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MANAGEMENT DECISIONS IMPACTING REPRODUCTION AND LONGEVITY IN THE SOUTHWEST

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Introduction

Profitability for beef cow-calf producers can be directly tied to the productive life span of a mature cow. Although there are several factors that may result in a cow leaving the herd (i.e., temperament, structural issues, or age) the main reason cows leave the herd relates to reproductive failure- whether it be failure to maintain a pregnancy or produce a live calf (Renquist et al., 2006). Improving cow longevity is a challenging process, due in part to the multitude of factors involved. Due to production delays inherent in beef cattle production (cows produce their first calf at 2 years of age), cows must produce between 3 to 5 calves for the producer to recoup heifer development costs (of which the opportunity cost of selling the animal as a heifer is included). Although this value will vary amongst producers due to differences in development systems, it is critical that we identify methods or indicators that may aid producers in recognizing which animals have the potential to be most productive.

Hohenboken (1988) suggested over 20 traits the ideal cow should possess, including: attain puberty early as a heifer and produce her first calf by the time she is 2 years old. Additionally, this animal should conceive at her first opportunity to mate each year and maintain a 365 calving interval. The cow should also fit her environment, provide adequate maternal care and transmit genetic merit to her calves for an acceptable growth rate and acceptable efficiency for feed use and carcass and meet quality (Hohenboken, 1988). Obstacles associated with selecting animals to fit these important traits are challenging as selection of heifers typically occurs prior to most of these traits being displayed. Also, measurement of several of the listed traits is challenging/ time consuming or expensive. Finally, most traits associated with fertility have a low heritability, suggesting that the environment may play a larger role in phenotypic expression of a trait than other production traits.

The objective of this presentation is to provide information regarding the role management and environmental factors play in impacting the reproductive lifespan of a cow, with emphasis placed on key management time points that may improve animal performance and longevity.

Calving Early in the Season

Within the first 2 years of life, heifers are expected to grow to nearly 65-75% of mature size, attain puberty, and produce their first viable offspring. Previous research (Lesmeister et al., 1973) reported increased lifetime productivity for cows calving at 2 years of age compared to 3. Additionally, it has been reported that heifers calving late increases the likelihood of the animal calving late or not calving the following year (Burris and Priode, 1958). This is important to note as maintaining a 365 day calving interval is important for production efficiency. Thus, management strategies must be put in to place to allow heifers to reach their reproductive potential. Given the importance of reproduction and longevity on the overall profitability of a cow-calf operation, reproductive traits are 3 to 9 times more influential on profitability than other production traits (Melton et al., 1995), it is critical to identify traits or management strategies that may improve lifetime production of a cow.

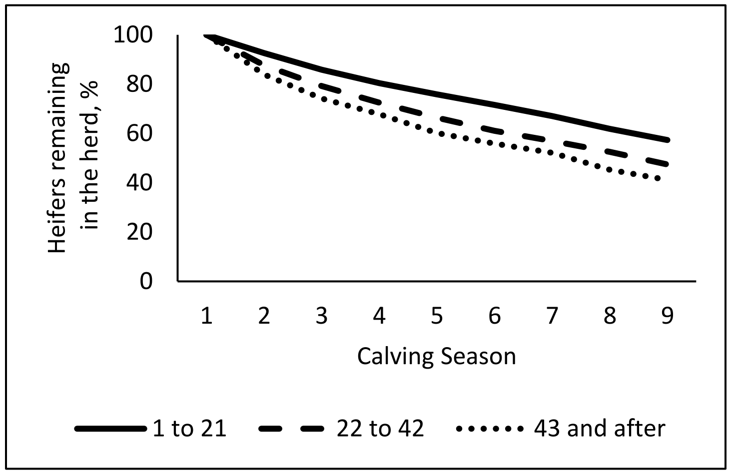

Figure 1. Influence of first calf calving period on cow longevity. Adapted from Cushman et al., 2013.

To determine the influence of calving date as a heifer on lifetime productivity of beef cows, researchers at the U.S. Meat Animal Research Center (USMARC) in Clay Center, Nebraska analyzed the calving records of 16,549 replacement heifers born from 1980 to 2000 (Cushman et al., 2013). Animals were placed in 1 of 3 calving groups (first, second, or third 21-day period) based on calving date as a 2 year old heifer. Heifers that calved in the first 21 days remained in the herd longer ($P < 0.05$) than those calving for the first time in the second or third 21 days of the calving season (Figure 1). Coincidentally, age when diagnosed as open was greater for cows that calved in the first 21 days as a 2 year old (8.2 ± 0.3 years) compared to those calving in the second (7.6 ± 0.5 years) or third 21 days (7.2 ± 0.1 years) of the calving season (Cushman et al., 2013). Additionally, pregnancy rate was greater for cows calving in the first 21 days each year from second breeding season through the sixth breeding season compared with cows from either the second or third 21 day calving groups. This improvement in pregnancy rate and overall increased herd retention is likely a function of improved physiological status in the cows calving in the first 21 days as a heifer. After parturition, fertility in cattle is reduced due to several physiological mechanisms, one of which is uterine involution (Graves et al., 1968). Due to type of placentation- cotyledonary- in a cow, involution of the placenta is a complex process involving contraction of organ size, loss of tissue and repair (Kindahl et al., 1999). Complete involution of the uterus can occur as quickly as a 3 weeks; however, it is often not completed until 4 to 5 weeks after calving (Kindahl et al., 1999). Due to the earlier calving date in cows that calved in the first 21 days compared to second or third 21 days, postpartum interval was 113 days compared to 92 and 71 days in second and third 21 day calving groups, respectively.

Cushman et al. (2013) also reported increases in calf weaning weights for cows calving in the first 21 days compared to their contemporaries through the first 6 calves (Figure 2). These data agree with Funston et al. (2012a) reporting steer progeny born in the first 21 d of the calving season were approximately 29 and 46 pounds heavier ($P < 0.01$) at weaning than steer progeny born in the second and third 21 days of the calving season, respectively. Differences in body weights among groups are maintained ($P < 0.01$) through slaughter as hot carcass weights were 13 and 26 pounds greater for calves born in the first 21 days compared with calves born in the second or third 21 days respectively. Additionally, carcass value was greatest ($P < 0.01$) for calves born during the

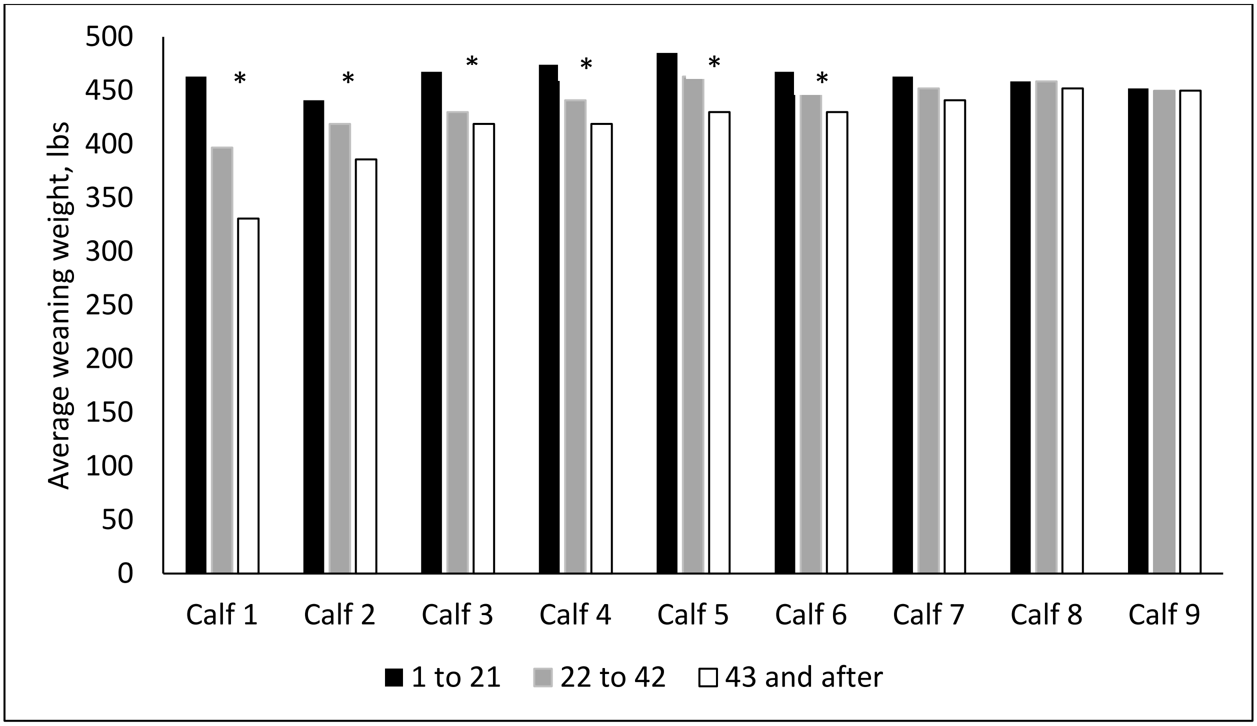

Figure 2. Calf weaning weights based on heifer calving period at USMARC. (**P* < 0.05). Adapted from Cushman et al., 2013.

first 21 days of the calving season (Funston et al., 2012a). Together these data highlight the production and economic advantages of managing cows to calve early in the calving season.

Impact of Maternal Environment

Cattle grazing western rangelands encounter a wide variety of forages and forage quality. Season, precipitation level, and plant maturity will all play a role in forage quality. Although cattle can select a diet approximately 2% greater in crude protein values than estimated or harvested forage values (Mathis, 2003), situations still arise in which forage quality does not meet the nutrient requirements of the cow. Additionally, drought may result in reduced forage availability or nutrient availability leading to reduced animal performance (Olberg, 1956; Scasta et al., 2015). To aid in

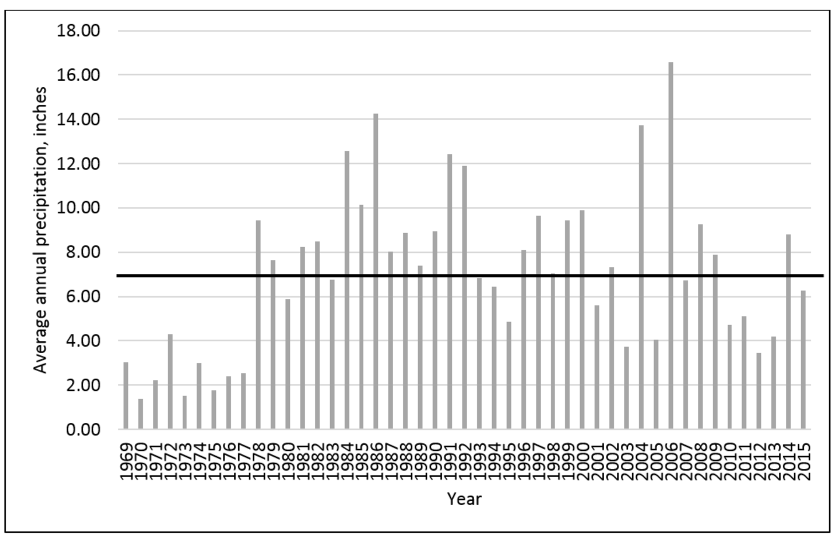

Figure 3. Annual precipitation reported on the Chihuahuan Desert Rangeland and Research Center from 1969-2015 in mm. Average precipitation level indicated as dark horizontal bar (7.08 in).

our understanding of how precipitation levels during key time points of gestation may impact progeny growth, precipitation data (Figure 3) and cattle performance records over a 46 year period from the NMSU Chihuahuan Desert Rangeland Research Center (CDRRC), located in southern New Mexico, were retrospectively analyzed (Beard et al., 2017). Average annual precipitation for the CDRRC was 7.08 inches with a low of 1.38 inches and a high of 16.58 inches. Key time points included early gestation (July to September), late gestation (December to February) and total precipitation (April through March), which coincides with a total production year- breeding to calving. For each period, a z-value, was determined based on the overall precipitation mean creating three classes of treatments defined as low (Low; z-value ≤ -1.00), average (Avg; z-value -0.99 - + 0.99), and high (High; z-value ≥ +1.00) using the similar method reported by Palmer (1965). Standard deviation (σ) being determined based on the overall precipitation mean from the 46 year period utilizing the following formula.

$$\sigma=\sqrt{\sigma^2}$$

A z-value was determined using the formula below, for each designated period. Each period mean was calculated based on the calf's birth year.

$$Z = (X - \mu) / \sigma$$

Z represents the z-value and X is the value of the element in this case it's the period mean. Additionally, μ represents population mean which is the overall period precipitation mean. Over the reporting period, 63% of years were considered Avg whereas 22% and 15% were considered High and Low, respectively. Calves experiencing Avg or High precipitation during gestation had greater birth weights when compared to calves experiencing Low precipitation levels. Additionally, calves that experienced High levels of precipitation during early gestation or the total

Table 1. Brangus calf growth performance based on precipitation received in-utero

	Treatments[1]				
Item	Low	Avg	High	SEM	*P*-value
Birth Weight (lb)					
Early Gest.[2]	70	77	77	3.7	0.05
Late Gest.[3]	75	77	-	2.0	0.89
Total[4]	68[a]	77[b]	81[b]	3.5	0.05
Weaning Weight (lb)					
Early Gest.	480[a]	519[ab]	570[b]	32	0.04
Late Gest	499	539	-	17	0.12
Total	480[a]	524[ab]	568[b]	35	0.05

[1]Treatments are Low (Low) = z-value ≤ -0.99, Average (Avg) = z-value -0.99 to +0.99 of the mean, and High (High) = z-value ≥ 0.99.

[2]Late Gest= Summation of monthly average rainfall received during the last trimester Dec-Mar.

[3]Early Gest= Summation of monthly average rainfall received the first trimester from July to September.

[4]Total = Summation of monthly average rainfall from average conception date to average parturition date.

[ab]Within a row means with different subscripts are different ($P < 0.05$).
Adapted from Beard et al., 2017.

period had greater weaning body weights ($P \leq 0.05$) compared with calves experiencing Low precipitation during the same time (Table 1). These data agree with Gatson et al. (2016), reporting calves born in years where prepartum growing seasons (April to October) were wetter than normal (received more precipitation than average) were heavier entering the feedlot than calves from dams exposed to a drier than normal environment. Alterations in calf body weight due to precipitation level would be expected based on the assumption that forage growth and availability would be affected by the precipitation level prior to the forage growing season. During prolonged drought events, reductions and forage yields and quality have been reported (Oelberg, 1956; Chaves et al., 2002).

Reproductive potential and longevity were also measured by Beard et al. (2017) based on precipitation level (Table 2). Although age at first calving and proportions of cows calving at 2 years age did not differ ($P > 0.06$) among treatments based on precipitation level at any time, heifers experiencing low precipitation levels during early gestation or total year produced more calves ($P < 0.0001$) during their lifetime than their counterparts experiencing High precipitation during the same periods. Alterations in nutrition during early gestation have previously been reported to alter female progeny reproduction (Da Silva et al., 2002; Sullivan et al., 2009; Mossa et al., 2013). Gonadal development occurs during early gestation with formation of the ovary occurring by approximately day 50 of gestation. This is followed by development of the primordial follicle pool, which occurs on approximately days 80 to 143 of gestation (Nilsson and Skinner, 2009). This pool of follicles, also referred to as the ovarian reserve represents the total number of high quality oocytes within the ovary which will be utilized by the animal during its reproductive

Table 2. Brangus female progeny performance based on precipitation received in-utero

	Treatments[1]				
Item	Low	Avg	High	SEM	*P*-value
Age at first calving					
Early Gest.[2]	2.27	2.20	2.33	0.10	0.17
Late Gest.[3]	2.24	2.25	-	0.05	0.90
Total[4]	2.22	2.26	2.20	0.09	0.82
Calved at 2 yrs of age,%					
Early Gest.	77	87	81	5	0.06
Late Gest.	85	84	-	2	0.81
Total	82	85	86	5	0.77
Calved after 8 yrs,%					
Early Gest.	48	18	9	5	<0.0001
Late Gest.	18	19	-	3	0.66
Total	38	15	16	5	<0.0001
Number of calves					
Early Gest.	5.90[a]	3.78[bc]	3.11[c]	0.40	<0.0001
Late Gest.	3.63	3.95	-	0.19	0.22
Total	5.23[a]	3.52[bc]	3.88[c]	0.36	<0.0001

[1]Treatments are Low (Low) = z-value ≤ -0.99, Average (Avg) = z-value -0.99 to +0.99 of the mean, and High (High) = z-value ≥ 0.99.

[2]Early Gest= Summation of monthly average rainfall received the first trimester from July to September.

[3]Late Gest= Summation of monthly average rainfall received during the last trimester Dec-Mar.

[4]Total = Summation of monthly average rainfall from average conception date to average parturition date.

[a,b,c]Within a row means with different subscripts are different (P <0.05).

Adapted from Beard et al., 2017.

lifespan. Mossa et al. (2013) reported fewer follicles (via ultrasonography) present when heifers were born to cows receiving only 60% of maintenance requirements compared with heifers born to cows receiving 100% maintenance requirements starting 11 days prior to artificial insemination up to day 110 of gestation. Similarly, Da Silva et al. (2002) reported a reduced ovarian follicles from progeny of ewe lambs fed to achieve rapid maternal growth rates throughout pregnancy compared with progeny from ewe lambs fed to gain 50–75 g/d through the first 100 d of gestation.

Although the mechanisms responsible for improved heifer longevity when experiencing a more harsh (low precipitation levels) environment in utero reported by Beard et al. (2017) are not well defined, the results could be explained by one of two theories: improved nutrient diffusion to the fetus and a programming of the fetus to deal with a harsher environment or 2) management intervention, providing an improved plane of nutrition for the animals experiencing a drought. Sheep born and developed in a nomadic environment in Wyoming had improved placental efficiency when experiencing 50% nutrient requirements compared to farm flock raised ewes (Vonnahme et al., 2006). This may suggest animals born in environments with limited resources are adapted to nutrient insults and can compensate to maintain normal nutrient allocation to developing fetuses while consuming a lower plane of nutrition. Conversely, reports from the University of Nebraska have indicated providing approximately 1 lb/hd/d 31 or 42% CP supplement to cows grazing dormant winter forage during late gestation may improve female progeny pregnancy rate and decreased age at puberty (Martin et al., 2007; Funston et al., 2010). These reports would suggest improving maternal plane of nutrition through management intervention will improve progeny fertility.

Influence of Heifer Development System on Productivity

The primary goal of heifer development systems is to develop replacement heifers while maximizing economic efficiency, reproductive performance, and longevity. Traditionally, heifers were targeted to achieve 60 to 65% of mature body weight prior to puberty and breeding (Patterson et al., 1992). However, developing heifers to traditional target body weight increased development costs compared to more extensive heifer development systems where either timing or rate of BW gain is altered. Clanton et al. (1983) reported no difference in reproductive performance in heifers developed on a constant rate of gain, late gain (with the majority of gain in the last half of the development period), or early gain (with the majority of gain achieved in the first half of the development period). This research reported timing of gain could be varied without a significant difference in reproductive performance. In addition, it brought about the concept of compensatory gain, with late gain heifers gaining more than predicted in each year of the 3 year study. Recent literature examining lower input systems, specifically pregnancy rates, calf birth date, and second season pregnancy rates (Table 3) reported no differences, although an increased age at puberty in some studies was reported. This potential shift in the negative impact of limited postweaning growth on reproductive performance could be caused by a number of factors. The transition in age at calving from 3 to 2 yr of age corresponded with the research contributing to the guidelines of developing heifers to 60 to 65% of mature body weight. Therefore, with increasing selection intensity for heifers to achieve puberty earlier, genetic selection may have decreased heifer age at puberty, allowing heifers developed in systems utilizing reduced nutrient intake to still attain puberty prior to the end of the breeding season (Funston et al., 2012b).

The objective of recent research has been to maximize economic efficiency of development systems through restricting nutrient intake early in the development system or developing heifers on dormant non-harvested forages (Table 3; Lynch et al., 1997; Freetly et al., 2001; Funston and Larson, 2011; Mulliniks et al., 2013). Altering rate and timing of body weight gain during heifer development can result in periods of compensatory growth, allow for reduced inputs, and may be a more economically feasible way to develop heifers (Lynch et al., 1997; Freetly et al., 2001; Funston et al., 2012b; Mulliniks et al., 2013). Lynch et al. (1997) reported similar pregnancy rates for heifers developed on restricted body weight gain until 47 or 56 d before the breeding season. In addition to altering pattern of body weight gain to reduce development costs recent research has investigated feeding to lighter target body weight. Roberts et al. (2009a) reported restricted heifers consumed approximately 27% less feed, resulting in a reduced ADG compared with control heifers during the individual feeding period. However, following the feeding period, ADG was greater for restricted heifers compared with control, suggesting a compensatory gain effect for restricted heifers. At initiation of the breeding season heifer body weight was equivalent to 55 and 58% mature body weight, with 60 and 68% of heifers achieving puberty prior to the breeding season for restricted and control heifers, respectively. While there was a trend for reduced AI pregnancy rates for restricted-fed heifers, final pregnancy rates were not different (Roberts et al., 2009b).

Funston and Deutscher (2004) reported heifers developed to 53% mature body weight prior to the breeding season had reduced body weight and percentage of heifers cycling prior to the breeding season compared to heifers developed to 58% mature body weight. However, pregnancy rates in the first three breeding seasons were not different between Low and High gain heifers (Funston and Deutscher, 2004). In addition, recent data suggests developing heifers to 50-57% mature body weight results in similar pregnancy rates to those developed to a greater percent mature body weight (Martin et al., 2008; reviewed by Funston et al., 2012b). Moreover, a recent study conducted by Eborn et al. (2013) investigated developing heifers on a lower plane of nutrition and

Table 3. Influence of postweaning nutrition on heifer reproductive performance.

Treatment	Age at puberty[a]	Heifer pregnancy rate[a]	Mean Calving date[a]	Second-year pregnancy rate[a]	Reference
Even gain vs. Late gain	INCR[b]	NS	—	—	Lynch et al., 1997
Low-High vs. High	—	NS	NS	NS	Freetly et al., 2001
Low gain vs. High gain	DECR[c,d]	NS	NS	NS	Funston and Deutscher, 2004
Restricted vs. Control	INCR[e]	NS	—	—	Roberts et al., 2009b
Drylot vs. Extensive	DECR[c,d]	NS	NS	NS	Funston and Larson, 2011
Corn Residue vs. Drylot	NS	NS	NS	—	Summers et al., 2014
Low-High vs Constant	NS	NS	NS	—	Rosasco et al., 2017

[a]Effect of reduced or late nutrient intake or growth compared with control; INCR = increased compared with control; DECR = decreased compared with control; NS = not significant.
[b]In year 2 only ($P < 0.01$).
[c]Reported as cyclic prior to breeding season.
[d]Means within study differ ($P < 0.05$).
[e]Means within study differ ($P < 0.10$).

subsequent effects on ovarian development and fertility. Specifically, developing heifers to 55% mature bodyweight did not influence ovarian development or follicle counts measured through transrectal ultrasound in the post-weaning development period compared with heifers developed to 64% mature body weight (Eborn et al., 2013). However, heifers on extremely low planes of nutrition throughout development can experience delayed puberty (Gonzalez-Padilla et al., 1975). Management of heifer body weight gain prior to the breeding season is critical for maximizing puberty attainment and pregnancy rates.

Incorporation of Reproductive Technologies

Although estrus synchronization and artificial insemination are tools that have been available for producer utilization for decades, incorporation of these tools has been limited in the beef cattle sector. Reports suggest producers have greater concerns about the difficulty of the procedure (17.8% surveyed) and labor/time involved (37.3%) than those concerned with the efficacy of estrus synchronization (2.1%; NAHMS, 2009). Utilization of estrus synchronization has been reported to shorten breeding the breeding season, initiate cyclicity in some anestrus animals, and increase the number of animals bred early in the breeding season (Lucy et al., 2001; Larson et al., 2009). Although synchronization did not influence overall pregnancy rates, Larson et al. (2009) reported a 13% increase in the proportion of heifers calving in the first 21 days of the calving season when a single injection of prostaglandin was administered approximately 108 hours after bull turn-in. Weaning weights did not differ (P = 0.58); however, postpartum interval would have been greater in the synchronized group of heifers which would likely aid in improving the proportion of the synchronized heifers becoming pregnant in the subsequent breeding season.

Another reproductive technology that could potentially aid producers in improving early breeding success, and thus improve herd longevity includes antral follicle count (AFC). Antral follicle count has been positively associated with fertility in *Bos taurus* cattle (Cushman et al., 2009; Mossa et al., 2012), with moderate to high heritability (Snelling et al., 2012; Walsh et al., 2014). Given that reproductive traits typically display low heritability, AFC may be an appropriate selection criteria to aid in improving reproductive performance of a population. Additionally, AFC is highly repeatable within an animal but varies among individuals (reviewed by Ireland et al., 2011).

Classifications are made based on the number of antral follicles identified by ultrasonography with animals having ≤ 15 being classified as low, 16-24 moderate, and ≥ 25 classified as high follicle count groups (Ireland et al., 2008). Typically, approximately 15 to 20% of individuals in a herd are classified as low or high AFC while the remainder of the herd classified as moderate AFC (reviewed by Ireland et al., 2011). Antral follicle counts are typically conducted in heifers prior to their first breeding season (13-15 mo of age). Previous studies report low AFC heifers had lower pregnancy rates and reduced numbers of morphologically healthy oocytes and follicles (Ireland et al., 2008; Cushman et al., 2009; Mossa et al., 2012) compared with high AFC heifers. Moreover, dairy cows classified as high AFC had 3.34 times greater (P < 0.05) odds ratio of getting pregnant compared with low AFC animals (Mossa et al., 2012). Additionally, Cushman et al. (2014) reported heifers calving in the first 21 days of the calving season had larger AFC than heifers calving in the second or third 21 days of the calving season. McNeel et al. (2015) reported similar findings, with AFC being significantly greater in heifers calving early in the calving season compared with those calving late, regardless of the use of estrus synchronization ($PGF_{2\alpha}$). Due to earlier calving, McNeel et al. (2015) also reported heavier weaning weights for heifers with higher AFC.

Conclusions

Cow longevity is vital for producer profitability. Although several factors can contribute to the ability of an animal to reproduce, management decisions can play a large role in allowing animals to reach their genetic potential. Although reproductive traits typically have low heritability, identifying traits that may aid in selecting animals which could increase longevity are important. Calving early as a heifer appears to be one of the greatest factors influencing overall productivity and longevity of a cow, thus using incorporating this trait as a measurement to help in management decisions may be of interest to producers. Reproductive technologies can be utilized to increase the probability of an animal being bred early in the breeding season, and consequently, calving earlier in the calving season. Year round nutrition programs and proper heifer development programs are also critical in establishing the foundation of reproduction and longevity in a beef herd. Although there is no specific trait or management tool that will identify the perfect cow, producers must identify management strategies that will allow for optimal animal performance while enhancing reproductive success and longevity to ensure profitability.

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