DIVERGENT SELECTION FOR SERUM INSULIN-LIKE GROWTH FACTOR I (IGF-I) CONCENTRATION IN BEEF CATTLE

M.E. Davis[1], M.D. Bishop[2], F.J. Michel[3] and R.C.M. Simmen[3]

[1]Dept. Anim. Sci., The Ohio State Univ., Columbus, 43210-1095, USA
[2]USDA, ARS, Roman L. Hruska U.S. Meat Anim. Res. Center, P.O. Box 166, Clay Center, NE, 68933-0166, USA
[3]Dept. Anim. Sci., Univ. of Florida, Gainesville, 32611-0701, USA

SUMMARY

A divergent selection experiment for blood serum IGF-I concentration has been ongoing since 1989 using 100 spring-calving and 100 fall-calving beef cows. To date, high line (H) sires have averaged 104 $\pm$ 10 ng/ml more IGF-I ($P < .001$) than low line (L) sires and H replacement heifers have averaged 11 $\pm$ 3 ng/ml more IGF-I ($P < .001$) than L replacement heifers. Thus far, realized h^2 of IGF-I in the spring- and fall-calving replicates has been .21 and .27, respectively. Means for preweaning and postweaning weights and gains of the most recent H and L progeny were not significantly different. Residual correlations of on-test IGF-I concentrations with preweaning and postweaning weights and gains ranged from .21 ($P > .10$) to .39 ($P < .05$). Correlations of IGF-I concentration at d 28 of the postweaning test with postweaning weights ranged from .11 ($P < .10$) to .18 ($P < .05$).

INTRODUCTION

Serum IGF-I is a potentially useful biological indicator trait. Lund-Larsen et al. (1977) suggested that IGF-I may aid in selection of breeding animals at an early age. Reports in the literature demonstrate that IGF-I is phenotypically associated with a wide variety of traits including growth and body size, feed efficiency, reproduction, milk production and carcass characteristics. However, little is known about the genetic relationships of IGF-I with other traits. If IGF-I is shown to be an important biological indicator of genetic merit, selection indexes containing IGF-I and performance traits (e.g., weights and gains) measured early in the lifetime of the animal, as well as pedigree information, could be developed to enable beef producers to accurately select breeding animals at an earlier age than now possible. The objectives of the current study are to (1) assess differences in serum IGF-I levels between two lines of Angus beef cattle selected for either increased or decreased blood serum IGF-I concentration and (2) assess changes in growth that occur due to such selection.

MATERIALS AND METHODS

Selection Procedures. Divergent selection for IGF-I concentration in blood serum is being practiced using 100 spring-calving (50 H and 50 L) and 100 fall-calving (50 H and 50 L) purebred Angus cows located at the Eastern Ohio Resource Development Center

(EORDC), Belle Valley, USA. Each year, the four bull calves with the highest and the four with the lowest residuals (adjusted for age of calf and age of dam) for IGF-I concentrations are saved for breeding within the respective selection lines. Selection is based upon the average of three IGF-I serum samples (taken at d 28, 42 and 56 of the postweaning test). Selected bulls are used for breeding as yearlings and then sold.

Approximately eight cows are culled from each line each year (based upon physical unsoundness, reproductive failure and oldest age) and replaced with approximately eight pregnant heifers having the highest or lowest residuals (adjusted for age of calf and age of dam) for blood serum IGF-I concentrations. Selection of heifers is based upon the average of three postweaning IGF-I serum samples collected at the same time as for bulls.

Management Procedures. Spring-born calves are reared by their dams without creep feed until weaning at approximately 7 mo of age. Following weaning, bull calves are fed a corn-soybean meal based concentrate diet and heifer calves are fed corn silage for an approximately 2 wk adjustment period and a 140-d test period. Bulls and heifers are fed ad libitum at different locations under drylot conditions. Fall-born calves are early weaned at an average age of approximately 140 d and then fed a growing diet in drylot for 112 d. The growing diet is intended to yield gains of approximately .9 kg/d. Following the 112-d growing period, bull calves remain at EORDC and are managed in the same fashion as spring-born bulls, whereas heifer calves are transported to another research branch and managed thereafter in the same manner as spring-born heifers.

Serum and Tissue Samples. Approximately 15 ml of blood is collected into sterile 16 x 150 mm glass tubes via jugular puncture of each animal. The blood is allowed to clot for 24 h at 4°C. Serum is obtained by centrifugation (1,800 x g for 20 min) and frozen at -20°C until assayed.

Radioimmunoassay for IGF-I. The RIA for IGF-I is performed in the laboratory of Dr. R. C. M. Simmen at the University of Florida using procedures described by Bishop et al. (1989). Briefly, following acid-ethanol extraction, each sample is diluted 1:10 in assay buffer and assayed in duplicate using human recombinant IGF-I as standard and iodinated tracer. Antisera raised against human IGF-I in rabbits (UBK487) is used at a dilution of 1:18,000. Antigen-antibody complexes are precipitated by addition of goat anti-rabbit gamma globulin and normal rabbit serum. Concentrations of IGF-I in serum samples are calculated from the standard curve.

Statistical Analysis. The IGF-I concentration, weights and gains of the four H and four L bulls selected for use in the 1990 through 1993 breeding seasons were compared using a statistical model that included the fixed effects of year-line-season and age of dam (2, 3, 4, 5 to 9, and 10 yr or greater), the random effect of sire of calf nested within year-line-season and a covariate for age of calf

(omitted for birth weight). Means of H and L heifers selected to date were compared using the same model. Linear functions of the year-line-season least squares means were used to compare means of selected H and L bulls and heifers. Means of H and L progeny born in spring and fall 1992, the last progeny evaluated to date, were compared using a model that contained line, sire within line, sex of calf, age of dam, important (P<.20) two-factor interactions and age of calf (where appropriate). Effects of selection line were tested using sire of calf within selection line as the error term.

Residual correlations of IGF-I concentration measured at various ages and mean IGF-I concentration (average of IGF-I values obtained at different ages) with weights, gains and heights of calves born from spring, 1989 through fall, 1992 were computed after removing variation due to year-line-season, sex of calf, sire of calf nested within year-line-season, age of dam, age of calf (omitted in the analysis of birth weight) and important ($P < .20$) two-factor interactions.

Calculation of Realized Heritability. Response (R) was calculated as the mean difference in IGF-I concentration between H and L progeny born in spring and fall, 1992. These R were then divided by the standard deviations for mean IGF-I concentrations of all spring and fall, 1992 calves. Total within-line effective selection differentials (SD) were estimated by calculating the simple average of within-sex effective SD for spring and fall, 1990 and 1991 breeding seasons. Effective SD used to estimate realized h^2 to date for the spring and fall replicates were calculated by subtracting the low line effective SD from the high line effective SD and then dividing the differences by the standard deviation of mean IGF-I for all calves available for selection. Realized h^2 was calculated as the ratio of standardized R to cumulative standardized SD.

RESULTS AND DISCUSSION

Means of Selected High vs Low Line Bulls. Pooled across years and breeding seasons, H sires have averaged 104 $\pm$ 10 ng/ml more IGF-I ($P < .001$) than L sires to date in this selection experiment. Selected L bulls have tended to have heavier birth, weaning, on-test, and 140-d (off-test) weights, as well as greater postweaning gains, than selected H bulls, although differences have been small ($P \geq .32$).

Means of Selected High vs Low Line Heifers. Pooled across years and breeding seasons, selected H heifers have averaged 10.7 $\pm$ 3.1 ng/ml more IGF-I ($P < .001$) than selected L heifers. In agreement with results found for selected H vs L bulls, birth weights and postweaning gains of selected L heifers have tended to exceed those of selected H heifers ($P = .36$ in both cases). However, selected H heifers have tended to have greater weaning, on-test and off-test weights ($P = .05$, .06 and .28, respectively).

Means of High vs Low Line Progeny Born in 1992. Mean IGF-I

concentrations of H and L progeny born in spring, 1992 were 210 ± 7 and 193 ± 8 ng/ml, respectively (P = .41). A line x sex interaction existed (P = .08) for mean IGF-I concentration. Birth weights, weaning weights, on-test weights, postweaning ADG and off-test weights of H progeny did not differ (P ≥ .48) from those of L progeny. Sex x line interaction tended to be important for weaning weight (P = .02) and for postweaning ADG (P = .09).

Mean serum IGF-I concentrations of H and L progeny born in fall, 1992 were 230 ± 9 and 191 ± 13 ng/ml, respectively (P = .04). Mean birth weight, weaning weight, on-test weight, postweaning ADG and off-test weight of H and L progeny did not differ (P ≥ .35). A sex x line interaction tended to exist (P = .13) for postweaning ADG and off-test weight.

Selection Differentials, Response and Realized Heritability. Standardized effective SD for the spring, 1990 and 1991 breeding seasons were 1.80 and 1.18, respectively, resulting in a cumulative SD to date of 2.98. Standardized R based on spring, 1992 progeny was .62. Therefore, realized h^2 to date in the spring replicate is .62 / 2.98 = .21.

In the fall, 1990 and 1991 breeding seasons, standardized effective SD were 1.99 and 1.03, respectively, for a cumulative SD of 3.02. Standardized R based on fall, 1992 progeny was .83. Realized h^2 thus far in the fall replicate is therefore .83 / 3.02 = .27.

Residual Correlations of IGF-I Concentration with Performance Traits. Residual correlations of on-test IGF-I concentration with preweaning and postweaning weights and gains were moderate in size, ranging from .21 (P > .10) to .39 (P < .05). Correlations of IGF-I concentration at d 28 of the postweaning test with postweaning weights ranged from .11 (P < .10) to .18 (P < .05). The IGF-I concentration at d 112 of the postweaning test tended to be moderately related to preweaning and postweaning weights and gains with correlations ranging from .21 (P > .10) to .39 (P < .05). Correlations of IGF-I concentration at d 42, 56, 84 and 98 of the postweaning test with performance traits were generally low and not significantly different from zero. Mean IGF-I concentration (i.e., the average of IGF-I values obtained for a given calf) was not significantly correlated with any of the recorded weights, gains or hip heights. Thus, it may be best to measure serum IGF-I concentration at d 0 or 28 of the postweaning test if it is desired to maximize the relationship between IGF-I and performance characteristics of beef cattle.

REFERENCES

LUND-LARSEN, T.R., SUNDBY, A., KRUSE, V. AND VELLE, W. (1977) J. Anim. Sci. 44:189-194.

BISHOP, M.D., SIMMEN, R.C.M., SIMMEN, F.A. AND DAVIS, M.E. (1989) J. Anim. Sci. 67:2872-2880.