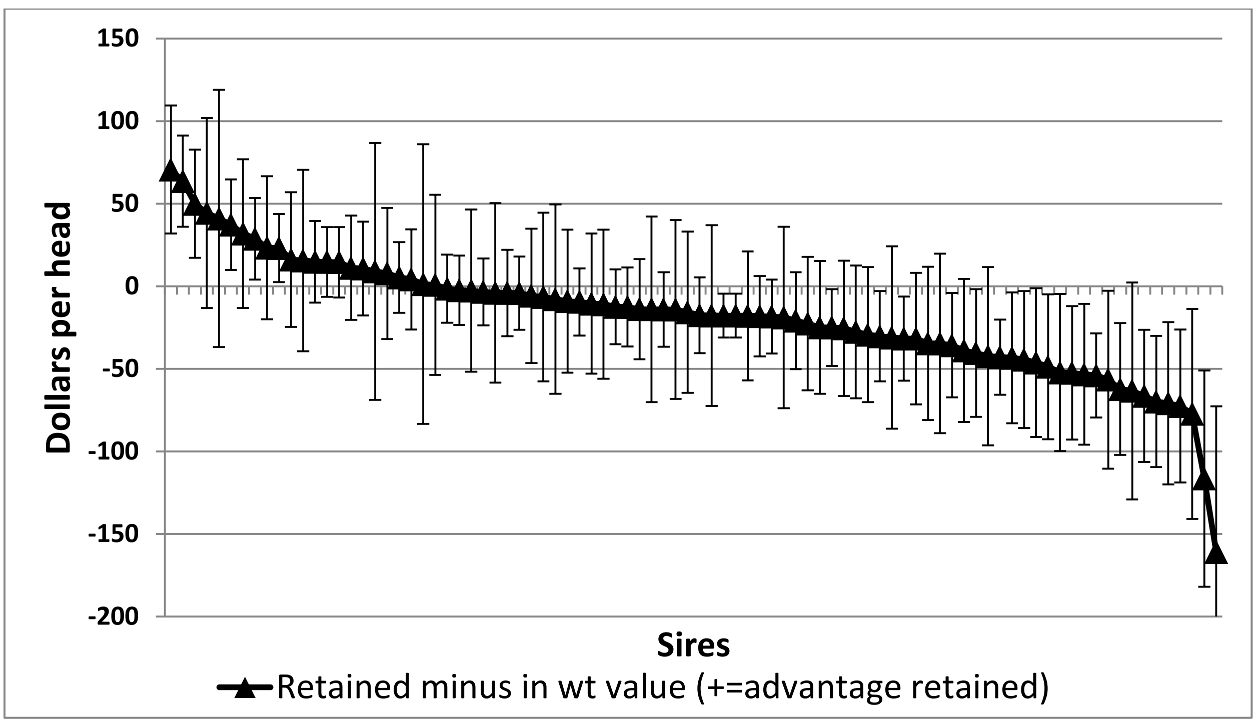


Figure 3. Average value ($/head) resulting from subtracting the estimated feeder calf value from the estimated retained calf value (grid value minus feed cost) of each calf sired by commercial ranch bulls.

It does show that for calves marketed on any given day the calves from some sires returned more money when sold as feeder calves, whereas other sires produced calves that derived more value when retained through the feedlot phase. The Holy Grail for producers interested in retained ownership is, of course, trying to select for bulls that are going to fall into the latter group of bulls producing calves that maximize the return from retained ownership.

This return maximization from retained ownership can be difficult to achieve at all periods of time as price of calves, cattle and feed all move relative to each other and can affect optimal selection criterion. Current record feed prices have tested the proposition of retained ownership. Despite all of the variability in relative prices many performance and quality traits remain important drivers for producers interested in retained ownership.

Total income from feeder calves and retained ownership. Ranch profit is strongly influenced by total income and bull evaluation for total income showed large and significant differences between sires for total income either as the feeder calf or grid value (retained ownership) as shown in Figure 4. Feeder calf income from progeny of sires was closely related to the same calves sold on a grid basis, 95.5%. Income was also very closely associated with the number of calves (Figure 4). In contrast, total income was not closely related to the mean value per calf (Figure 4). These relationships can be described statistically. The number of progeny per sire explained 98.4% of the variation in the sires' total income, whereas the individual calf value explained only another 0.88% of the variation. This clearly supports the old adage that any calf is better than no calf. But more precisely a few highly prolific bulls are contributing the majority of the income to the ranch. An average bull with 19 progeny and a feeder value of $866/head contributes about $16,000 compared to a highly prolific bull with 40 calves and $34,000 in total income or $0 for the bull with no progeny. The same trend is seen for retained ownership. Clearly highly prolific bulls are worth much more to the ranch enterprise.

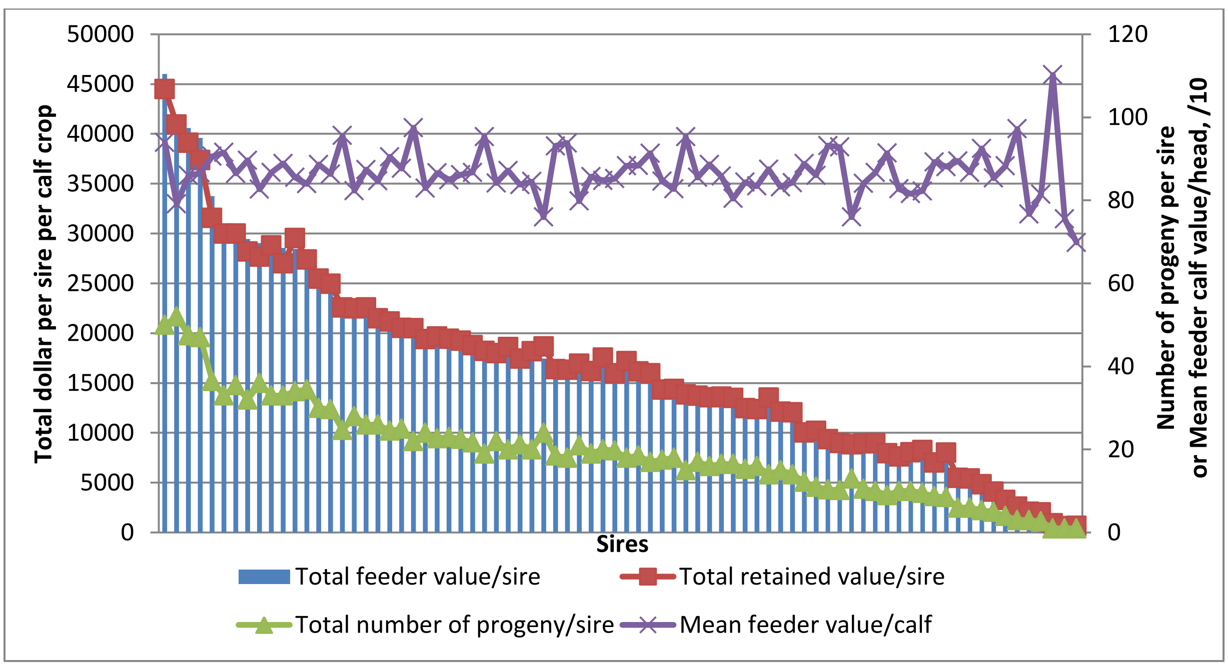


Figure 4. Total income as feeder calves per sire or total retained ownership (Total retained value/sire) varied by sire (Total dollar per sire per calf crop, left axis), and the number of progeny per sire (right axis) and the mean individual feeder value/calf (right axis, $/10)

EPDs, prolificacy and total income. Recognizing the tremendous differences in sires for total income we evaluated the EPDs of these sires for their relationship to income. Total income is a function of both the number of calves and the value of individual calves. Therefore we examined potential relationships between EPDs and total income (measured as either feeder calf value or retained owner) and the number of progeny per sire. Three evaluations were conducted to help identify trends.

1. Set 1 – No filtering - All calves with sire, carcass data and EPDs.
2. Set 2 – ACC=>0.2 - All calves with sire, carcass data and EPDs with accuracies at 0.2 or better
3. Set 3 – Without Bull 0901 - All calves with sire, carcass data and EPDs except bull 0901, an influential bull that was removed after statistical analysis revealed it was a true statistical outlier. This bull is marked with a circle in Figure 5A

The results of these EPD evaluations are shown in Table 1 and a consistent pattern emerged. Scrotal circumference (SC) and cow energy value index ($EN) EPDs were positively related to total feeder calf income per sire, total retained ownership value per sire and sire prolificacy.

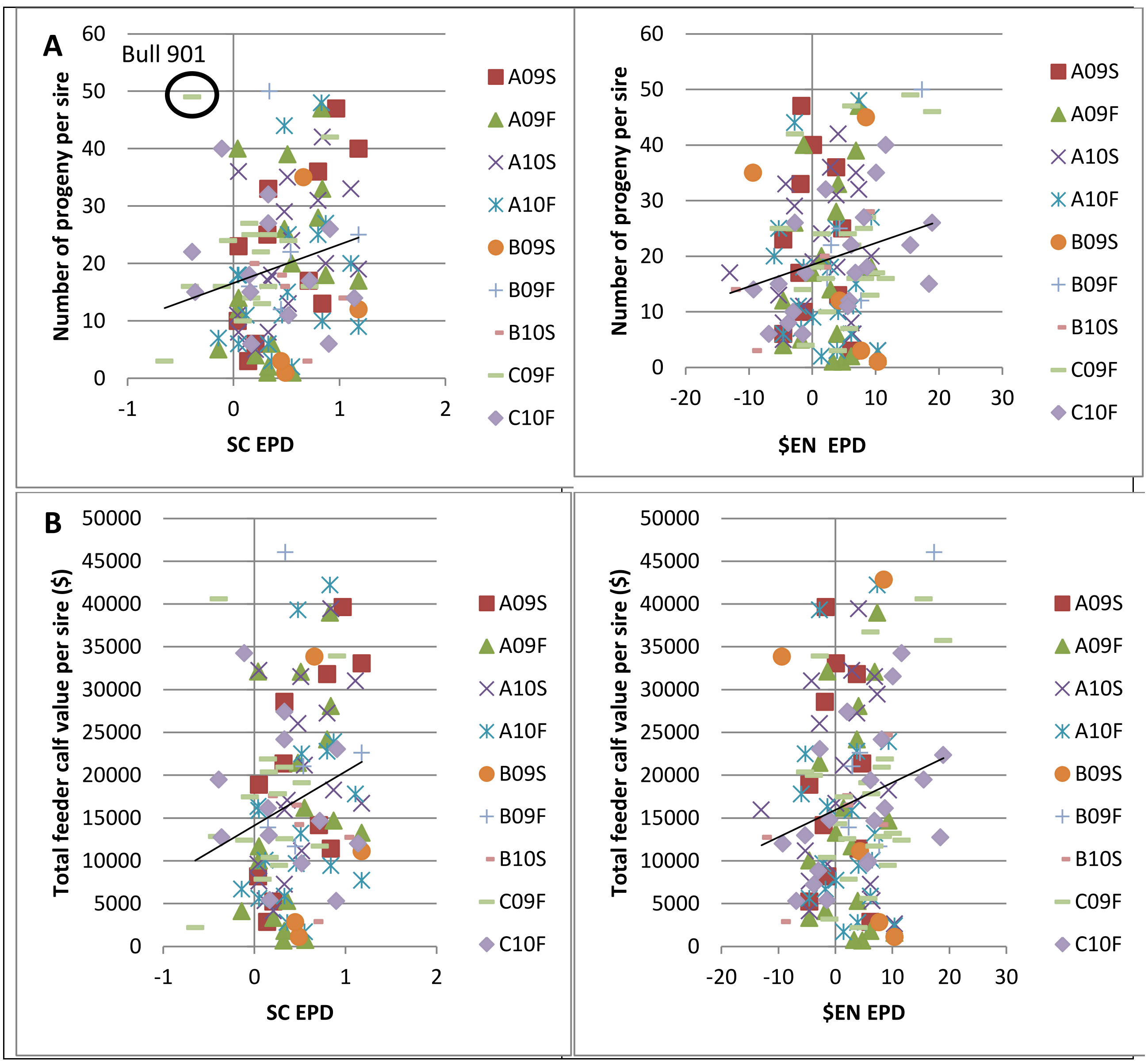
A. **EPD**	**Set 1 No filtering**		**Set 2 ACC =>0.2**		**Set 3 without Bull 0901**		**Relation to number of progeny/sire**
	N	**P value**	**N**	**P value**	**N**	**P value**	
CED	153	NS	43	NS	151	NS	
BW	128	0.09	44	NS	126	NS	
WW	128	NS	43	NS	126	NS	
YW	128	0.14	43	NS	126	NS	
SC	**108**	**0.0046**	**78**	**0.0022**	**106**	**0.0014**	**POSITIVE**
CEM	153	NS	6	NS	151	NS	
MILK	**128**	**0.066**	**38**	**NS**	**126**	**0.032**	**NEGATIVE**
CW	**124**	**0.012**	**22**	**NS**	**122**	**0.019**	**NEGATIVE**
MARB	153	NS	32	NS	151	NS	
RE	124	NS	38	NS	122	NS	
FAT	124	NS	31	NS	122	NS	
$EN	**128**	**0.059**			**126**	**0.032**	**POSITIVE**
$W	153	NS			151	NS	
$F	124	NS			122	NS	
$G	124	NS			122	NS	
$QG	153	NS			151	NS	
$YG	124	NS			122	NS	
$B	153	NS			122	0.09	**NEGATIVE**

Table 1. EPDs were tested for a relationship with A) Number of progeny/sire/calf crop, B) Total feeder calf/sire/calf crop, and C) Total retained ownership value/sire/calf crop using 3 slightly different data sets (see text above). EPDs consistently and significantly related to these factors were SC and $EN (positively related) and MILK and CW (negatively).

B. **EPD**	**Set 1** **No filtering**		**Set 2** **ACC =>0.2**		**Set 3** **without Bull 0901**		**Relation to total feeder calf/sire/calf crop**
	N	**P value**	**N**	**P value**	**N**	**P value**	**Relation**
CED	153	NS	43	NS	151	NS	
BW	128	0.12	44	NS	126	NS	
WW	128	NS	43	NS	126	NS	
YW	128	NS	43	NS	126	NS	
SC	**108**	**0.005**	**78**	**0.0016**	**106**	**0.0017**	**POSITIVE**
CEM	153	NS	6	NS	151	NS	
MILK	**128**	**0.08**	**38**	**NS**	**126**	**0.044**	**NEGATIVE**
CW	**124**	**0.018**	**22**	**NS**	**122**	**0.026**	**NEGATIVE**
MARB	153	NS	32	0.09	151	NS	
RE	124	NS	35	NS	151	NS	
FAT	153	NS	31	NS	151	NS	
$EN	**128**	**0.07**			**126**	**0.045**	**POSITIVE**
$W	153	NS			151	NS	
$F	124	NS			122	NS	
$G	153	NS			151	NS	
$QG	153	NS			151	NS	
$YG	124	NS			122	NS	
$B	153	NS			151	NS	

C. **EPD**	**Set 1** **No filtering**		**Set 2** **ACC =>0.2**		**Set 3** **without Bull 0901**		**Relation to total feeder calf/sire/calf crop**
	N	**P value**	**N**	**P value**	**N**	**P value**	**Relation**
CED	153	NS	43	NS	151	NS	
BW	128	NS	44	NS	126	NS	
WW	128	NS	43	NS	151	NS	
YW	128	NS	43	NS	126	NS	
SC	**108**	**0.004**	**78**	**0.0016**	**106**	**0.0014**	**POSITIVE**
CEM	153	NS	6	NS	151	NS	
MILK	**128**	**0.11**	**38**	**NS**	**126**	**0.062**	**NEGATIVE**
CW	**124**	**0.016**	**22**	**NS**	**122**	**0.02**	**NEGATIVE**
MARB	153	NS	32	NS	**122**	NS	
RE	124	NS	38	NS	**122**	NS	
FAT	153	NS	31	NS	**151**	NS	
$EN	**128**	**0.099**			**126**	**0.06**	**POSITIVE**
$W	153	NS			**151**	NS	
$F	124	NS			**122**	NS	
$G	153	NS			**151**	NS	
$QG	153	NS			**151**	NS	
$YG	124	0.129			**122**	NS	
$B	153	NS			122	0.09	NEGATIVE

Generally at least 5% of the total variation (as measured by R^2) in each trait was explained by SC EPD (Figure 5). $EN EPD also tended to be positively related to those traits (Figure 5) but typically explained only about 3% of the variation. CW EPD and to a lesser extent MILK EPD were negatively related to the three traits, but again only explained about 3% of the variation. Complex traits such as total income per sire or sire prolificacy would be expected to be under the control of numerous factors so it is not surprising that only a small percentage of the observed variation is explained by a single EPD. We are not aware of other literature that has reported the relationship of EPDs to prolificacy and total income derived from sires in multisire breeding pastures. Selecting sires with superior growth (e.g. yearling wt. EPD) or carcass traits (e.g. ribeye area EPD) with no consideration of prolificacy will not always result in a crop of genetically superior calves! Bulls with few or no progeny make little contribution to genetic improvement or ranch income.



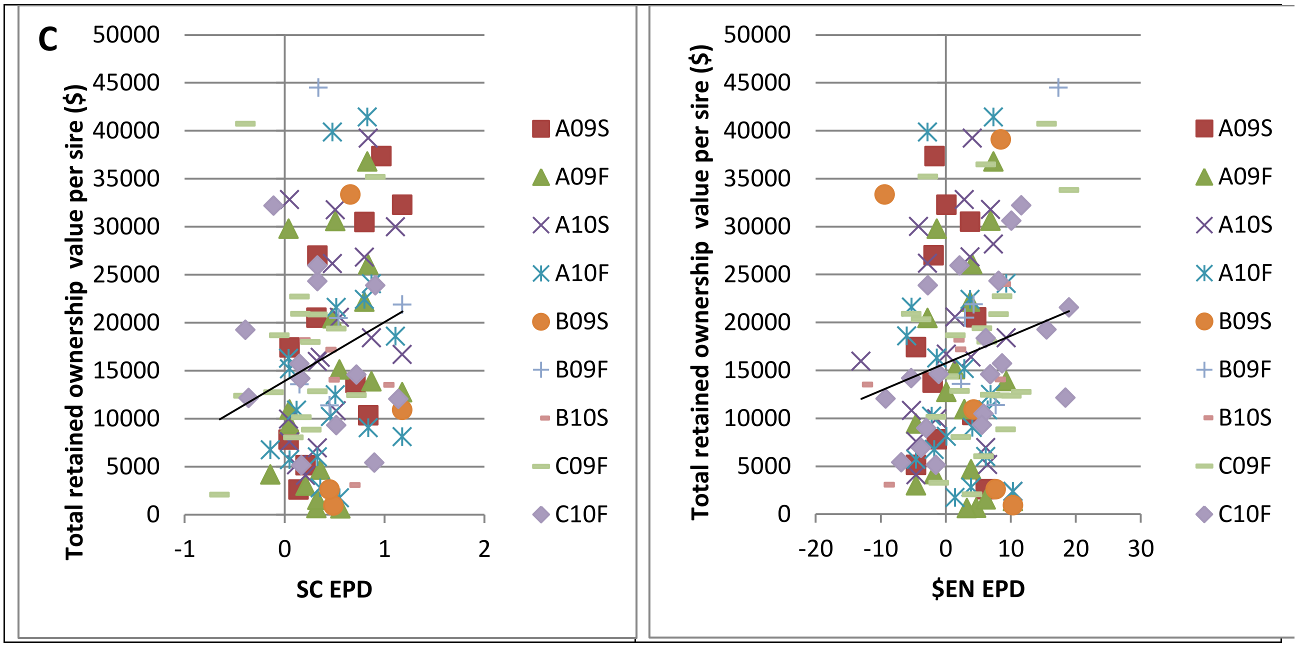


Figure 5. The A) number of progeny, B) total feeder calf income, and C) total retained ownership value per sire were related to SC EPD (left panel) and $EN EPD (right panel). Legend refers to Ranch (A, B or C), Year (2009 or 2010), and Season (Spring or Fall).

When SC, $EN, CW and MILK EPDs were considered simultaneously the best combination of significant EPDs is SC EPD and $EN EPD for predicting total feeder calf income, total retained ownership income or number of progeny per sire using either the full data set or with bull 0901 removed. This relationship can be mathematically represented as:

Total number of progeny per sire= **8.2**±3.0*SC EPD (P=.008) + 0.45±.20*$EN EPD (P=.03) + 14.9 (P=.008)
R^2=.090 SE=12.1

Total feeder calf value per sire= **7615**±2615*SC EPD (P=.004) + 378±173*$EN EPD (P=.03) + 12669 (P=.006)
R^2=.095 SE=10479

Total retained value per sire= **7369**±2562*SC EPD (P=.005) + 353±171*$EN EPD (P=.04) + 12555 (P=.007)
R^2=.091 SE=10267

Based on this relationship each unit increase (1 cm) in SC EPD would be associated with 8.2±3.0 more progeny, $7,615±2615 more total feeder calf value, and $7369±2562 more total retained ownership value per sire. Similarly each unit increase in $EN EPD would be associated with .45±.2 more progeny, $378±173 more total feeder calf value, and $353±171 more retained ownership value per sire. These specific dollar values are contingent on the prices used in this evaluation but provide a benchmark as to the likely magnitude. Current 50th percentile Angus sires have a SC EPD of 0.50, compared to about 1.0 for the 20th percentile. This difference would be predicted to generate about 4.1 more calves, and $3,800 more total income per calf crop. Similarly, using the same 50th (-1.47) and 20th (7.87) percentiles for $EN EPD the difference would be about 4.2 more calves and $3,300 more total income per calf crop.

According to the American Angus Association web site the Cow Energy Value Index ($EN) EPD uses components including lactation energy requirements and mature cow size (http://www.angus.org/Nce/ValueIndexes.aspx). These components maybe correlated to factors used in MILK EPD and CW EPD. In this group of bulls the correlation between $EN EPD and MILK EPD was -0.89 and -0.39 with CW EPD. However, neither MILK EPD nor CW EPD nor both together could replace $EN EPD (when used with SC EPD), although MILK EPD approached significance at a P value of 0.06-0.08. Clearly the SC EPD relationship to total income is due to the dependence of total income on prolificacy. But nonetheless this SC EPD relationship with total income can be directly expressed numerically (as above). Scrotal circumference has consistently been reported to be a useful method for assessing reproductive function in bulls (Burns *et al*.. 2011). Scrotal circumference EPDs have been positively associated with sperm motility and total BSE score (Moser *et al*.. 1996). It has also been identified with age of puberty in female offspring as well as several other reproductive traits (see Drake *et al*. 2011). An Australian outback study with *Bos indicus* bulls found prolificacy was repeatable, 0.43-0.69 (Holroyd 2002) and preliminary work with the CA commercial ranch data suggests a low to moderate heritability for prolificacy. Collectively this suggests SC EPD, and possibly $EN EPD, should be included in bull selection decisions to increase prolificacy and total income under natural breeding systems similar to these ranches.

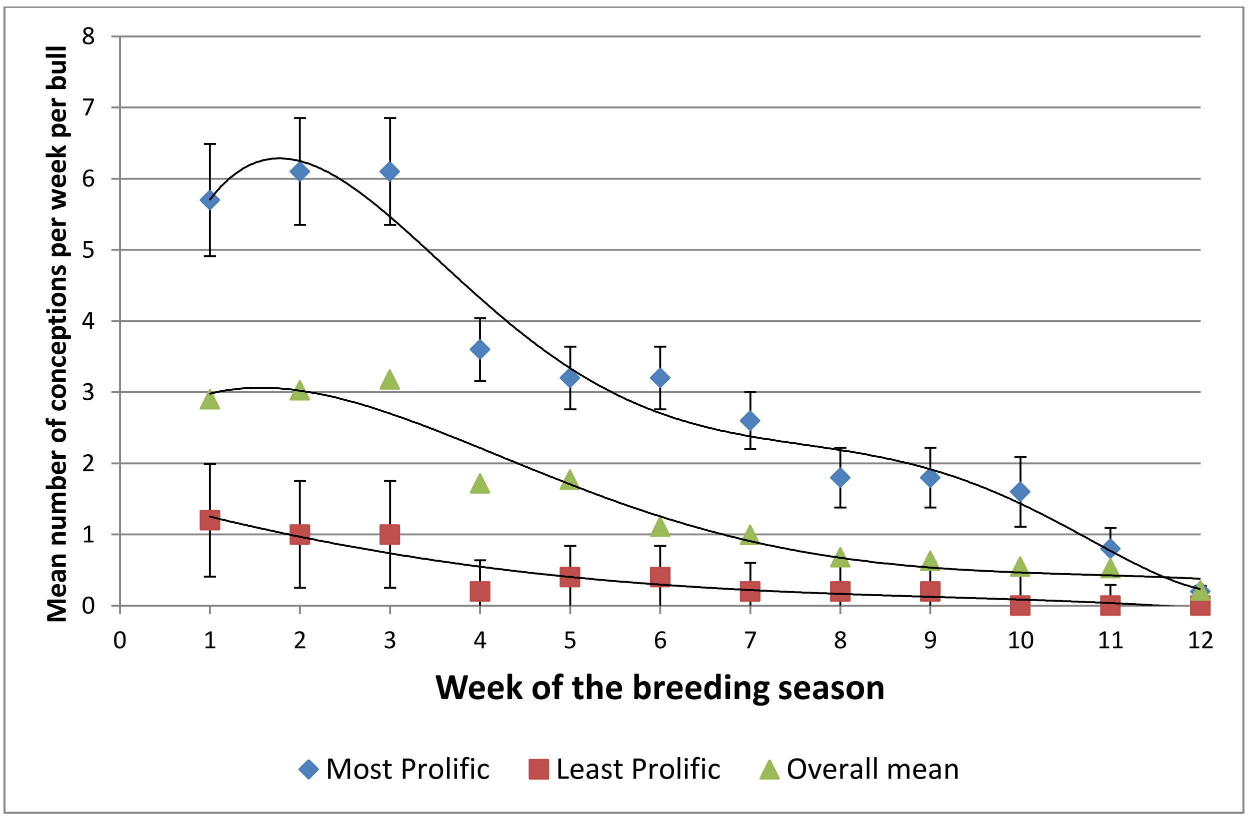


Figure 7. Conceptions per week were greater (P<.02) during each week of the breeding season for the first 10 weeks of the breeding seasons for the two most prolific bulls (from each calf crop) compared to the least prolific bulls. Weekly conception means for all bulls were about 3 during the first 21 days of the breeding season, dropping to 1.5 for the next 21 days, and dropping to about 0.5 for the next 21 days.

Calving Distribution (Day of calving). If the genetic potential of sires differs by day of calving, then the impact of days of calving will be confounded by sire effects. DNA paternity testing has the added advantage in that it allows sire effects to be teased apart from day of calving effects in multisire herds. Calves born during the first 21 days of the calving season will likely not be randomly distributed among sires in multi-sire breeding pastures: highly prolific sires will sire more early calves than low prolificacy sires (Figure 7 on previous page).

Feeder calf. Feeder calf weight and value per head declined for each calving period (Table 2). Due to the lighter weights of the later born calves, they received higher prices per pound, but were still worth less per head. Calves born in the first 21 days were worth about $8 (0.9%) more per head than those born in the second period, and nearly $29 (3.4%) more than those born in period 3. When sire effects were removed from feeder calf value, the effects of day of calving were larger: period 1 calves were $13 (1.4%) higher than period 2 and $31 (3.7%) higher than period 3. As expected earlier born calves were older as feeder calves sold on the same calendar date. Birth weights from these commercial calves were unavailable to calculate daily pre-weaning gain so weight per day of age (WDA) was used. WDA was lower for calves born earlier similar to heifers observed by Funston *et al*. 2012. This effect may have been influenced by a slowing of the growth rate with age. Therefore, calf age was used as a covariate, showing that with age removed growth rate was higher for early-born calves when adjusted for sire differences.

Retained ownership calves. Day of calving also influenced various feedlot traits. Earlier born calves returned carcasses of greater value (Table 2); and sire effects were statistically significant. Daily gain and feed costs in the feedlot were not influenced by day of calving. Funston *et al.* 2012 also found day of calving did not influence feedlot ADG. Day of calving did not significantly impact carcass price premiums. Retained value, $/head, from retained ownership (carcass value minus feed costs) was higher for calves born earlier in the calving season; sire effects were also significant. Calves from periods 1 and 2 were similar in value but were about $30/head (3.7%) more valuable than calves born in period 3.

Carcass traits. Carcass weights, marbling scores and yield grades declined for calves born later in the calving season (Table 2). These observations matched those of Funston *et al.* 2012. Ribeye area also declined for later calves. Yield grade differences were not due to differences in fat thickness which were similar across all four calving periods.

Table 2. Calving distribution categorized as 21-d periods affected feeder calf, retained ownership and carcass traits[1]. Periods were evaluated without removing sire effects (left), and with sire effects removed (right).

Trait	Calving Period	Without Sire Effects Removed			With Sire Effects Removed		
		Mean		SEM	Mean		SEM
Feeder calf wt	1	723	a	2.8	722	a	3.5
	2	715	b	2.7	710	b	3.6
	3	695	c	4.1	692	c	4.7
	4	676	d	5.1	669	d	5.6

	Calving Period	Without Sire Effects Removed			With Sire Effects Removed		
		Mean		SEM	Mean		SEM
Feeder calf price/lb	1	121.96	a	0.08	121.98	a	0.25
	2	122.09	a	0.08	122.23	b	0.25
	3	122.53	b	0.12	122.62	c	0.27
	4	123.05	c	0.15	123.25	d	0.29
Feeder calf value, $/hd	1	878.93	a	2.9	877.60	a	9.4
	2	870.91	b	2.9	865.25	b	9.5
	3	850.06	c	4.3	846.60	c	9.9
	4	829.22	d	5.4	821.60	d	10.4
Calf age into feedlot,d	1	353.6	a	0.44	356.6	a	2.07
	2	336.8	b	0.43	340.0	b	2.09
	3	316.5	c	0.64	319.9	c	2.15
	4	280.3	d	0.80	283.4	d	2.21
WDA at feedlot entry without age adjustment	1	2.05	a	0.009	2.04	a	0.037
	2	2.13	b	0.009	2.11	b	0.037
	3	2.21	c	0.013	2.19	c	0.039
	4	2.41	d	0.016	2.39	d	0.040
WDA at feedlot entry with age adjustment	1	2.19	a	0.013	2.20	a	0.017
	2	2.17	a	0.009	2.17	b	0.013
	3	2.14	b	0.014	2.13	c	0.016
	4	2.13	ab	0.026	2.09	c	0.027
Carcass grid value,$/hd	1	1244.89	a	4.4	1250.39	a	18.2
	2	1244.62	a	4.4	1247.52	a	18.3
	3	1213.31	b	6.5	1219.61	b	18.8
	4	1200.06	b	8.1	1200.34	b	19.6
Feed cost, $/hd	1	389.00	a	1.64	386.17	a	5.24
	2	392.13	a	1.61	389.38	a	5.17
	3	389.43	a	2.41	385.89	a	5.44
	4	396.25	a	3.00	392.71	a	5.74
Retained value, $/hd (Carcass grid Value minus feed cost)	1	859.00	a	3.9	852.80	a	7.8
	2	855.59	a	3.8	846.72	a	7.8
	3	826.98	b	5.7	822.30	b	8.7
	4	806.91	c	7.0	796.21	c	9.9
Feedlot price prem/disc $/hd	1	1.73	a	0.23	0.85	a	1.18
	2	2.01	a	0.23	1.29	a	1.18
	3	1.86	a	0.34	1.13	a	1.20
	4	1.42	a	0.42	0.70	a	1.24
Feedlot ADG, lb/d	1	3.21	a	0.025	3.27	a	0.038
	2	3.22	a	0.024	3.28	a	0.037
	3	3.14	a	0.036	3.22	a	0.045
	4	3.17	a	0.045	3.24	a	0.053

	Calving Period	Without Sire Effects Removed			With Sire Effects Removed		
		Mean		SEM	Mean		SEM
Carcass wt, lb	1	753	a	2.7	756	a	4.2
	2	752	a	2.6	753	a	4.1
	3	733	b	3.9	736	b	5.1
	4	728	b	4.9	727	b	5.9
Yield grade	1	3.30	a	0.026	3.25	a	0.090
	2	3.24	ab	0.026	3.20	ab	0.091
	3	3.18	b	0.038	3.13	b	0.094
	4	3.17	b	0.048	3.15	b	0.098
Marbling number	1	5.85	a	0.033	5.88	a	0.039
	2	5.78	ac	0.033	5.85	ab	0.039
	3	5.68	bc	0.049	5.77	bc	0.053
	4	5.53	b	0.061	5.63	bc	0.064
Fat Thickness	1	0.661	a	0.008	0.663	a	0.012
	2	0.651	a	0.008	0.651	a	0.013
	3	0.632	a	0.012	0.629	a	0.015
	4	0.648	a	0.015	0.643	a	0.018
Ribeye area	1	12.89	a	0.046	12.8499	a	0.063
	2	12.96	a	0.045	12.8587	a	0.0627
	3	12.78	a	0.068	12.6875	b	0.0802
	4	12.83	a	0.084	12.6358	b	0.0953

[1] Means within columns with different letters are statistically different, P≤0.05.

Quality Grade. The percentage of cattle grading USDA Choice plus or better varied by sire, ranging from 0 to 81 percent (Figure 8). In contrast the percentage of those grading Choice minus or better was not significantly different by sire. For both groups there were moderate correlations between a.) Choice minus or better percent: MARB 0.54, RE 0.24, FAT -0.42, $G 0.71, $QG 0.54, $YG 0.52 and B 0.38; b.) with Choice plus or better percent: MARB 0.84, RE 0.41, FAT -0.24, $G 0.79, $QG 0.82, $YG 0.31 and $B 0.68. Four EPDs were linearly related to the percent grading Choice plus or better, $G, MARB, $QG and $B (Table 3).

Table 3. The percent cattle grading USDA Choice+ or better for each sire varied and was linearly related to American Angus Association $G, MARB, $QG and $B EPDs.

EPD	Coefficient	SE	R2	P value	SE of prediction
$G	1.11	0.22	0.38	<.00001	12.2
MARB	35.9	7.8	0.34	<.00001	12.5
$QG	1.09	0.25	0.32	0.0001	12.8
$B	0.48	0.16	0.19	0.0039	13.9

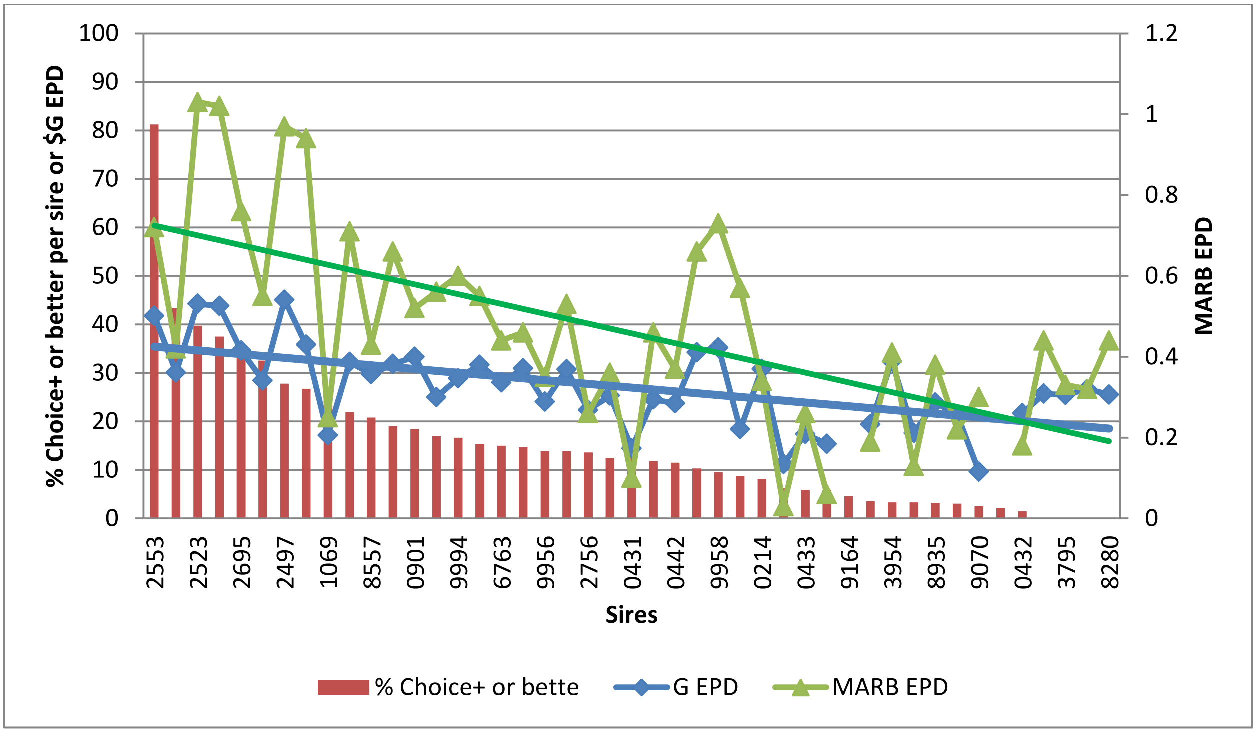


Figure 8. The percentage of progeny grading USDA Choice plus or better (black columns) ranged from 0 to 81 with differences between sires. $G (left axis; solid line) and MARB EPDs (right axis; dashed line) were linearly related to this value.

The $G and MARB EPDs were very similar in their relationship to percent grading Choice plus or better. A combination of EPDs was not superior to either $G or MARB EPDs by themselves. FAT, RE, and $YG EPDs were not linearly related to the percent grading Choice plus or better. These results support the use of $G or MARB EPDs in commercial beef herds to increase the percentage of higher quality grade cattle.

Total calf income. Calves born in the first 21 days contributed a cumulative total of about 40% of the total income as either feeder calves (Figure 9) or through retained ownership (Figure 10). Calves from periods 1 and 2 cumulatively contributed about 72% of the total income.

Summary and conclusions

The implementation of DNA paternity testing allowed for the evaluation of the bull prolificacy of multi-sire breeding pastures on commercial ranches. Under western US conditions bulls in commercial ranches sired between 0 and 54 calves per calving season. This range in the prolificacy of sires resulted in large differences in their contribution to total ranch income whether progeny were sold as feeder calves or retained ownership. Some bulls produced calves that returned more value when their progeny were sold as feeder valves and others when they were retained ownership calves. Scrotal circumference (SC) EPD previously reported important for female fertility traits was identified as positively correlated with sire prolificacy, as was the Cow Energy Value Index ($EN) EPD. Small, but significant, effects of early calving was found for numerous traits including subsequent returns as either feeder or retained ownership calves. Selection for prolific bulls and management to reduce late calves would improve carcass traits and over economics of the ranch.

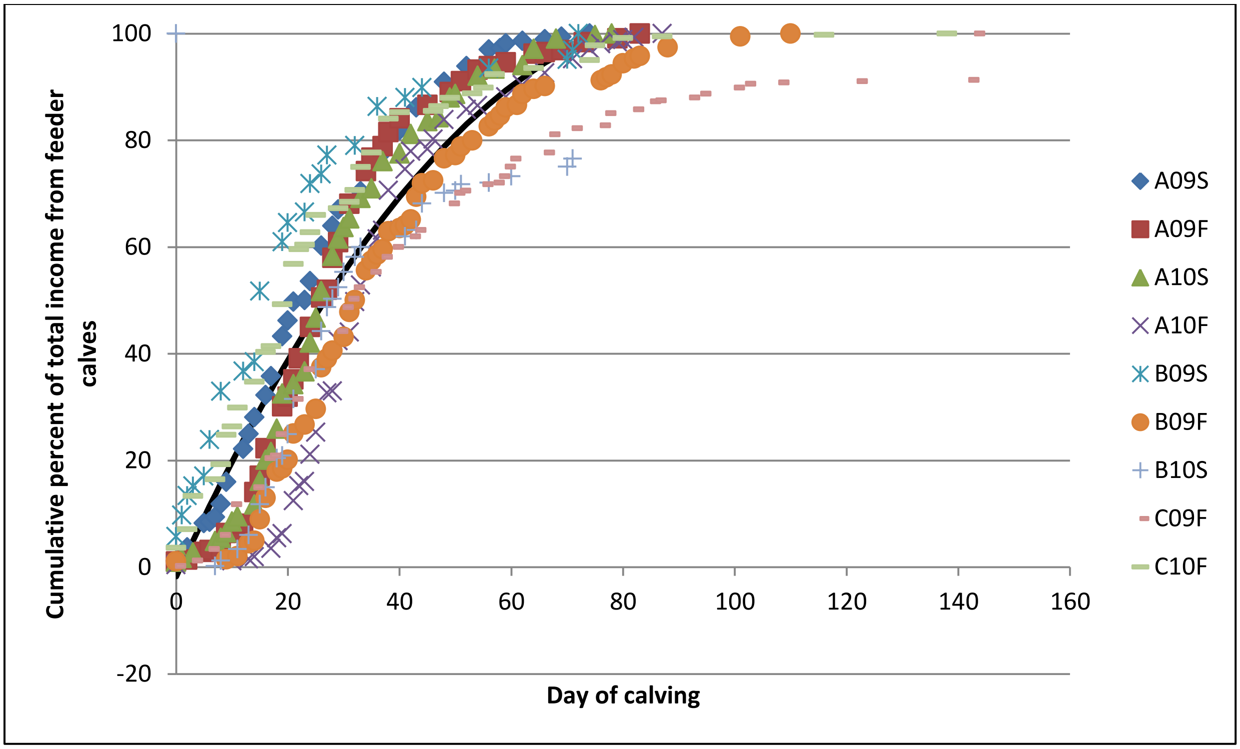


Figure 9. Cumulative percent of total feeder calf value increases rapidly with about 40% of the total income from feeder calves generated by the end of the first 21 days of the calving season. About 72% of the total feeder calf income was generated by calves born in periods 1 and 2.

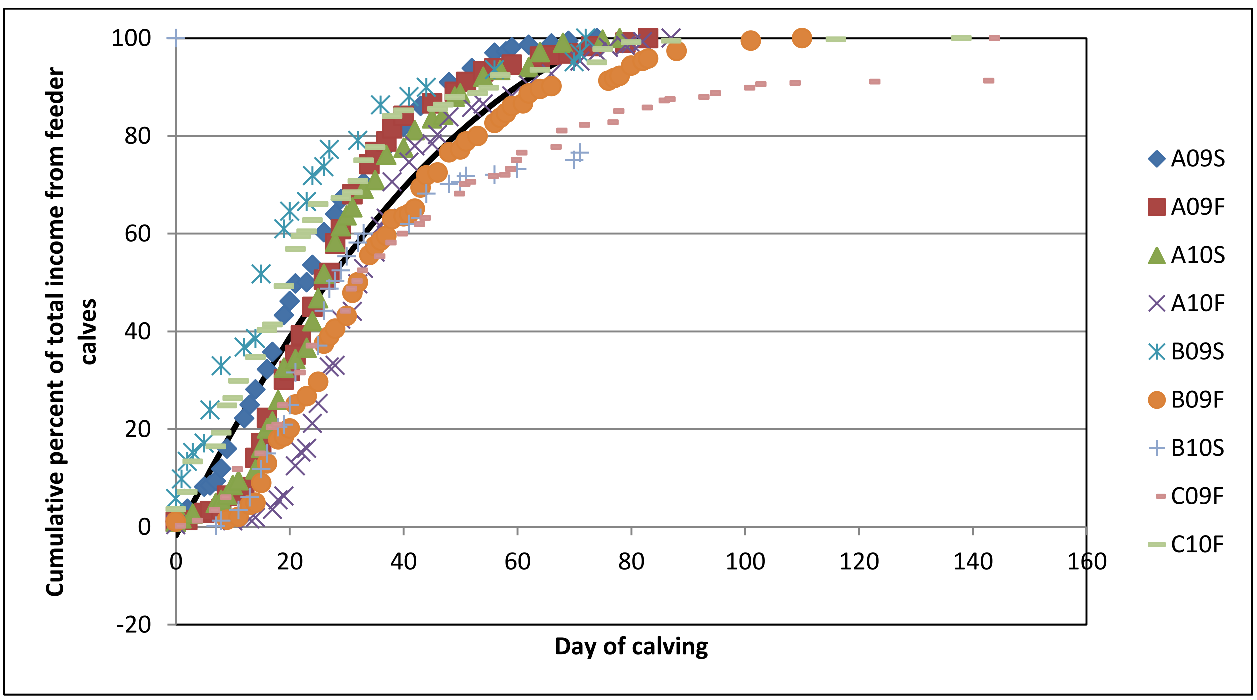


Figure 10. Cumulative percent of total retained ownership value increases rapidly with about 40% of the total income from feeder calves generated by the end of the first 21 days of the calving season. About 72% of the total feeder calf income was generated by calves born in periods 1 and 2. Legend refers to Ranch (A, B, C), Year (09, 10), and Season (Spring or Fall) .

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