Predicting Bull Growth Performance and Carcass Composition from Growth Hormone Response to Growth Hormone-Releasing Hormone 1


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ABSTRACT: Development of practical, physiologically based methods that provide an early, yet accurate, evaluation of a bull’s genetic merit could benefit the beef industry. The use of GH response to a single, acute dose of GHRH was evaluated as a predictor of future growth performance and carcass characteristics of weanling bulls. Fifty-six Angus bulls averaging 229 d (SD = 27) of age were administered three doses i.v. (0, 1.5, and 4.5 µg/100 kg BW) of human GHRH (1–29) analog in a Latin square design balanced for residual effects. Blood samples were collected via jugular catheter at −60, −45, −30, −15, 0, 5, 10, 15, 30, 45, 60, 90 and 120 min relative to GHRH injection. Serum concentrations of GH were plotted over time. Response to GHRH was calculated as the area under the GH response curve (AUC-GH) using the trapezoidal approximation. Relationships between AUC-GH, weaning weight adjusted to 205 d of age (205-d WW), and direct weaning weight EPD (WWEPD) versus age-adjusted BW (BW_adj), ADG, and carcass measurements from a 140-d growth performance test were evaluated using simple linear regression. A positive correlation between AUC-GH and ADG and an inverse relationship between AUC-GH and carcass fat were observed. The present study provides evidence that AUC-GH is a better predictor of future growth performance in beef bulls than 205-d WW or WWEPD values. Thus, GH response to GHRH is associated with subsequent growth and may be a useful tool for sire selection in beef production.

Key Words: Beef Cattle, Somatotropin, Selection, Composition


Introduction

The role of GH in the regulation of growth and metabolism in cattle is well established. The hypothalamic hormone GHRH stimulates anterior pituitary gland secretion of GH, which increases lipolysis and, via IGF-I, promotes protein synthesis and growth of long bones. Exogenous GH increases rate of gain and decreases carcass fat percentage in cattle (Groenewegen et al., 1990; Binelli et al., 1995) and lambs (McLaughlin et al., 1994) and increases milk yield in dairy cows (Bauman et al., 1985). Administration of GHRH to lambs improves growth rate and lean gain (Beermann et al., 1990) and increases milk production in dairy cows (Dahl et al., 1991, 1993).

Because of its role in ruminant growth and lactation, variation in GH secretion may provide a tool to assess an animal’s potential for meat or milk production. Secretion patterns of GH including peak frequency and peak duration are related to dairy merit; however, mean serum GH is not related to dairy merit (Klindt, 1988; Kazmer et al., 1990, 1991). Purchas et al. (1970) found no relationship between basal GH and growth performance of cattle, and no relationship has been demonstrated between GH pulse characteristics and growth of lambs (Klindt et al., 1985) or cattle (Ohlson et al., 1987). Conversely, sheep and cattle selected for rapid gain exhibit higher plasma GH concentrations than unselected lines (Dodson et al., 1983; Ohlson et al., 1987).

In contrast, pituitary gland responsiveness to GHRH is a reliable indicator of dairy merit and provides more consistent results than measurement of spontaneous serum GH (Løvendahl et al., 1991; Zinn et al., 1994). Further, studies of fat and lean sheep (Suttie et al., 1991) suggest that responsiveness to GHRH is predictive of composition of gain. The objective of the present study was to determine whether GH response to a...
GHRH challenge in young beef bulls is predictive of subsequent growth performance and carcass traits.

Materials and Methods

Animals

Weanling Angus bulls (n = 56, Wye cross) owned by and housed at the University of Maryland Wye Research and Education Center, Queenstown, MD, were used. Bulls averaged 229 d (SD = 27) of age and 239 kg BW (SD = 34). Bulls were maintained in four groups of approximately 15 animals each in covered loose housing under natural photoperiod. Bulls were provided ad libitum access to feed consisting of corn silage, shelled corn, and protein supplement to provide a gain of 1.3 kg/d according to NRC requirements (NRC, 1996). Bulls were offered feed once daily between 0700 and 0800. Feed was last offered to bulls at least 12 h before GHRH challenge. Pedigree data from which direct weaning weight EPD (WWEPD) values were calculated were available for only 55 of the bulls tested. All experimental procedures were performed according to animal use regulations; animal procedures were approved by the Institutional Animal Care and Use Committee.

GHRH Challenge

The GHRH challenge was conducted in mid-September. Jugular veins in all bulls were catheterized 1 d before GHRH challenge and blood collection. Catheters were flushed with 100 U of sodium heparin (Elkington-Sinn, Inc., Cherry Hill, NJ) in .9% saline to prevent blood clot formation. Bulls received three doses (0, 1.5, and 4.5 µg/100 kg BW) of human GHRH (1–29) analog (Hoffmann-LaRoche Ro23-7863, Nutley, NJ). One dose of GHRH was administered to each bull during each of three consecutive 3-h blood collection periods in a Latin square design balanced for residual effects. The GHRH was diluted to a final concentration of 5 µg/mL in .9% saline with .1% BSA (Sigma Chemical Co., St. Louis, MO) and injected to achieve the desired doses of 1.5 and 4.5 µg/100 kg BW. All bulls were restrained by halter in a corral during blood sampling and GHRH injection. Blood (5 mL) was collected via a jugular catheter (Abocath-T 14 Ga × 14 cm LA Indwelling Radiopaque i.v. Catheter/Teflon, 4535-84) at −60, −45, −30, −15, 0, 5, 10, 15, 30, 45, 60, 90, and 120 min relative to GHRH injection. On the first day of treatment, 27 bulls were challenged with GHRH (15 bulls beginning at 1000 and 12 bulls beginning at 1300), and, on the second day, 29 bulls were treated (14 bulls at 1000 and 15 bulls at 1130). Blood samples were stored at room temperature for 2 to 4 h and then at 4°C for a maximum of 72 h. Serum was harvested from whole blood after centrifugation (1,850 × g, 20 min, 4°C) and stored at −20°C until assayed for GH. Serum GH concentration was measured with a RIA using the method of Elsasser et al. (1989). Bovine serum (25 to 200 µL) depressed binding in parallel to the standard curve in the GH assay, and recovery from supplemented samples averaged 110%. Mean inter- and intraassay CV (15 assays) were 7.90 and 3.29%, respectively; assay sensitivity averaged .89 ng/mL. Concentration of GH was plotted over time, and total GH response was determined by calculating the area under the response curve (AUC-GH) by trapezoid summation. One week following the GHRH challenge experiment, all bulls were assigned to a 140-d growth performance test during which BW, hip height, and scrotal circumference were measured every 28 d. Ultrasound was performed on d 140 of the growth performance test to estimate external backfat thickness (EBF), ribeye area (REA), and percentage of intramuscular fat (IMF). All animals were evaluated with an Aloka 500-V real-time diagnostic ultrasound unit (Aloka USA, Wallingford, CT) equipped with a 172-mm scanning width, 3.5-MHz linear array transducer (UST-5049-3.5) using a technique similar to that of Perkins et al. (1992). To determine the accuracy of the ultrasound estimates, 13 of the bulls were slaughtered 4 d after ultrasound to obtain actual measurements of EBF and REA.

Statistical Analyses

All statistical analyses were conducted using the SAS system version 6.12 (SAS, 1996). The AUC-GH in response to the three doses of GHRH (0, 1.5, and 4.5 µg/100 kg BW) was analyzed with ANOVA to determine whether a GHRH dose response existed. Linear regression was used to adjust BW data for differences in weaning weight (WW). The adjustment equation was

\[ \text{Y adjusted} = \text{Y observed} - b \times (\text{X observed} - \text{mean of X}), \]

where Y is BW at d 140 of the growth performance test (d-140 BW adj), X is WW, and b is the least squares linear regression coefficient for Y regressed on X. Linear regression was used to evaluate the following relationships: 1) the ability to predict d-140 BW adj on-test ADG, and carcass ultrasound measurements from AUC-GH; 2) the relationships between weaning weight adjusted to 205 d of age (205-d WW) on-test ADG and carcass ultrasound measurements; and 3) the relationships between WWEPD vs on-test ADG and carcass ultrasound measurements. For models including AUC-GH as the independent predictor variable, a mixed model procedure was used with collection time (block) as a random effect. To compare ultrasound estimates of EBF and REA with actual measurements collected at slaughter from a subset of 13 bulls, the differences between actual measurements and ultrasound estimates for each animal were calculated and plotted against actual measurements.

Results

General

Bulls exhibited the projected feed consumption and growth, gaining an average of 1.5 kg/d during the 140-d growth performance test period.
Figure 1. Mean GH responses in weanling Angus bulls (n = 56) to three intravenous injections of GHRH (SEM = 1.87); 0 µg/100 kg BW (○), 1.5 µg/100 kg BW (●), and 4.5 µg/100 kg BW (▲). The three doses of GHRH were administered to bulls in a Latin square design balanced for residual effects.

**AUC-GH Predicts d-140 BW adj and ADG**

Injection of GHRH caused a rapid increase in circulating GH in nearly all bulls tested, with peak GH concentration occurring on average within 15 min after GHRH injection (Figure 1). Indeed, AUC-GH averaged across all animals within treatment exhibited a dose-dependent response to GHRH (P < .001; Figure 1). Two bulls, however, exhibited practically no increase in serum GH concentration in response to both 1.5 and 4.5 µg GHRH/100 kg BW. Responses to GHRH in both animals were below 640 min × ng × mL⁻¹ vs an overall mean saline response (n = 56) of 657 min × ng × mL⁻¹. Because no technical limitation was noted during the injections, their data were included in the analyses.

The relationships between d-140 BW adj vs AUC-GH for the 1.5 and 4.5 µg/100 kg BW dose of GHRH were similar (Figure 2; Table 1). Only GH response to 1.5 µg GHRH/100 kg BW was predictive of ADG (Figure 3). Neither WWEPD nor 205-d WW were predictive of ADG (Table 1).

**Ultrasound Accurately Estimates Carcass Measurements**

Measurements of actual carcass EBF and REA of a subset of 13 bulls collected at slaughter were consistent with ultrasound estimates. Mean (± SE) EBF estimated by ultrasound was .81 (± .05) cm vs actual EBF, which averaged .81 (± .08) cm. Ultrasound estimated mean REA at 78.42 (± 2.66) cm² and actual averaged 74.64 (± 1.92) cm². A plot of actual carcass measurements vs the calculated differences between actual measurements and ultrasound estimates showed that ultrasound estimates of REA and EBF were consistent with actual measurements on an individual-animal basis (data not shown).

**AUC-GH Predicts Carcass Fat; 205-d WW and WWEPD Predict REA**

In general, estimates of carcass fat (i.e., EBF and IMF) decreased with increasing AUC-GH values; although the strength of the relationships between AUC-GH and carcass characteristics varied, depending on the dose of GHRH administered (Table 1). There was no relationship between REA and AUC-GH in response to either 1.5 or 4.5 µg GHRH/100 kg BW. Both 205-d WW and WWEPD were directly related to REA, but neither predicted measurements of carcass fat (Table 1).

**Discussion**

As observed in similar studies with Holstein cattle (Kazmer et al., 1992; Zinn et al., 1994), injection of...
Table 1. Regression coefficients of growth and carcass measurements of Angus bulls (n = 56) regressed on GH response to intravenous GHRH injection, 205-d weaning weight (205-d WW), and direct weaning weight EPD (WWEPD)

<table>
<thead>
<tr>
<th>Response variable</th>
<th>Statistic</th>
<th>AUC-GH1.5a</th>
<th>AUC-GH4.5b</th>
<th>205-d WW</th>
<th>WWEPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADGc</td>
<td>Slope (SE)</td>
<td>$4 \times 10^{-5}$ $(2 \times 10^{-5})^a$</td>
<td>$1 \times 10^{-5}$ $(2 \times 10^{-5})$</td>
<td>.001 (.001)</td>
<td>.003 (.004)</td>
</tr>
<tr>
<td>R²</td>
<td>.07</td>
<td>.01</td>
<td>.05</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>REA4d</td>
<td>Slope (SE)</td>
<td>$8 \times 10^{-4}$ $(1.2 \times 10^{-3})$</td>
<td>$5 \times 10^{-4}$ $(0.001)$</td>
<td>.14 (.04)</td>
<td>.50 (.21)</td>
</tr>
<tr>
<td>SD</td>
<td>8.50</td>
<td>8.51</td>
<td>7.78</td>
<td>8.17</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>.01</td>
<td>.00</td>
<td>.17</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>IMFe</td>
<td>Slope (SE)</td>
<td>$-7 \times 10^{-5}$ $(2 \times 10^{-4})^a$</td>
<td>$-5 \times 10^{-4}$ $(2 \times 10^{-4})^a$</td>
<td>.001 (.01)</td>
<td>-.002 (.05)</td>
</tr>
<tr>
<td>SD</td>
<td>1.74</td>
<td>1.66</td>
<td>1.74</td>
<td>1.76</td>
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</tr>
<tr>
<td>R²</td>
<td>.00</td>
<td>.09</td>
<td>.00</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>EBFf</td>
<td>Slope (SE)</td>
<td>$-7 \times 10^{-5}$ $(2 \times 10^{-5})^a$</td>
<td>$8 \times 10^{-6}$ $(2 \times 10^{-5})^a$</td>
<td>$4 \times 10^{-4}$ $(0.001)$</td>
<td>-.006 (.005)</td>
</tr>
<tr>
<td>SD</td>
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<td>.19</td>
<td>.19</td>
<td>.19</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>.12</td>
<td>.00</td>
<td>.00</td>
<td>.02</td>
<td></td>
</tr>
</tbody>
</table>

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**GH response to 1.5 µg GHRH/100 kg BW; AUC = area under the response curve.**

**GH response to 4.5 µg GHRH/100 kg BW; AUC = area under the response curve.**

**Average daily gain, kg/d.**

**Ribeye area, cm².**

**Intramuscular fat, %.**

**External backfat, cm.**

* *P < .05.*

**P < .01.**

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human GHRH (1–29) analog in the present study increased serum GH concentration of weanling beef bulls in a dose-responsive manner. We demonstrated that injection of as little as 1.5 µg GHRH/100 kg BW results in a robust increase in serum GH. Results of studies relating dairy merit to GH response to GHRH (Kazmer et al., 1992; Zinn et al., 1994) revealed that doses in excess of 22 µg GHRH/100 kg BW are less effective in identifying superior dairy sires than concentrations between 4 and 11 µg GHRH/100 kg BW. Indeed, previous studies support the concept that differences in milk production traits are related more to pituitary gland sensitivity rather than maximal response to GHRH (Zinn et al., 1994). In the present study, GH response to both the 1.5 and 4.5 µg/100 kg BW doses of GHRH were predictive of bull growth performance. To our knowledge, this study is the first to demonstrate a relationship between GH response to GHRH and future growth characteristics of young, unproven beef bulls.

The physiological mechanism underlying high GH responders vs low GH responders to the same dose of GHRH is not known. Pituitary gland sensitivity to GHRH may play a significant role. Increases in pituitary sensitivity to GHRH among animals may be due to increased GHRH receptor number, increased binding affinity of GHRH receptor for GHRH, or increased efficiency of postreceptor signal transduction. Further research in these areas could be useful for identifying animals with greater growth potential and desirable carcass characteristics.

A number of studies investigating the GH axis and its relationship with growth performance characteristics focus on IGF-I. Both positive and negative associations between rates of gain in cattle and serum IGF-I concentration have been reported (Lund-Larsen, 1977; Davis and Simmen, 1997; Stick et al., 1998). For example, Anderson et al. (1988) observed a negative correlation between mean serum IGF-I concentration vs carcass fat and a positive correlation between IGF-I vs carcass protein. The ability to select for high or low serum IGF-I concentration has been demonstrated (Davis and Bishop, 1991; Enns et al., 1991; Davis and Simmen, 1997), and the usefulness of its selection in animal production is clearly evident. However, a number of envi-
Environmental factors influence secretion of IGF-I in cattle, including photoperiod (Dahl et al., 1997) and nutritional status (McGuire et al., 1992). Due to the variability associated with IGF-I release, its measured association with growth characteristics is limited. Furthermore, the presence of IGF binding proteins and difficulty in their measurement compound the problems related to measuring available IGF-I as it affects growth. In any case, the relationships between IGF-I and growth or carcass characteristics examined thus far have been associative rather than predictive of growth potential. The use of a stimulated release of GH to assess an animal’s growth potential and carcass characteristics is less likely to be influenced by environmental factors, it should be less variable, and it should provide a more consistent relationship with growth. Because GHRH integrates the various influences on GH secretion, we believe that GHRH challenge is a more reliable physiological indicator of growth and composition of gain than IGF-I.

Because EPD and WW may be used by producers as selection criteria, we compared the use of WWEPD and 205-d WW to GH response to GHRH as indicators of subsequent growth performance and carcass traits. Although WWEPD refers to predicted performance of a sire’s offspring and not the individual sire, we believe that WWEPD may be informative of a sire’s future performance because he must possess the trait of interest in order to transmit it to his offspring. No relationships were found between WWEPD vs weight gain or carcass fat, yet WWEPD was associated with REA, a characteristic not predicted by GH response to GHRH. Likewise, 205-d WW was related to REA but not to ADG or ultrasound estimates of carcass fat. Therefore, GH response to GHRH provides useful information that WWEPD and 205-d WW do not provide and could be combined with WWEPD and 205-d WW to select the most desirable sires. An interesting question is whether WWEPD values of sire are related to the GHRH responsiveness of their offspring. Planned matings of high and low GHRH-responding bulls from this study will be made in an effort to develop high and low GHRH-responsive lines in which questions such as these can be examined.

In the present study, a positive relationship was found between GH response to GHRH and weight gain and an inverse relationship was found between GH response and body fat measurements. We would expect animals with a greater sensitivity to GHRH to have a greater propensity to secrete GH, resulting in greater lean mass accretion and less fat deposition than animals with a lesser sensitivity to GHRH. Specific relationships between carcass fat measurements and GH response to GHRH were consistent between the two doses of GHRH administered, but the general tendency of an inverse relationship between GH response and carcass fat held true. Because carcass ultrasound measurements were conducted at d 140 of the growth performance test, carcass finishing was incomplete, and ultrasound measurements likely were not representative of each bull’s true finishing potential. Actual carcass evaluation of a subset of 13 bulls indicated that ultrasound estimates of carcass composition at d 140 of the growth performance test were accurate. A consistent relationship between GH response and carcass fat measurements may be evident if carcass evaluation is conducted at a later stage of growth. Additional research with beef cattle through the finishing stage is necessary to evaluate the usefulness of GH response to GHRH as a predictor of final carcass quality.

Implications

In young, growing beef bulls, growth hormone response to injection of growth hormone-releasing hormone was predictive of future growth performance and carcass composition. Growth hormone response was a better predictor of composition of future gain than 205-d weaning weight or weaning weight expected progeny difference values. This method may provide useful selection information. However, additional research is needed to simplify the growth hormone-releasing hormone challenge technique to make it a practical tool in beef production.

Literature Cited


