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Genotype × environmental interaction for mature size and rate of maturing for Angus, Brahman, and reciprocal-cross cows grazing bermudagrass or endophyte infected fescue1


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ABSTRACT: Mature weight and rate of maturing were estimated in 177 Angus, Brahman, and reciprocal-cross cows grazing bermudagrass or endophyte-infected tall fescue over a 4-yr period to evaluate genotype × environment interactions. Data were collected every 28 d until cows were approximately 18 mo of age and then at prebreeding, postcalving, and weaning of calf. All cows with weight data to at least 42 mo of age were included in the analysis. Mature weight and rate of maturing were estimated using the three-parameter growth curve model described by Brody (1945). Data were pooled over year and analyzed by the general linear model procedure of SAS. Included in the models for mature weight and rate of maturing were the independent variables of genotype, environment, and genotype × environment interaction. There was a genotype × environment interaction (P < 0.01) for mature body weight (BW) but not for rate of maturing. Angus cows grazing fescue pastures had greater (P < 0.01) mean mature BW than Brahman × Angus cows grazing bermudagrass or endophyte-infected fescue and Brahman cows grazing bermudagrass (546 ± 16 vs 624 ± 19, 614 ± 22 and 598 ± 20 kg, respectively). Brahman cows grazing endophyte-infected fescue had smaller (P < 0.05) mean mature BW than all genotype × forage combinations except for Angus × Brahman cows grazing bermudagrass. Angus cows had a smaller (P < 0.05) mean rate of maturing than Angus × Brahman and Brahman × Angus cows (0.039 ± 0.002 vs 0.054 ± 0.002 and 0.049 ± 0.002%/mo, respectively), respectively, and Angus × Brahman cows had a larger (P < 0.05) mean rate of maturing than Brahman × Angus and Brahman cows (0.054 ± 0.002 vs 0.049 ± 0.002 and 0.041 ± 0.002%/mo, respectively). There was a direct breed × forage interaction (P < 0.05) for mature BW. These data suggest that the choice of breed type is important in maintaining a crossbreeding program, in that mature BW and rate of maturing are critical to the matching of animal requirements to available production resources.

Key Words: Body weight, Environment, Genotypes, Maturity Stage

Introduction

Previous research suggests that production efficiency of the cow herd is influenced by traits of mature weight and rate of maturing, which influence variation in specific responses to management practices and nutrient input with regard to growth and development, reproduction, and carcass traits (Taylor, 1971; Fitzhugh and Taylor, 1971). In the past, variation in mature weight and rate of maturing were synonymous with breed differences; however, with selection emphasis switching to larger cow size in the early 1970s, there is now a greater array of growth patterns within any particular breed (Taylor and Field, 1999). The choice of mating system and the level of performance for these traits in the cow herd determine nutrient requirements. Failure to correctly match the nutrient requirements of the cow herd to the nutritional environment will reduce production efficiency through conception failure, extended calving interval, and decreased weaning weight and weaning rate. The quantity and quality of forage available for production is also important in matching animal resources to production environment. The major

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nutritional environments for cow-calf production in the mid-southern United States are common bermudagrass and endophyte-infected tall fescue. Cattle grazing endophyte-infected tall fescue often have lower weight gain, milk yield, and fertility (Jackson et al. 1988; Porter and Thompson, 1992; Patterson et al. 1995) than cattle grazing endophyte-free forage. Given the relative importance of mature BW and rate of maturing and the predominance of endophyte-infected tall fescue for beef production in the mid-south, the objective of this study was to evaluate the interactions of genotype \times environment for mature BW and rate of maturing in Angus, Brahman, and reciprocal-cross cows grazing bermudagrass or endophyte-infected tall fescue forage.

Materials and Methods

Data on 177 Angus (n = 52), Brahman (n = 36), Angus \times Brahman (n = 53), and Brahman \times Angus (n = 36, sire breed listed first) heifers born from 1988 to 1991 were used to evaluate genotype \times environment interactions for the growth parameters of mature weight and rate of maturing. Heifers were assigned to 16-ha endophyte-infected tall fescue pastures (100% infected) or 16-ha common bermudagrass pastures and remained on these forages throughout the study. Pastures were fertilized with a total of 155 kg of N/ha in two applications: early May and mid-July for bermudagrass and early October for endophyte-infected fescue pastures. Applications of P and K were done as suggested by soil tests. Pastures were shredded in early summer to remove seed heads in tall fescue and in late summer to control broadleaf weeds in bermudagrass. Heifers were managed as commercial replacement heifers to gain approximately 0.35 kg/d by supplementing with cottonseed meal, corn and tall fescue, or bermudagrass hay according to visual estimates of forage DM availability. Normally, supplemental feed was provided from late November to late April in both forages (0.9 kg/cow per day). Cows had ad libitum access to a commercially available all-purpose mineral mix throughout the year. Heifers were bred as 2 yr olds to calve at 3 yr of age to preclude introducing parity differences into the study due to the low percentage of purebred Brahman reaching sexual maturity at 15 mo of age. Brown et al. (1997) reported no differences in calving percentage across genotypes. A total of 15 Polled Hereford sires were used in this study. Breeding seasons were early May through mid-July each year. Sires were rotated among breeding pastures in both forage treatments to prevent confounding of sire and forage effects. Heifers were pregnancy checked in the fall each year during brucellosis certification procedures. Weight and height data were collected every 28 d from birth to 18 mo of age and then at prebreeding in mid-May, postcalving in February and March, and weaning of calf in mid-October. A detailed description of production and management of animals used in this study is given by Brown et al. (1993, 1997).

Growth parameters of mature BW and rate of maturing were estimated using the three-parameter growth curve model described by Brody (1945). This model is defined as $W(t) = A - B e^{-kt}$, where $W(t)$ is weight at age $t$, $A$ is asymptotic weight or mature weight, $B$ is a constant of integration necessary for accurate curve fit especially at early ages, $k$ is the rate of approach to maturity in percentage of estimated mature weight gain per month, and $t$ is age. Shown in Figure 1 are the mean growth curves by genotype. According to Brown et al. (1972) accurate estimates of mature weight and rate of maturing can be obtained on females that have weight data to 42 mo of age. Consequently only animals with data to 42 mo of age were included in the analysis. Preliminary models were run that included mature BW and rate of maturing as independent variables and genotype, environment, genotype \times environment interaction, and year as dependent variables. Year was not a significant source of variation, therefore, data were pooled over year and analyzed by the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Included in final models for mature BW and rate of maturing were the independent variables of genotype, environment, and genotype \times environment interaction. When interactions were significant, the PDIF option of LSMEANS in SAS was used to separate means. Heterosis, maternal effects, and direct effects were estimated using linear contrasts of least squares means from the final model. Individual heterosis was computed as the difference between the means of crossbred and purebred cows. Maternal and direct breed effects were computed as the difference in means between reciprocal-cross cows and sires, respectively. These contrasts were analyzed by GLM procedure of SAS and were calculated as (Angus–Brahman). Throughout the study, husbandry was in accordance with guidelines recommended by the Consortium (1988).

Figure 1. Mean growth curves by genotype. AA = Angus \times Angus, y = 603 – 548 * exp (−0.039 * t), AB = Angus \times Brahman, y = 565 – 531 * exp (−0.053 * t), BA = Brahman \times Angus, y = 619 – 564 * exp (−0.049 * t), and BB = Brahman \times Brahman, y = 554 – 510 * exp (−0.042 * t).
Table 1. Least squares means and standard errors of estimated mature body weight (kg) for genotype × environmental interaction

<table>
<thead>
<tr>
<th>Forage</th>
<th>Genotype</th>
<th>Effect</th>
<th>Maternal**</th>
<th>Direct**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bermudagrass</td>
<td>AA</td>
<td>590 ± 17bc</td>
<td>546 ± 16cd</td>
<td>624 ± 19bc</td>
</tr>
<tr>
<td>Fescue</td>
<td>AB</td>
<td>611 ± 17b</td>
<td>583 ± 18bc</td>
<td>614 ± 22bc</td>
</tr>
</tbody>
</table>

**- Within a row and column, means without a common superscript letter differ (P < 0.05).

There was a genotype × environment interaction (P < 0.01) for mature BW, indicating the importance of the correct match of genotype to production environment. Presented in Table 1 are the least squares means and standard errors for estimated mature BW for genotype × forage environment subclasses. There was no difference (P > 0.05) in mature BW for straightbred Angus cows on either forage, with means of 590 and 611 kg, respectively, for bermudagrass and endophyte-infected fescue. These estimated values for Angus cows are higher than those reported by Stewart and Martin (1983) and Brown et al. (1972), who reported mean A values of 485 and 441 kg, respectively. Brown and Butts (1979) reported average A values of 451 kg for Angus herds in Southern regions of the United States.

Table 2. Heterosis, maternal, and direct breed effects, and standard errors for estimated mature body weight of cows reared on common bermudagrass or endophyte-infected tall fescue

<table>
<thead>
<tr>
<th>Forage</th>
<th>Effect</th>
<th>Maternal**</th>
<th>Direct**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bermudagrass</td>
<td>-9 ± 18</td>
<td>77 ± 24</td>
<td>-86 ± 36bc</td>
</tr>
<tr>
<td>Fescue</td>
<td>38 ± 20</td>
<td>31 ± 24</td>
<td>71 ± 40d</td>
</tr>
</tbody>
</table>

**- ANGUS × BRAHMAN = (BRAHMAN × ANGUS).

Results and Discussion

There was a genotype × environment interaction (P < 0.01) for mature BW, indicating the importance of the correct match of genotype to production environment. Presented in Table 1 are the least squares means and standard errors for estimated mature BW for genotype × forage environment subclasses. There was no difference (P > 0.05) in mature BW for straightbred Angus cows on either forage, with means of 590 and 611 kg, respectively, for bermudagrass and endophyte-infected fescue. These estimated values for Angus cows are higher than those reported by Stewart and Martin (1983) and Brown et al. (1972), who reported mean A values of 485 and 441 kg, respectively. Brown and Butts (1979) reported average A values of 451 kg for Angus herds in Southern regions of the United States.

In the reciprocal-cross cows there was no difference (P > 0.05) between Angus × Brahman cows grazing bermudagrass or endophyte-infected fescue. However, it is not entirely clear why the Angus × Brahman cows grazing bermudagrass had smaller A values than the mean of their parental breed types (mean = 594 kg). This could be due to an interaction between the direct breed effects of the Angus cows and the maternal breed effects of the Brahman cows on bermudagrass. Angus sires used to produce cows in this study may have had less potential to produce a higher growth rate calf than Brahman sires and Brahman dams used to produce cows in this study may have had less potential for maternal and or milking ability than Angus dams. These results are supported by Brown et al. (1993), who reported a trend for higher milk yield in Angus than Brahman cows grazing bermudagrass. This can also be supported by the fact that in cows grazing bermudagrass, maternal effects favored Angus (+78 kg), whereas direct effects favored Brahman (+86 kg, Table 2). The Brahman cows seemed to have a difficult time coping with the endophyte-infected forage. Brahman cows grazing endophyte-infected fescue had a lower mean mature BW (P < 0.05) than all other genotype × forage combinations with the exception of the Angus × Brahman crosses grazing bermudagrass at 546 kg. In a study by Menchaca et al. (1996), A values estimated using the Brody (1945) model for small-, medium- and large-framed Brahman cattle were 523.5, 568.5, and 578.7 kg, respectively.

Our estimated mature BW values for Angus cows ranged from 590 to 611 kg, which are similar to the mean mature BW value for Angus cows of 600 kg reported by Kaps et al. (1999). However, mean values for mature BW in Angus and Brahman cows in this study are larger than those for Angus and Brahman cattle in Louisiana, 473.7 kg and 537.6 kg respectively, Moin (1978). This may be due to the fact that the cattle in the study by Moin (1978) were the smaller-framed Angus cattle that were popular in the 1960s. The estimates for mature BW found in Moin (1978) for Brahman cattle are only slightly lower than we found in our study.

Presented in Table 2 are the heterosis, direct, and maternal breed effects means and standard errors of mature BW by forage. There were no differences in heterosis or maternal breed effects between the two forages. However, there was a direct breed effect × forage interaction (P < 0.01) for mature weight (Table 2). This interaction likely resulted from the direct breed effects favoring the Angus-sired cows grazing fescue and the Brahman-sired cows grazing bermudagrass.

There was no genotype × environment interaction for rate of maturing in this study. Angus × Brahman crosses had the largest (P < 0.05) rate of maturing of all breed types maturing at a rate of 0.053 ± 0.002%/mo. There were no differences (P > 0.05) between the rate of maturing values for either of the straightbred genotypes with Angus at 0.039 ± 0.002%/per month and Brahman at 0.042 ± 0.002%/per month. These values for rate of maturing are lower than values reported by Morrow et al. (1978) for Angus cows (0.056%/per month) and Franke and Burns (1975) for Brahman cows (0.062%/per month). There was, however, a difference between the two reciprocal-crosses with Brahman × Angus cows maturing at a slower (P < 0.05) rate than the Angus × Brahman (0.049 ± 0.002 vs. 0.053 ± 0.002%/per month). Heterosis for rate of maturing was estimated at 26% for this study. Our estimate was considerably higher than that of Nelson et al. (1982), who reported a percentage heterosis increase in maturing rate of 3.5% in Brahman × Angus cross cattle. In a growth
With limited resources. A variety of production environments, including those with different biological types of animals on a wide herd. Further research is needed in this area, particularly in the field of crossbreeding to help producers deal with different biological types of animals on a wide variety of production environments, including those with limited resources.

Implications

These results suggest that genetic effects for the growth parameters of mature body weight and rate of maturing may differ with forage environment, and this interaction needs to be carefully considered when attempting to correctly match genotype to available production resources. Failure to provide this critical match may result in decreased overall performance in the cow herd. Further research is needed in this area, particularly in the field of crossbreeding to help producers deal with different biological types of animals on a wide variety of production environments, including those with limited resources.

Literature Cited

References

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