Growth Hormone Variability and its Predictive Value in Beef Females

Thomas W. Lingscheit

Follow this and additional works at: https://openprairie.sdstate.edu/etd

Recommended Citation
https://openprairie.sdstate.edu/etd/4154

This Thesis - Open Access is brought to you for free and open access by Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange. For more information, please contact michael.biondo@sdstate.edu.
GROWTH HORMONE VARIABILITY AND ITS PREDICTIVE
VALUE IN BEEF FEMALES

BY

THOMAS W. LINGSCHEIT

A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science
Major in Animal Science
South Dakota State University
1982
GROWTH HORMONE VARIABILITY AND ITS PREDICTIVE VALUE IN BEEF FEMALES

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

C. A. Dinkel
Thesis Adviser

John R. Romans
Head, Animal Science Dept.
## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREFACE</td>
<td>1</td>
</tr>
<tr>
<td>1. Experimental Procedure</td>
<td>4</td>
</tr>
<tr>
<td>2. Collection of GH Samples</td>
<td>5</td>
</tr>
<tr>
<td>3. Production Measurement</td>
<td>8</td>
</tr>
<tr>
<td>4. Statistical Analysis</td>
<td>10</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>14</td>
</tr>
<tr>
<td>MATERIALS AND METHODS</td>
<td>15</td>
</tr>
<tr>
<td>1. Sample Collection</td>
<td>15</td>
</tr>
<tr>
<td>2. Production Traits Studied</td>
<td>16</td>
</tr>
<tr>
<td>3. Statistical Procedure</td>
<td>17</td>
</tr>
<tr>
<td>RESULTS AND DISCUSSION</td>
<td>20</td>
</tr>
<tr>
<td>SUMMARY</td>
<td>26</td>
</tr>
<tr>
<td>LITERATURE CITED</td>
<td>28</td>
</tr>
</tbody>
</table>
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>DISTRIBUTION BY YEAR OF BIRTH AND AGE AT GH SAMPLING</td>
<td>4</td>
</tr>
<tr>
<td>2.</td>
<td>YEAR OF RECORD WITHIN YEAR OF BIRTH AND AGE CLASSIFICATION</td>
<td>8</td>
</tr>
<tr>
<td>3.</td>
<td>GROWTH HORMONE MEANS BY YEAR</td>
<td>21</td>
</tr>
<tr>
<td>4.</td>
<td>GROWTH HORMONE MEANS BY AGE</td>
<td>21</td>
</tr>
<tr>
<td>5.</td>
<td>GROWTH HORMONE MEANS BY BREED GROUP</td>
<td>23</td>
</tr>
<tr>
<td>6.</td>
<td>COEFFICIENTS FOR COMPONENTS OF MULTIPLE REGRESSION EQUATIONS FOR 8-MO DATA</td>
<td>24</td>
</tr>
<tr>
<td>7.</td>
<td>COEFFICIENTS FOR COMPONENTS OF MULTIPLE REGRESSION EQUATIONS FOR 14-MO DATA</td>
<td>24</td>
</tr>
</tbody>
</table>
PREFACE

Metabolic regulation by the endocrine system determines the manner and extent of an animal's growth and production within environmental limits. Evaluation of factors that affect specific hormones or hormonal interactions is necessary to explain biological functions of growth and production. Knowledge of influencing factors may help provide the livestock industry an ability to increase efficient production by selection for naturally occurring hormones, by treatment with exogenous hormones or by controlling environmental factors that influence hormonal effects.

Growth hormone (GH) effects on growth and metabolism justifies closer examination of its biological role. Greep (1975) lists some biological effects of GH. They include stimulation of protein synthesis in muscle tissue, liver and other organs; regulation of electrolytes, including calcium, phosphate, potassium and sodium; growth of cartilage and bone; determination of uptake rate of carbohydrates; effects on lipid metabolism and participation in immunological response. Previous examination of GH demonstrates effects of artificially increasing levels by injection of exogenous GH. Wrenn and Sykes (1953) reported increased milk production in lactating dairy cattle injected with exogenous GH. Similar results were obtained by Machlin (1973), who also reported a reduction in kilograms of feed required for kilogram of milk produced.

Differences in plasma circulating levels of GH and pituitary GH have been reported by various researchers. Baird et al. (1952)
produced a selected line of "fast growing" swine and a line of "slow growing" swine. Comparison of pituitary GH levels between lines showed higher levels of GH (P<.05) for the "fast growing" line. Dev and Lasley (1969) reported differences (P<.05) in GH levels among sire groups of Hereford cattle. Differences in plasma GH were reported by Hart et al. (1975) between dairy and beef females which were at the same point on the lactation curve, of like age and fed the same ration. Dairy females had 4.5 ng of GH per ml of blood serum, while beef females had 1.5 ng of GH per ml (P<.005).

An estimate of heritability of .56 ± .25 for level of GH in Hereford cattle was calculated by Dev and Lasley (1969). Tucker et al. (1974) reported a half-sib correlation heritability estimate of .04 for GH level in Holstein bulls.

Correlation of GH level to production traits was reported by Dev and Lasley (1969). Using preweaning GH levels in Hereford cattle, they obtained correlation coefficients of -.18, -.14, -.09 and .02 when correlating GH to birth weight, weaning weight, preweaning gain and feedlot gain, respectively. Postpartum GH level was correlated with first lactation milk yield (r = .14) in Holstein heifers by Tucker et al. (1973).

Previous research demonstrated that differences exist in level of GH but indicated significant environmental effects which must be identified to assess intrinsic differences in GH level. Age has been documented as a source of variation in GH level in studies by Nalbandov (1963), Curl et al. (1968), Dev and Lasley (1969) and Tucker et al.
(1974), all indicating levels of plasma GH decrease with age. Irwin and Trenkle (1971) reported no age influence in beef calves between ages of 18 and 371 days. Convey et al. (1971) reported higher levels of plasma GH in older (3 to 6 yr of age) bulls than younger (1.5 to 2.5 yr of age) bulls (P<.01) following ejaculation.

Different results of temperature effects on GH levels have been published. Mitra and Johnson (1972) reported a +.75 correlation coefficient for GH level and temperature, while Tucker and Wettemann (1976) reported no significant changes in GH level due to temperature.

Trenkle (1971) reported higher levels of GH in sheep on rations containing high levels of roughage; however, level of feed intake did not affect GH.

Ingalls et al. (1971) compared prepartum and postpartum levels of GH in first calf heifers. Level of GH increased from prepartum levels for 36 hr following parturition but returned to prepartum levels thereafter.

Previous evidence indicates differences in amount of GH existing between individuals and among selected lines of livestock, thus suggesting the possibility of changing levels of GH by selection. The objectives of this study were to examine sources of variation in GH level. After removal of extraneous environmental influences, the relationships between GH level and production traits were evaluated to assess the value of GH measures in predicting performance.

Year, age, management, breed and reproductive status were components evaluated as extraneous sources of variation in GH level.
Performance traits examined included weight at time of sampling (WAB), weight to height ratio at sampling (WH), mature weight (MW), most probable producing abilities for weaning weight (MPWW) and milk production (MPMP) and first lactation record (FL).

**Experimental Procedure**

This experiment was conducted at the South Dakota State University Animal Science Department Beef Cattle Breeding Unit using 170 head of female Angus, Charolais and reciprocal cross beef cattle. Production of these animals began in 1968 with the collection of straightbred female Angus (A x A) and Charolais (C x C) which were bred to two sires (A x A and C x C) to produce four breed classifications (AA, CC, AC and CA) in three consecutive calf crops (1970, 1971 and 1972). Distribution of animals in this study by year of birth and age at GH sampling is presented in table 1.

<table>
<thead>
<tr>
<th>Year of birth</th>
<th>Age (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
</tr>
<tr>
<td>1970</td>
<td>--</td>
</tr>
<tr>
<td>1971</td>
<td>58</td>
</tr>
<tr>
<td>1972</td>
<td>48</td>
</tr>
</tbody>
</table>

At weaning individuals were randomly assigned within breed to a pasture or drylot management regime. Animals assigned to drylot were confined to a dirt lot and fed in individual pens inside a
nonheated metal shed. Animals were confined twice daily for feeding for approximately 1 h with the remainder of time spent in the lot. This practice was continued for the animal's lifetime to maintain feeding records. The ration fed included chopped alfalfa hay, alfalfa pellets and ground corn if cattle were lactating (Marshall, 1975). The pasture group was maintained to evaluate production under a different management system and to act as a control for weight gain of the drylot cattle. Pasture cattle were grazed for approximately 6 mo each year on improved pastures and wintered in a dirt lot the remaining 6 months. While confined, the ration consisted of corn or sorghum-sudangrass silage with alfalfa hay fed to meet protein requirements. Oat straw or Reed canarygrass hay was fed in addition in some years. The ration was group-fed in concrete, fence-line feed bunks.

All cows were maintained within the project until completion of this phase of the project in November of 1979. Individuals were removed from the project for failure to conceive in the first breeding season, palpated reproductive abnormalities, failure to wean a calf in 2 consecutive yr or physical injury.

Collection of GH Samples

Samples were collected from each individual on 4 consecutive d at each age interval shown in table 1. Only 3 days' samples were collected at the 44-mo bleeding of the 1971 cattle due to a blizzard on d 4. The project was not begun until the 1970 calf crop was 20 mo of age, so measurements of GH at 8 and 14 mo are missing.
Previous work in blood sample collection relative to hormone assay indicates use of two methods, venous cannulation and venous puncture. Controversy exists on the merit of the two methods. Eaton et al. (1968) postulated that stress of confinement and puncture increased variability of samples because each individual reacts to stress differently. Trenkle (1970) suggested stress of puncture as a factor responsible for observation of elevated levels of GH above those previously reported. Other studies indicate that stress of puncture does little to elevate GH level. Kaprowski and Tucker (1973) used venapuncture of an artery in the tail of lactating dairy cows to collect blood samples for GH assay. Puncture was made 1 h prior to, directly after and 1 h after milking. Repeatability of measurement was .85, indicating little influence due to stress of puncture sampling. Elevation of GH levels was observed by Shirley et al. (1973) for 1 d following surgical removal of one-half of the mammary system of first calf heifers. Levels on d 2 postsurgery were no different than those prior to surgery. Reasons given for GH level elevation were reaction to 30 Km transport and reaction to anesthesia, not stress due to a major surgical operation.

Jugular cannulation was preliminarily attempted for this study using several heifers. However, animals failed to retain cannulas so this method was abandoned. Jugular venapuncture was used to collect samples for 4 consecutive d at each age interval.

All cattle were withheld from feed and water for a minimum of 14 h prior to each day's sample collection with the exception of
8-mo-old 1972 drylot cattle which were fed at 0730 and bled at 1300 hours. Increases in blood glucose levels cause decreases in blood levels of GH. McAtee and Trenkle (1971) reported depression of GH level shortly after feeding, with GH slowly returning and then exceeding prefeeding levels with a peak approximately 2 to 4 h postfeeding. Greep (1975) explained this reaction to blood glucose level was due to the role of GH in lipid metabolism to initiate gluconeogenesis. Low blood glucose appears to release GH from the pituitary, while high levels of glucose suppress GH release. McAtee and Trenkle (1971) reported fasting tends to stabilize plasma GH and has no significant effect if continued for up to 60 hours.

Sampling was accomplished with a 7.6-cm bleeding needle inserted in the jugular vein after confining the animal in a squeeze chute. Approximately 15 ml of blood were collected in a test tube containing one drop of heparin at each sampling. The sample was placed in ice and kept at 20 C until all of that day's samples were collected. All samples were centrifuged for 20 min at 10,000 rpm at 0 to 14 C. Plasma was drawn off and divided into two equal portions and frozen. One of the duplicates was sent to Iowa State University to the laboratory of Dr. Allen Trenkle where analysis for GH was conducted by radioimmunoassay. Results from 1971 data were reported in ng/.05 ml of plasma, while all other years were recorded as ng/ml of plasma, so 1971 data were converted to ng/ml of plasma.
Production Measurement

Quantitative measures of production were examined in relationship to plasma GH levels. A record of weaning weight for each individual sampled for GH and records of weaning weights of all calves produced were collected. Adjustments for age and sex of calf and age of dam were made according to guidelines established by the Beef Improvement Federation (1974). All cattle were weighed at 28-d intervals throughout the experiment. Weight at time of bleeding (GH sampling) was defined as the closest 28-d weight to the date of bleeding. Mature weight was an average of all 28-d weights taken at the ages of 5, 6 and 7 yr, with an additional weight taken at calving each year. Ages of 5, 6 and 7 yr were defined as mature due to record availability common to all experimental units (table 2).

<table>
<thead>
<tr>
<th>Age</th>
<th>1970</th>
<th>1971</th>
<th>1972</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1975</td>
<td>1976</td>
<td>1977</td>
</tr>
<tr>
<td>6</td>
<td>1976</td>
<td>1977</td>
<td>1978</td>
</tr>
<tr>
<td>7</td>
<td>1977</td>
<td>1978</td>
<td>1979</td>
</tr>
<tr>
<td>8</td>
<td>1978</td>
<td>1979</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1979</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 2. YEAR OF RECORD WITHIN YEAR OF BIRTH AND AGE CLASSIFICATION

Weight/height ratio is weight at sampling divided by a height measurement taken at GH sampling. Measurements of height were taken
over the points of the shoulder with the head held in a position so the top of the poll was slightly higher than the shoulders. In addition, height was measured at weaning and calving throughout the project. Mature height was defined as the arithmetic mean of the six measurements taken at the ages defined as mature.

Most probable producing ability (Lush, 1945) for weaning weight is based on records of weaning weight produced by each cow during her lifetime. Adjustments for weights were the same as those for the cow as previously described. Calculation was by the equation

\[
MPWW = \frac{nr}{1 + (n-1)r} (\hat{p} - \bar{p})
\]

where \( n \) = number of calves produced by a dam, \( r \) = repeatability of weaning weight record, \( \hat{p} \) = mean weight produced at weaning by a dam and \( \bar{p} \) = mean weight produced at weaning by all dams having progeny in the same years. A repeatability estimate of .45 was used in calculation. This agreed with the estimates obtained by Kress and Burfenning (1972) of .44 and Boston et al. (1975) of .50.

Milk production was calculated as most probable producing ability (Lush, 1945) using the equation

\[
(MPMP) = \frac{nr}{1 + (n-1)r} (Mdiff)
\]

where \( n \) = number of lactations, \( r \) = repeatability of milk yield and Mdiff is the average deviation from year x management means in which the animal has a lactation record.

To obtain data for MPMP calculation, measurements of 24-h lactation were collected four times during each lactation. Calves were separated from dams 14 h prior to an am collection, then separated immediately afterward and a pm measurement taken. Both measurements were totalled and represent a 24-h production. All records were
collected by the weigh-suckle-weigh method (Neville, 1962). Collection was made in the first weeks of June and July and the last weeks in August and September in all years. Age of calf ranged from 50 to 180 days. The 50-d minimum age allowed calves to consume all milk produced by the dam and allowed for adjustment in milk production for the pasture group which was moved from wintering lots to pasture during the first 2 wk of May. The repeatability estimate for milk yield used was .46 (Dillard et al., 1978). Neville et al. (1974) reported a similar estimate of .48.

Statistical Analysis

Analysis of the data initially included a linear additive model with year (Y), age (A), breed (B), status (S), management (M) and first order interactions as discrete fixed sources of variation in GH level. Year was defined as the year in which GH sample was obtained. Years included were 1971 through 1975. Age was the months of age an animal was at time of sampling, which were 8, 14, 20, 32 and 44 months. Breed denoted one of the four classifications, A x A, C x C, C x A or A x C. Management defined the management system under which an animal was maintained, either drylot or pasture. Status indicated whether an animal was pregnant or open at time of GH sampling.

Performance variables previously defined were included as continuous variables in the model. A step-down procedure was followed removing nonsignificant (P > .20) main effects and interactions and pooling their sum of squares with the error term. Continuous variables were
retained in the analysis regardless of test of significance on GH level.
Least-squares analysis adjusted for unequal subclass numbers.

The complete linear additive model was

\[ GH_{ijklmn} = \mu + Y_i + B_j + A_k + S_l + M_m + YxB_{ij} + YxA_{ik} + YxS_{il} + YxM_{im} + \]
\[ BxA_{jk} + BxS_{jl} + BxM_{jm} + AxS_{kl} + AxM_{km} + SxM_{lm} + e_{ijklmn} \]

where

GH is an individual observation of GH level,
\( \mu \) is the population mean level of GH,
\( Y_i \) is the effect common to all observations in the \( i \)th year,
\( B_j \) is the effect common to all observations of the \( j \)th breed,
\( A_k \) is the effect common to all observations of the \( k \)th age,
\( S_l \) is the effect common to all observations of the \( l \)th status,
\( M_m \) is the effect common to all observations of the \( m \)th management,
\( YxB_{ij} \) is the interaction of the \( i \)th year with the \( j \)th breed,
\( YxA_{ik} \) is the interaction of the \( i \)th year with the \( k \)th age,
\( YxS_{il} \) is the interaction of the \( i \)th year with the \( l \)th status,
\( YxM_{im} \) is the interaction of the \( i \)th year with the \( m \)th management,
\( BxA_{jk} \) is the interaction of the \( j \)th breed with the \( k \)th age,
\( BxS_{jl} \) is the interaction of the \( j \)th breed with the \( l \)th status,
\( BxM_{jm} \) is the interaction of the \( j \)th breed with the \( m \)th management,
\( AxS_{kl} \) is the interaction of the \( k \)th age with the \( l \)th status,
\( AxM_{km} \) is the interaction of the \( k \)th age with the \( m \)th management,
SxM\textsubscript{lm} is the interaction of the \textsuperscript{l}th status with the \textsuperscript{m}th management and

\( e_{ijklmn} \) is the random effect specific to the \textsuperscript{i}th year, \textsuperscript{j}th breed, \textsuperscript{k}th age, \textsuperscript{l}th status and the \textsuperscript{m}th management that produces a deviation of the \textsuperscript{n}th observation from the expected mean.

Reduction of the model to significant main effects (P<.20) was accomplished with continuous variables included as sources of variation in GH. This maintained maximum sum of squares for these measures which were examined residual to linear model discrete variables. Assessment of influences on GH and relationship of GH to performance was accomplished using individuals with records of lifetime performance, reducing observations of GH from 2,481 to 1,848.

A separate analysis of variance was conducted using significant discrete variables from the initial analysis with breed and breed x management interaction terms included. All observations of GH were included. Total sum of squares was increased due to increases in GH observations and model degrees of freedom were decreased. Breed effect was found to significantly (P<.025) influence GH. However, this breed effect disappeared (P = .65) when the continuous variables were included, indicating that they described breed differences influencing GH.

Breed effect was dropped and the final linear model \( Y_{ijkl} = \mu + Y_1 + A_j + M_k + YxM_{ik} + e_{ijkl} \) was used to obtain residuals for GH, WAB, WH, MW, MH, MPWW, MPMP and FL. Residuals were used in stepwise regression procedure to determine the relationship of GH to performance.
GH was considered as both a dependent and an independent variable to assess whether the more easily measured performance traits could be used to predict GH level and to determine GH assay worth in predicting future performance. GH values for all ages were used and two separate analyses were conducted using data collected at 8 and 14 mo of age, which are two common times of selection for breeding animals by producers. Traits measurable at these times (WW, WAB and WH) were used along with GH as independent variables to predict lifetime performance traits MW, MH, MPWW, MPMP and FL. Quadratic terms for GH, WW and WAB were also included to test for curvilinear effects.
INTRODUCTION

Endocrine influence on metabolism determines the rate and extent of growth of an animal. A thorough understanding of hormones and their influence is necessary to the meat animal industry for advancement of efficient production to supply a growing world demand for food. Many hormones affect metabolism, but growth hormone (GH) appears to have one of the smallest fluctuations in circulating levels. Previous research indicates nonsignificant changes in plasma growth hormone (GH) due to season (Tucker et al., 1974), circadian rhythm (Kaprowski et al., 1972) or level of nutrient intake (Trenkle, 1971). Factors that have been identified as influencing GH level are sex (Eaton et al., 1968), age (Curl et al., 1968; Dev and Lasley, 1969; Tucker et al., 1974), roughage content of the diet (Trenkle, 1971), breed (Hart et al., 1975), estrus (Kaprowski et al., 1972) and lactation (Kaprowski et al., 1972; Trenkle, 1978).

This study provided for examination of GH levels in beef females over a period of time (8 to 44 mo of age) not previously reported. The objectives of this study were to examine environmental influences on GH and to evaluate the relationship of GH levels to performance. Continued observation of performance collected for lifetime efficiency studies permitted investigation of relationships to performance in beef cattle that have not been previously examined.
MATERIALS AND METHODS

Data from 170 female Angus, Charolais and reciprocal cross beef cattle produced in three consecutive calf crops (1970 to 1972) were used in this study of plasma growth hormone (GH) which was a part of a total project investigating efficiency of production. Cattle were assigned randomly within breed to either a drylot or pasture management regime (Marshall, 1975). Culling criteria were failure to conceive during first breeding season, failure to wean a calf in 2 consecutive yr and disabling physical injury. Cattle were maintained until completion of the project in 1979.

Sample Collection

Collection of blood samples for GH analysis was completed once daily on 4 consecutive d at the ages of 8, 14, 20, 32 and 44 months. Cattle were withheld from feed 14 h prior to sampling to stabilize blood serum metabolites.

Cannulation of the jugular vein was initially attempted since research by Eaton et al. (1968) and Trenkle (1970) had suggested stress of confinement and venous puncture as a factor responsible for elevating GH. Kaprowski and Tucker (1973), taking three samples from venapuncture of a tail artery within 3 h, found a repeatability measure of .85, indicating that stress of puncture might not have as much influence as had been suggested. Cannulation was attempted in a few animals prior to starting the experiment, but cannulas were not retained and jugular venapuncture was used for collection. Cattle were confined and a 7.6-cm
bleeding needle was inserted in the jugular vein to obtain approximately 15 ml blood in a test tube containing one drop of heparin. The test tube was immediately placed in ice until all samples for that day were collected. Samples were then centrifuged, plasma drawn off and duplicates were made from each sample. All plasma was frozen until analyzed for GH by radioimmunoassay at Iowa State University. Results were recorded as nanograms per milliliter (ng/ml) of plasma.

Production Traits Studied

Measures of production were taken throughout the animal's lifetime. Traits selected for investigation were weaning weight, weight at sampling, weight to height ratio at sampling, mature height, mature weight, first lactation record and most probable producing ability for both milk production and weaning weight.

Weaning weights for all animals were adjusted for age and sex of calf and age of dam according to guidelines established by the Beef Improvement Federation (1974). All cattle were weighed at 28-d intervals throughout their life. Weight at time of blood sampling (WAB) was the 28-d weight closest to time of GH collection. Weight to height ratio (WH) was calculated by dividing WAB by a shoulder height measurement taken at the time of GH sampling.

First lactation record (FL) was a total of four measurements of 24-h milk production taken by the weigh-suckle-weigh method (Neville, 1962) at approximately d 40, 70, 130 and 160 of the animal's first lactation. Only first calf 2-yr-olds were included.
Lifetime production of milk (MPMP) and weaning weight (MPWW) were calculated as most probable producing abilities (Lush, 1945). MPMP was estimated from four 24-h measurements per lactation taken during all lactation periods of an individual. Herd average comparison was calculated within management group from all individuals having records in like years. In calculation of MPWW, all weaning weights were adjusted for age and sex of calf and age of dam (Beef Improvement Federation, 1974). Herd average comparison again was calculated within management group from animals having records in like years.

Maturity was defined at ages of 5, 6 and 7 yr, the oldest ages common to all animals. Mature weight (MW) was the average of thirty-nine 28-d weights plus a weight taken at calving. Height at the shoulder was measured at calving and weaning of each year. Mature height (MH) was the average of six measurements taken at maturity.

Statistical Procedure

Five discrete main effects and all two-factor interactions were included in an initial fixed linear model. Main effects included year, breed, age, management and status. Year (Y) in which the sample was collected included the years 1971 through 1975. Breed (B) was identified as one of the four groups of cattle which were Angus (A x A), Charolais (C x C), Angus x Charolais (A x C) and Charolais x Angus (C x A). Management (M) consisted of drylot and pasture groups. Age (A) was age of the animal at GH collection and included 8, 14, 20, 32 and 44 mo of age. Status (S) indicated whether an animal was pregnant or nonpregnant at time of GH sampling.
Performance measures were included in the initial linear model as continuous independent variables. This was necessary so variation in GH level related to variation in performance traits was retained for further regression analysis. Without the continuous performance variables, breed differences which are described principally by performance differences would have been attributed solely to breed effect and lost for further analysis.

A step-down procedure eliminated nonsignificant (P<.20) main effects and interactions. Continuous variables were retained regardless of significance.

Final linear model containing all significant main effects and interactions was

\[ Y_{ijkl} = \mu + Y_i + A_j + M_k + Y_xM_{ik} + e_{ijkl} \]

where

- \( Y_{ijkl} \) is an observation of GH,
- \( \mu \) is the population GH mean,
- \( Y_i \) is the effect common to all animals sampled in the \( i^{th} \) year,
- \( A_j \) is the effect common to all animals of the \( j^{th} \) age,
- \( M_k \) is the effect common to all animals of the \( k^{th} \) management,
- \( Y_xM_{ik} \) is the effect common to all animals of the \( k^{th} \) management sampled in the \( i^{th} \) year and
- \( e_{ijkl} \) is the random deviation peculiar to the \( l^{th} \) individual of the \( j^{th} \) age in the \( i^{th} \) year and \( k^{th} \) management group.
Sums of squares for GH and performance variables residual to the model were used in stepwise multiple regression (MaxR) procedure (Goodnight, 1979) to examine the relationship of GH to performance. Growth hormone was considered as both a dependent and an independent variable to determine if the more easily measured performance variables could be used to predict GH level and to examine the ability of GH assay to predict the future production of an animal. Measures of early performance (WW, WAB and WH) were used with GH as independent variables to predict production measured at later ages (FL, MW, MH, MPWW and MPMP). Quadratic terms for GH, WW, WAB and MW were also included to evaluate possible curvilinear effects.

Individual analyses of samples taken at 8 and 14 mo of age were conducted because these are two common ages at which selection for breeding stock is done. Thus, the relationship of GH levels at these ages to performance exhibited at later ages was of interest to determine if GH level was a useful selection trait.
RESULTS AND DISCUSSION

Least-squares means for year effects (table 3) indicated higher GH levels in 1972 than any other year (P<.001) which agreed with Dev and Lasley (1969) who reported year differences in GH level.

The difference in GH levels due to management effect was significant (P<.001). The least-squares mean for the pasture group was 7.18 ng/ml ± .20 compared with 5.74 ng/ml ± .19 for the drylot group. Trenkle (1970) found higher (P<.05) levels of GH in sheep on rations containing higher levels of roughage. Drylot cattle in this experiment were receiving alfalfa pellets and corn during lactational periods (Marshall, 1975), while pasture cattle were on pasture or a roughage ration (silage and hay). These differences in rations could be a contributing factor to differences in GH levels between groups.

Least-squares means by age (table 4) indicate cattle at 14 and 20 mo of age have higher (P<.01) levels of GH than cattle at 8 mo of age. A decrease in circulating levels of GH with increasing age has been reported by Nalbandov (1963), Curl et al. (1968), Trenkle (1970), Tucker et al. (1974) and others. Kaprowski et al. (1972) reported increases in GH levels at or near estrus. Hormonal imbalances at time of puberty may also be a factor in higher 14-mo levels. Lowest circulation levels were observed at 32 and 44 mo of age, indicating that GH levels decrease with age.
### TABLE 3. GROWTH HORMONE MEANS BY YEAR

<table>
<thead>
<tr>
<th>Year</th>
<th>GH, ng/ml</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>6.93&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.42</td>
</tr>
<tr>
<td>1972</td>
<td>10.42&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.28</td>
</tr>
<tr>
<td>1973</td>
<td>4.63&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.41</td>
</tr>
<tr>
<td>1974</td>
<td>5.19&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.48</td>
</tr>
<tr>
<td>1975</td>
<td>5.11&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.48</td>
</tr>
</tbody>
</table>

<sup>a,b,c</sup> Means without a common superscript differ (P<.05).

### TABLE 4. GROWTH HORMONE MEANS BY AGE

<table>
<thead>
<tr>
<th>Age, mo</th>
<th>GH, ng/ml</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>6.23&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.41</td>
</tr>
<tr>
<td>14</td>
<td>9.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.41</td>
</tr>
<tr>
<td>20</td>
<td>7.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.43</td>
</tr>
<tr>
<td>32</td>
<td>4.77&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.33</td>
</tr>
<tr>
<td>44</td>
<td>5.08&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>.48</td>
</tr>
</tbody>
</table>

<sup>a,b,c</sup> Means without a common superscript differ (P<.05).
Year x management interaction had a significant influence on GH level (P < .001). Growth hormone level was higher for the pasture group (P < .05) in all years except 1973 when no significant difference (P > .10) existed between pasture and drylot cattle.

Breed effect was found to be a nonsignificant (P = .64) source of variation in GH levels in the step-down procedure when continuous variables were included. An analysis of variance conducted without continuous variables in the model resulted in significant breed differences (table 5). Apparently, the performance traits explained breed differences in GH level. However, these differences between breeds agreed with observations by Hart et al. (1975). In order to examine differences in GH and its relationship to performance in residuals to the linear model, breed effect was not included in the final model to maintain variability in performance traits.

Multiple regression analysis with GH as the dependent variable and WAB, WH, FL, MH, MW, MPWW and MPMP as independent variables identified WH as the best single predictor of GH in the following equation: $\hat{GH} = 13.76 + (.0011 \times WAB) - (1.79 \times WH) - (.0257 \times MH) + (.0040 \times MW) - (.0094 \times MPWW) + (.0831 \times MPMP) - (.0557 \times FL)$. The probability of F for test of significance of the regression model was .001, but the $R^2$ value was .019, indicating little relationship between measures of circulating GH and measures of performance.

GH data collected at 8 mo of age were analyzed by multiple regression using WW and GH as independent variables predicting MPMP, MPWW, MW and MH. Analysis indicated that WW accounted for .2, .8, 15,
TABLE 5. GROWTH HORMONE MEANS BY BREED GROUP

<table>
<thead>
<tr>
<th>Breed</th>
<th>GH, ng/ml</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>6.90a</td>
<td>.20</td>
</tr>
<tr>
<td>AC</td>
<td>6.60ab</td>
<td>.22</td>
</tr>
<tr>
<td>CA</td>
<td>6.49ab</td>
<td>.19</td>
</tr>
<tr>
<td>CC</td>
<td>6.01b</td>
<td>.22</td>
</tr>
</tbody>
</table>

a Means without a common superscript differ (P<.10).
b Means without a common superscript differ (P<.05).

26 and 28% of the variation, respectively, in the dependent variables. GH accounted for less than 2% of the variation in any performance trait. Other variables were added to GH and WW as predictors of performance in further multiple regression analyses (GH^2, WAB and WAB^2). These five variables accounted for 9, 10, 25, 46 and 34% of the variation in FL, MPMP, MPWW, MW and MH, respectively. GH and GH^2 accounted for less than 3% of the variation in any trait (table 6).

GH data from the 14-mo sampling were examined by multiple regression in the same manner as the 8-mo data. GH and WW accounted for .2, 1, 15, 26 and 24% of the variation in FL, MPMP, MPWW, MW and MH, respectively. GH accounted for less than 2% of the variation in any performance trait. Addition of WAB, GH^2 and WAB^2 to WW and GH as predictors of performance accounted for 1.5, 11.7, 18, 50 and 36% of variation in FL, MPMP, MPWW, MW and MH, respectively (table 7).
### TABLE 6. COEFFICIENTS FOR COMPONENTS OF MULTIPLE REGRESSION EQUATIONS FOR 8-MO DATA

<table>
<thead>
<tr>
<th>Trait</th>
<th>Intercept</th>
<th>GH</th>
<th>GH²</th>
<th>WW</th>
<th>WAB</th>
<th>WAB²</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW</td>
<td>43.87</td>
<td>-1.76</td>
<td>.05</td>
<td>1.40</td>
<td>-1.92</td>
<td>.005</td>
<td>.46</td>
</tr>
<tr>
<td>MH</td>
<td>74.84</td>
<td>-.16</td>
<td>.004</td>
<td>.12</td>
<td>-.08</td>
<td>.0002</td>
<td>.34</td>
</tr>
<tr>
<td>MPWW</td>
<td>-58.46</td>
<td>-.27</td>
<td>.0006</td>
<td>.57</td>
<td>-1.99</td>
<td>.005</td>
<td>.25</td>
</tr>
<tr>
<td>MPMP</td>
<td>59.94</td>
<td>.35</td>
<td>-.008</td>
<td>-.10</td>
<td>-.25</td>
<td>.0007</td>
<td>.11</td>
</tr>
<tr>
<td>FL</td>
<td>48.67</td>
<td>.18</td>
<td>-.005</td>
<td>-.07</td>
<td>-.08</td>
<td>.0004</td>
<td>.07</td>
</tr>
</tbody>
</table>

### TABLE 7. COEFFICIENTS FOR COMPONENTS OF MULTIPLE REGRESSION EQUATIONS FOR 14-MO DATA

<table>
<thead>
<tr>
<th>Trait</th>
<th>Intercept</th>
<th>GH</th>
<th>GH²</th>
<th>WW</th>
<th>WAB</th>
<th>WAB²</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW</td>
<td>-47.47</td>
<td>.96</td>
<td>-.014</td>
<td>.81</td>
<td>.74</td>
<td>-.0002</td>
<td>.50</td>
</tr>
<tr>
<td>MH</td>
<td>81.24</td>
<td>.10</td>
<td>-.002</td>
<td>.09</td>
<td>0.04</td>
<td>.0002</td>
<td>.36</td>
</tr>
<tr>
<td>MPWW</td>
<td>-209.51</td>
<td>-.16</td>
<td>.003</td>
<td>.68</td>
<td>-.44</td>
<td>.0005</td>
<td>.18</td>
</tr>
<tr>
<td>MPMP</td>
<td>49.25</td>
<td>-.25</td>
<td>.005</td>
<td>-.02</td>
<td>-.23</td>
<td>.0003</td>
<td>.12</td>
</tr>
<tr>
<td>FL</td>
<td>28.18</td>
<td>-.14</td>
<td>.003</td>
<td>-.01</td>
<td>-.03</td>
<td>.00007</td>
<td>.02</td>
</tr>
</tbody>
</table>
Regression analysis revealed little relationship between GH measurements and measures of performance traits, which agreed with results obtained by Dev and Lasley (1969) and Tucker et al. (1973). Early measures of growth (WW and weights at 8 and 14 mo of age) were much better predictors of FL, MPMP, MPWW, MW and MH than GH level.

Research by Trenkle (1970) noted significant increases in GH levels in feedlot steers fed DES. Frantz and Rabkin (1965) noted increased levels of GH in estrogen-treated male and female humans. Kelly et al. (1974) postulated that steroid hormones play a significant role in increasing number of GH receptor sites in rats and rabbits. As an intrinsic factor in metabolism, GH relationship to economically important performance may be described by further research into receptor sites or relationship of GH to other hormones, presenting an opportunity for description and selection on a cellular basis.
SUMMARY

Circulating levels of growth hormone were measured in 170 head of Angus, Charolais and reciprocal cross females to examine variability in plasma GH levels and to investigate the relationship of measures of production to GH levels. Animals were maintained for a minimum of 7 yr to collect records of lifetime production. Growth hormone samples were obtained from the animals at 8, 14, 20, 32 and 44 mo of age and examined by radioimmunoassay. A total of 2,481 samples were collected.

Analyses identified (P<.001) year, age, management and year x management interaction as sources of variation in growth hormone level. These factors accounted for 24% of variation observed. Overall least-squares mean for growth hormone was 6.46 ng/ml ± .14. Least-squares means for year effect indicated 1972 (10.42 ng/ml ± .28) was higher than all other years (P<.001). Animals at 14 mo of age had highest (P<.001) growth hormone levels (9.08 ng/ml ± .41) with 8 and 20 mo (6.23 ng/ml ± .41 and 7.14 ng/ml ± .43) showing intermediate levels and lowest levels at 32 and 44 mo of age (4.77 ng/ml ± .33 and 5.04 ng/ml ± .48).

Management means revealed higher levels (P<.001) of growth hormone for cattle under pasture management than under drylot management. Animals on pasture had higher levels of growth hormone in all years except 1973 which contributed to a significant (P<.001) year x management interaction term.
Growth hormone data collected at all ages and data collected at 8 and 14 mo of age were used in three separate regression analyses to determine relationship of growth hormone and performance measures. Growth hormone, linear and quadratic, explained less than 3% of variation observed in any performance trait.
LITERATURE CITED


