Regional and seasonal analyses of weights in growing Angus cattle

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ABSTRACT: This study evaluated the impact of region and season on growth in Angus seed stock. To assess geographic differences, the United States was partitioned into 9 regions based on similar climate and topography related to cow–calf production. Seasonal effects were associated with the month that animals were weighed. The American Angus Association provided growth data, and records were assigned to regions based on the owner’s zip code. Most Angus cattle were in the Cornbelt, Lower Plains, Rocky Mountain, Upper Plains, and Upper South regions, with proportionally fewer Angus in Texas compared with the national cow herd. Most calves were born in the spring, especially February and March. Weaning weights (WW; n = 49,886) and yearling weights (YW; n = 45,168) were modeled with fixed effects of age-of-dam class (WW only), weigh month, region, month–region interaction, and linear covariate of age. Random effects included contemporary group nested within month–region combination and residual. The significant month–region interaction (P < 0.0001) was expected because of the diverse production environments across the country and cyclical fluctuations in forage availability. Additionally, significant seasonal contrasts existed for several regions. Fall-born calves were heavier (P < 0.01) than spring-born calves in the hot and humid Lower South region coinciding with fall being the primary calving season. The North and Upper Plains regions had heavier, spring-born calves (P < 0.01), more than 90% spring calving, and colder climates. Interestingly, no seasonal WW or YW differences existed between spring- and fall-born calves in the upper South region despite challenging environmental conditions. Angus seed stock producers have used calving seasons to adapt to the specific environmental conditions in their regions and to optimize growth in young animals.

Key words: adaptability, beef cattle, cow–calf production, weaning weight, yearling weight

INTRODUCTION

Numerous factors affect the success, production, and profitability of cow–calf operations. It is well known that feed costs make up two-thirds of enterprise expenses (McBride and Mathews, 2011). In addition, matching cow nutritional status to the environment by altering the calving season to align maximum cow requirements with peak forage quality has well-documented effects on profitability (Adams et al., 1996). The ideal calving season varies due to seasonal fluctuations in cattle markets and the diverse geographic and climatic landscape of the United States. This diversity contributes to genotype × environment interactions and complicates identifying the ideal cow type and most profitable management practices.

Many studies have focused on either regional or seasonal impacts on cattle production but not both on a comprehensive, national scale. Producer surveys characterize beef enterprises on regional and national scales but are subject to nonresponse bias. Animal experiments require substantial time and monetary investment to investigate regional, seasonal, or both effects. Moreover, much of the peer-reviewed research occurred decades ago. Modern Angus cattle have drastically changed from the Angus cow in the 1990s because of selection for greater milk production and growth (AAA, 2016). Consequently, modern cattle have greater nutritional needs, which could affect environmental fitness. The beef industry would

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benefit from a reevaluation of regional and seasonal factors associated with calf growth.

The purpose of this observational study was to quantify regional and seasonal weight differences for growing cattle. These factors were characterized using a large, breed association data set to better understand regional and seasonal aspects of calving distributions and calf growth in Angus herds on a national scale. The results have economic implications for users of Angus genetics to maximize profit for specific management and environmental conditions.

**MATERIALS AND METHODS**

Animal Care and Use Committee approval was not needed because data were obtained from existing databases. The American Angus Association (AAA; St. Joseph, MO) provided weaning and yearling data in August 2015. All records met AAA data quality requirements for use in their national cattle evaluation. Contemporary groups consisted of sex, owner-defined group codes, weigh date, and herd; yearling contemporary group also included weaning contemporary group. Data were edited to include only animals located in the continental United States, multiple-sire contemporary groups, minimum contemporary group size of 5 animals, weigh years in 2005 or later, and an owner zip code. Embryo transfer calves were removed because of extensive use of cooperator herds in the Angus breed and potential inaccuracies from assigning these animals to regions based on the owner’s zip code. Additionally, records were removed if the owner’s zip code was known to be different from the primary herd location. Inaccuracies in assigning locations may occur for cattle raised far from the farm headquarters including satellite ranches, bull test stations, heifer development centers, and feed intake facilities. The resulting data set contained 2,194,339 weaning weights (WW) from 7,665 herds and 1,133,706 yearling weights (YW) from 4,921 herds and was used to quantify the numbers of records and calving distributions by region.

The continental United States was partitioned into 9 regions based on similar geography and environmental conditions including temperature and precipitation. Region definitions were similar to those in Leighton et al. (1982), and producers were assigned to regions based on the zip code associated with each weight record. Region boundaries are shown in Fig. 1, and regional record counts are presented in Fig. 2. For the season component, month corresponded to the month of the animal’s weigh date and differed for WW and YW analyses.

To evaluate phenotypic weight differences between seasons and regions, the data were further refined to reduce dimensionality by randomly selecting 25 contemporary groups per month–region combination for both WW and YW. If fewer than 25 groups existed in a month–region combination, all contemporary groups were included with a minimum of 10 contemporary groups per combination for WW and YW. All animals within the chosen contemporary groups were included in the analyses. This procedure ensured that selection based on contemporary group size did not introduce bias and that all month–region combinations were represented in the final data despite differences in calving seasonality across regions. The final data set contained 49,886 WW from 1,482 herds and 45,168 YW from 1,258 herds.

Regional and seasonal weight differences were evaluated using the following linear mixed model implemented in the nlme package (Pinheiro et al., 2015) in R (R Core Team, 2015):

$$y_{ijklmn} = \beta_1 a_i + aod_j + m_k + r_l + mr_{kl} + c_{klm} + e_{ijklmn},$$

in which $y_{ijklmn}$ was the weight for animal $n$, $\beta_1$ was the regression coefficient for age, $a_i$ was the age of the animal on the weigh date (120 to 280 d for WW and 320 to 620 d for YW), $aod_j$ was the fixed age-of-dam class effect for WW only (2, 3, 4, 5 to 10, or $\geq$11 yr; BIF, 2008), $m_k$ was the fixed month effect corresponding to the weigh date (January through December), $r_l$ was the fixed effect for 1 of the 9 regions previously defined (Fig. 1), $mr_{kl}$ was the fixed interaction effect between month $k$ and region $l$, $c_{klm}$ was the $m$th random contemporary group effect within the $k$th month and $l$th region combination, and $e_{ijklmn}$ was the random residual for animal $n$. Contemporary groups were assumed to be normally distributed with variance

$$\text{var}(e) = \sigma_c^2 I_n,$$

in which $\sigma_c^2$ was the contemporary group variance and $I_n$ had dimension equal to the number of animals.
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for WW or YW. This model was used separately for WW and YW analyses. Orthogonal contrasts were constructed to compare the difference between spring and fall weights within each region. Spring was defined as January through June, and fall was defined as July through December.

RESULTS AND DISCUSSION

Characterization of the Growth Database

Based on the number of records per region (Fig. 2), the majority of Angus cattle were raised in the Cornbelt, Lower Plains, Rocky Mountain, Upper Plains, and Upper South regions of the United States. The Lower South, North, and Pacific had little practical impact on Angus seed stock production and corresponded to areas with greater population densities and lesser agricultural production. The Rocky Mountain region had many records despite the effect of altitude on growth and survival (Williams et al., 2012). Interestingly, many Angus cattle were raised in the Upper South region despite being less heat tolerant than *Bos indicus* and tropically adapted *Bos taurus* breeds (Hammond et al., 1996), potentially resulting in economic losses for beef producers (St-Pierre et al., 2003). In contrast, the Lower South and West regions, both containing states with hot climates, had substantially fewer weight records, suggesting that either Angus were less adaptable to these environments or the areas had less overall cow–calf production. Limited research existed on the national distribution of beef cattle breeds for comparison at the time of this study. According to USDA surveys from 2005 to 2015, Texas had the most beef cows on inventory with 15% of the national cow herd whereas Montana had only 5% (USDA, 2016). Comparing those results with the results of this study, Texas had only 4% of all WW records whereas Montana had 13%. The distribution of weights across different regions in Fig. 2 suggested that southern producers raised other pure breeds, composites, or crossbreeds that were more adapted to the hotter climate but that Angus genetics were well adapted to colder northern climates.

Calving seasonality has not been characterized with data encompassing the entire United States. In the present study, spring and fall calving seasons were clearly distinguished based on counts by birth month (Fig. 3). The spring calving season contained more than 75% of calves, primarily born in February and March. Summer calving was rare in this data set, and fall calving peaked in September. Less spring calving occurred in the Lower South and Upper South regions where heat stress can occur from mid April until mid September (Fig. 4). The Pacific and West regions had an intermediate proportion of spring calving, which was probably because these 2 regions spanned a large range in latitudes. Meanwhile, the North, Rocky Mountain, and Upper Plains regions had at least 90% spring calving. These regions have very cold winters and producers most likely needed to align cow requirements during lactation with the peak quantity and quality of grazed forages. Cow–calf producers reported similar patterns in an earlier study, where producers in states associated with the Pacific, Rocky Mountain, Upper Plains, and West regions reported predominately spring calving and producers in the Lower South and Upper South regions reported more year-round calving (USDA, 2010b). In another USDA survey, 25% of cow–calf producers selected weather as the most important factor affecting the breeding season (USDA, 2010a). Seasonal fluctuation in feeder calf prices also affected the best calving strategy in this study. Overall, regional differences existed for the choice of calving season and producers appeared to determine the calving season that was optimal for their specific production environment.
For the phenotypic weight analyses, age, age-of-dam class (WW only), month, region, and month \(\times\) region interaction were all significant \(P < 0.0001\). The interaction was expected and resulted from the diverse combinations of topography and climate, which caused variation in feed resources, management practices, and cattle performance. These results are important for the design and interpretation of livestock field trials and experiments, as findings may not be generalizable to other seasons or regions.

Contrasts were summarized as the difference between spring and fall WW and YW (Fig. 5). Positive contrasts indicated spring weights were heavier than fall weights, corresponding with heavier fall-born calves than spring-born calves for WW and heavier spring-born calves than fall-born calves for YW. Fall-born calves had lighter WW \(P < 0.05\) in 3 regions (the Cornbelt, North, and Rocky Mountains), all located in colder climates. These findings were similar to results of a lesser magnitude observed in the Nebraska Sandhills (Griffin et al., 2012). Lighter WW for fall-born calves could be caused by feeding poorer-quality, harvested forages to lactating cows during their greatest nutritional demand, which coincided with harsh winters in this region. Only the Lower South region had fall-born calves with heavier WW \(P < 0.05\) coinciding with fall being the predominant calving season. Earlier studies showed similar results but to a lesser extent in Louisiana and Texas, where fall-born calves were heavier at weaning and consumed better quality cool-season grasses than their spring-born counterparts (Bagley et al., 1987; Gaertner et al., 1992). In this region, fall-born calves would experience less heat stress, resulting in greater weights. Based on these results, seasonal WW differences existed in regions with either very cold winters or very hot, humid summers.

The Lower South and West regions had heavier YW for fall-born calves \(P < 0.05\), and the Upper Plains had heavier YW for spring-born calves \(P < 0.05\). The Lower South and West had dramatically different climates with the Lower South being much more humid than the West, yet both had fall-born calves with 100-kg heavier YW (Fig. 5). Fall-born calves were expected to have lighter YW in these 2 regions due to the negative impact of heat stress on summer weight gain (Mitlöchner et al., 2001). Alternatively, spring-born calves were heavier as yearlings in the Upper Plains, which had a colder climate and substantial snowfall. The 100- to 150-kg YW contrasts (Fig. 5) could be caused by seasonal differences in feeding strategies for some regions. Few researchers have investigated seasonal effects for YW in seed stock or even stocker cattle. Carcass weights were heavier for spring-born calves in Iowa (Janovick-Guretzky et al., 2005), but these animals were managed differently than seed stock bulls and replacement heifers.

One unexpected result was the lack of significant seasonal weight differences \(P > 0.10\) in the Upper South region. The Lower Plains region also had no significant weight difference \(P > 0.10\) between seasons and was a western extension of the Upper South region. Many factors contributed to the expectation of differences in either WW or YW in the Upper South region. The southern portion of the South region should have a climate similar to that of the Lower South, where Angus heifers suffer from greater heat stress than heifers from other breeds (Hammond et al., 1996). Additionally, the primary forage base in the northern part of the Upper South region probably consisted of endophyte-infected tall fescue (West, 1998), which has been shown to increase body temperature, causing more severe heat stress and decreasing calf WW (Paterson et al., 1995; Brown et al., 1997; Caldwell et al., 2013). Previously, fall-born calves were heavier at weaning than spring-born calves in Arkansas, one of the characteristic states in this environment (Caldwell et al., 2013). Despite these factors, the environmental conditions in the Upper South region did not cause significant seasonal differences in WW or YW in this analysis. From this study, producers in the South region appeared to have identified the genetics and production systems best suited to where they resided within this region, or cattle were receiving supplementation to maintain consistent weights throughout the year. The current study had no information regarding forage type and could not specifically identify weight differences attributed to endophyte-infected tall fescue. With yearly variation in temperature and precipitation, a
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Figure 5. Contrasts were evaluated between spring (January through June) and fall (July through December) weaning weights (WW) and yearling weights (YW) in Angus cattle by geographic region. Positive contrasts indicated spring weights were heavier than fall weights, corresponding with heavier fall-born calves than spring-born calves for WW and heavier spring-born calves than fall-born calves for YW. †P < 0.10; *P < 0.05; **P < 0.01.

year × month × region interaction may provide valuable insight into forage quantity and quality fluctuations.

Some regions had a single calving season in which calves were heavier for WW and YW. For the Lower South region, cattle born in the fall were heavier than spring-born cattle at weaning and as yearlings. On the other hand, spring-born cattle tended to be heavier than fall-born cattle for WW and YW in the North and Upper Plains regions, which were characterized by colder winters with significant snowfall. Based on these results, the heaviest calves were born in the primary calving season, indicating that producers had embraced the success of this calving season. Systematic environmental and management factors were contributing to the WW and YW differences, highlighting the importance of the environment for cattle production.

Some seasonal weight contrasts were greater than 100 kg and may have a substantial economic impact for cattlemen. Earlier studies found significant seasonal effects with a magnitude of 10 to 25 kg, although some were from previous decades (Bagley et al., 1987; Gaertner et al., 1992; Griffin et al., 2012; Caldwell et al., 2013). The modern beef cow is biologically very different from the cow of the 1990s, and the offspring have greater genetic potential for growth. The current study represented a sample of the Angus population for a 10-yr period, and part of the large magnitude in weight differences could be attributed to sampling. This period might not be long enough to average out effects of significant weather events, such as the Texas drought (2011 to 2014).

In recent decades, breeders have selected Angus cattle for increased production traits with correlated increases in mature size, milk production, and feed requirements (AAA, 2016). With feed being one of the largest production costs and agricultural acreage being lost to development, matching animal production to the environment becomes even more important. The most profitable herds have lesser feed costs, irrespective of region (Dunn, 2002; Ramsey et al., 2005). Body size and milk production potential affect nutritional demand and thus feed costs and require optimization for specific production systems (Dickerson, 1970; McMorris and Wilton, 1986). Therefore, matching cow type and nutritional status with seasonal forage fluctuations is critical for the profitability of cow–calf enterprises.

Climatic characteristics affect growth differently depending on the region. Heat stress has been shown to cost the beef industry more than an estimated $350 million annually (St-Pierre et al., 2003) through reduced feed intake, less weight gain, reduced milk production, and greater reproductive failure in males and
females. In addition, hide color has been shown to impact weight gain with dark-hided cattle growing less because of greater susceptibility to heat stress (Finch et al., 1984). Differences in humidity between the Lower South and West regions cause differing responses to these hot environments in dairy cattle (Bohmanova et al., 2007). On the other extreme, cold temperatures and wet conditions cause greater calf death (Sprott et al., 2001) in some regions but contribute to greater growth in other regions (Olson et al., 1991). These differential responses further highlight the need for region-specific production schemes.

Genotype × environment interactions exist both within and across beef cattle breeds. Many studies have examined breed × environment interactions, particularly comparing breed performance in cooler versus hotter climates in the United States. *Bos indicus* cattle are more heat tolerant and resistant to environmental stressors than Angus (Turner, 1980; Hammond et al., 1996), and *B. indicus* crosses grow faster than *B. taurus* crosses in subtropical conditions (Olson et al., 1991). Within-breed genotype × environment interactions have also been documented for growth traits (Butts et al., 1971; Bertrand et al., 1987). Therefore, cattle were not expected to perform uniformly across regions in this study. Although Angus perform well in temperate conditions, other breeds may have better growth potential in southern areas, which may explain the lesser representation of Angus in Texas.

**Conclusions**

Most Angus calves are born in the spring, although fall calving is more common in the Lower South and Upper South regions than in other regions. Regions differ in the effect of season on WW and YW. Colder regions appear suitable for spring calving based on the data set. Fall calving appears advantageous for producers in the hot, humid Lower South region to increase calf weight. Southern Angus producers would potentially benefit from genetic selection tools to improve adaptability and heat tolerance. Further research is needed to establish a genetic evaluation for these traits.

**LITERATURE CITED**


