W-1010 annual meeting
July 1-2, 2010
Columbia, MO

Participants:

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Brief Summary of Minutes of Annual Meeting:

Members Not Attending: Jason Ahola and Cassie Welch, Idaho; Larry Berger, Illinois; Grant Crawford, Minnesota; Gustavo Cruz, California; Robert Dailey and Eugene Felton, West Virginia; Robert Herd, Australia; Travis Maddock, Florida; Robert Myer, Florida; Roberto Sainz, California; Thomas Welsh, Texas; Robert Wettemann, Oklahoma; Scott Whisnant, North Carolina.

The annual meeting of the W1010 technical committee was held in Columbia, Missouri on July 1 and 2, 2010. The meeting was called to order by esteemed chair, Professor Gordon Carstens. The group was welcomed to the University of Missouri by Dr Rod Geisert, Director of the Division of Animal Sciences. Each of the stations attending prepared a brief written report and presented this information to the group in attendance. In the business meeting, Dr Bret Hess provided programmatic updates relevant to the technical committee and also provided insight into NIFA funding opportunities. It was decided that the next year meeting would be held immediately after BIF meetings in Montana. Dr Kerley will serve as Chair in 2010-11. Dr Kriese-Anderson was elected to serve as Secretary. Following experiment station presentations, the committee explored avenues, mechanisms and future plans for collaborative research and joint grant submissions. A great time was had by all, the weather was typical for Missouri in July, and all noted the children were above average in Columbia.

Accomplishments and Short Term Outcomes:

(West Virginia) As of spring 2010, we completed the 7th bull, 4th ram and 3rd buck performance evaluation program in which we have provided feed efficiency (RFI) and intake data to producers and purchasers of these potential sires. In addition to sire performance testing, we have conducted 4 matriarchal cow tests evaluating common production factors that may influence cow maternal feed efficiency. From these tests, sires were identified, purchased and utilized in both artificial insemination and natural breeding, to both efficiency tested and non tested cows to investigate the ability to transmit feed efficiency from parent to offspring and identification of efficiency in non tested animals. Approximately 150 offspring, over 2 years have been tested for feed efficiency at weaning under a uniform environment with data indicating that paternal ranked RFI is distinguishable in offspring of mixed sexes. Steer calves from both of the weaning tests were subsequently placed on pasture their following spring in uniform weight and sire groups and maintained there for the entire pasture growing season (May to early October). Steers were allotted to treatments having equal stocking rates evaluating potential differences in pasture utilization by steers sired by high and low efficiency sires. Although not statistically significant, numerical trends do indicate that there are large differences in utilization of pasture between high and low efficiency sired steers that is affected by forage quality and quantity. Furthermore, at the end of the grazing season for both years in which steers were tested, steers were transported to feedlot facilities for uniform testing to determine differences in carcass quality between the different efficiency sired steers. Year one of finishing occurred at the University of Missouri, where a collaborating project was conducted to determine if previously determined efficiencies were maintained in a high grain feedlot environment. Data indicate that sire differences detected at weaning on a moderate energy diet, previous differences in efficiency of pasture utilization and previous sire efficiency ranking still holds true when offspring are taken to slaughter under differing conditions from which sires were tested. Concurrently with the pasture and feedlot testing, heifers from the same previous matings were uniformly developed, evaluated for reproductive soundness and have recently calved, determining potential influences of selecting for efficiency may have on subsequent daughter reproductive performance. One influential result thus far is that high efficiency heifers tend to carry less body fat and appear to reach puberty approximately 7 days later for each one kg improvement of RFI.

(Texas A&M University) Objective 1: Understand biological sources of variation in efficiency of feed utilization as quantified by traits like RFI. Objective 2: Discover physiological biomarkers and genetic markers for RFI. Objective 3: Examine the effects of selection for RFI on other economically relevant traits.

Few studies have characterized meal criterion in beef cattle, which is an estimate of the longest nonfeeding interval that is considered to be part of a meal. A study was conducted to quantify meal criteria, and to examine within-animal repeatability of feeding behavior traits and their associations with RFI in beef heifers fed high-grain diets. An electronic feed intake system (GrowSafe) was used to record bunk visit frequency (BVF) and duration (BVD) for 62 heifers (initial BW = 286) fed a high grain diet (3.1 Mcal ME/kg DM) for 81 d. A mixture 2-pool distribution model (R mixdist) was fitted to log10-transformed interval lengths between BVF. The intersection of the 2 distributions, which represents intervals within and between meals, was computed as the meal criteria and used to calculate meal frequency (MF) and duration (MD). RFI was calculated as the difference between actual and expected DMI from linear regression of DMI on ADG and mid-test $BW^{0.75}$. The overall means (± SD) for BVF and MF were 50 ± 8.9 and 8 ± 1.5 events/d, respectively; 61 ± 17.3 and 129 ± 26.6 min/d for BVD and MD; respectively, and 6 ± 1.1. for number of bunk visits per meal (BVM). The pooled meal criteria calculated on the 62 animals in this study was 12.5 min. RFI was positively correlated ($P < 0.05$) to BVF (0.42), BVD (0.41), MD (0.32), and BVM (0.44), but not with MF (0.03). Feed behavior traits for period 1 (d 1 to 40) were regressed on feed behavior traits on period 2 (d 41 to 81) to access within-animal repeatability of these traits. The r^2 of the regression equations for BVF, BVD, MF, MD were 0.63, 0.76, 0.73, 0.77, respectively, and for number of bunk visits per meal was 0.55. These results suggest that within animal repeatability of feed behavior traits are high and that they may be useful indicator traits for RFI in beef cattle.

A meta-analysis was conducted to examine phenotypic correlations between feed efficiency traits, scrotal circumference and semen-quality traits in yearling bulls. Data evaluated were obtained from 4 trials involving Angus (N = 92) and Bonsmara (N = 62) bulls fed diets that ranged from 1.70 to 2.85 Mcal ME/kg DM. Following an adaptation period of 24 to 28 d, feed intake was measured daily and BW measured at 14-d intervals. Ultrasound carcass traits (12^{th} rib backfat thickness; longissimus muscle area) and scrotal circumference (SC) were measured at the start and end of each trial. Semen samples were collected by electroejaculation within 50 d of the end of the trials when age of bulls averaged from 365 to 444 d, and were evaluated for progressive sperm motility and morphology. RFI was calculated as the difference between actual DMI and expected DMI from linear regression of DMI on ADG and mid-test $BW^{0.75}$; with trial, trial by ADG, and trial by mid-test $BW^{0.75}$ as random effects. G:F was strongly correlated with ADG (0.56) and weakly correlated with initial age and BW (-0.15; -0.18) and DMI (-0.21). RFI was not correlated with ADG, initial age or BW, but was correlated ($P < 0.01$) with DMI (0.67), G:F (-0.68) and BF (0.21). Initial SC (0.19), gain in SC (-0.31), and percent normal sperm (-0.19) were weakly correlated ($P < 0.05$) with G:F, but these traits were not correlated with RFI. Across studies, bulls with low RFI phenotypes (< 0.5 SD below the mean) consumed 20% less DMI and had 35% less BF, but had similar ADG, SC and semen-quality traits compared to high-RFI bulls (> 0.5 SD above the mean). Results suggest that RFI was not phenotypically associated with SC or semen-quality traits in growing bulls.

(Auburn University) Data were collected on Angus and Simmental bulls consigned to the Auburn University Bull Test from 1977 to 2007. All bulls (N=1433) were housed at the Auburn University Beef Evaluation Center (AUBEC) throughout the duration of each test. Additionally, in 2007, a group of progressive Alabama Simmental producers leased the facility to conduct a feeding trial on large contemporary groups of yearling bulls (n=96). Upon arrival, bulls were grouped by breed and weight then assigned to one of 8 pens. For the 2007 test group, bulls were grouped by contemporary group then by weight upon arrival. Each pen had a maximum capacity of 12 head. During a 21 d warm-up period, bulls were trained to the Calan Gate® system (American Calan, Northwood, NH), diet and to pens. Bulls had ad libitum access to a total mixed ration (TMR) balanced for energy (TDN= ~70%), protein (not < 12.5%) and fiber content (not > 20%). Exact composition of the TMR varied over years due to availability and cost of ingredients. Bulls were fed by hand, twice daily, an amount initially determined by 2.5% of their BW and from then on fed based on an amount they could eat with 0.45 to 2.27 kg of orts remaining in the bunk. Between the years of 1977 and 1989 the length of the test was 140 d. Test length shortened with the tests of 1990, 2000 and 2007 to 112 d, 84 d and 70 d, respectfully. Bull weight and hip heights were recorded bi-weekly for the 2007 test. For previous tests, bull weights and hip height were measured every 28 d.

Many bulls tested at AUBEC shared common ancestors with steers fed at the University of Illinois, Urbana, IL as part of the American Simmental Association's (ASA) Carcass Merit Program. Data from steers were courtesy of Dr. Wade Schaffer and the American Simmental Association (Bozeman, MT). The Carcass Merit Program was designed to allow Simmental/Simbrah producers to progeny test herd sires for both carcass merit and feed efficiency. After calving, steers were reared and managed in adherence with a typical beef cattle operation in the Midwestern United States. Steers were born in the months of January through March then weaned when the average age of the calf crop was 205 d. Approximately two weeks after weaning, steers were divided into pens, each equipped with a GrowSafe® feeding system (GrowSafe Systems Ltd., Airdrie, Alberta, Canada). DMI was measured on each steer. BW measurements were taken for in-weight, mid-test weight, and final weight. Steers harvested in 2007 were measured initially for 12th rib fat thickness (Initial_USBF), longissimus doris area (Initial_USREA), and intramuscular fat percentage (Initial_USIMF) using ultrasound. Steers harvested in 2006 were not measured for Initial_USREA, but had Initial_USBF and Initial_USIMF measurements recorded. When yearling weights were taken on the steers harvested in 2007, ultrasound measurements were taken for 12th rib fat thickness (USBF), longissimus doris area (USREA), and intramuscular fat percentage (USIMF). Steers harvested in 2006 were only measured as yearlings for USIMF.

Calculation and Classification of RFI

RFI for bulls and steers were calculated from the regression equation of: daily DMI = $\beta_0 + \beta_1$ (ADG) + β_2(WT) +RFI where daily DMI is the average daily feed intake, β_0 is the regression intercept, β_1 is the partial regression coefficient of daily intake on ADG and β_2 is the partial regression coefficient of daily intake on body weight. ADG and MidWt$^{0.75}$ were used as regressors on daily DMI (SAS Inst., Inc., Cary, NC, 2003). RFI values were calculated by year in which bulls were on test. In most instances, producers only consigned 1 or 2 elite bulls from their calf crop. Thus, determining RFI values using weaning contemporary group would not have yielded meaningful results. RFI for steers was calculated within contemporary group (CG). Each steer was assigned to its respective CG based on birth farm, year and pen. Steers born in 2005 and 2006 were from one of four farms. Pen in which the steers were fed was also an important fixed effect since diets differed across pens. High percentage Angus bulls consumed more DM per day, had higher FCR and RFI than purebred Angus, 50% Angus: 50% Simmental (50:50), high percentage Simmental and Simmental bulls. Angus steers consumed more DM per day, and exhibited higher FCR and RFI than high percentage Angus and 50:50 steers. Heritability was estimated for RFI using a bivariate model and MTDFREML in bulls and in steers. Fixed effects for bulls included year and breed percentage. Fixed effects for steers included cg and breed percentage. Covariates of final age or final wt were used. Table 1 contains heritability estimates in the bull and steer populations. Heritability estimates were approximately twice as large in the bull dataset. This could be due to the relatively small size of contemporary groups in the steer population. However, both estimates of heritability are within estimate ranges found in the literature.

Table 1. Estimates of heritability for RFI

Covariate	Bull RFI h^2	Steer RFI h^2
Age, d	0.43 ± 0.05	0.23 ± 0.07
Final Weight, kg	0.41 ± 0.05	0.17 ± 0.07

Genetic correlation estimates were found between bull and steer RFI values. If RFI was the same trait in bulls and steers, a genetic correlation of 1 is expected (Table 2). This study suggests RFI in bulls and steers is not the same trait. This is probably not unexpected given the physiological differences between steers and bulls. As bulls and steers get older, bulls continue to grow and gain muscle. Steers will continue to put on muscle to a certain extent, and then begin the finishing phase. The physiological differences probably explain the moderate, positive correlation at the same age and also an inverse relationship at a final weight. If these genetic correlations are indeed correct, they will need to be taken into consideration when making genetic selection decisions.

Table 2. Genetic correlations between bull and steer RFI

Covariate	Genetic Correlation
Age, d	0.33 ± 0.04
Final Weight, kg	-0.18 ± 0.04

(Oklahoma State University) Spring calving, Angus cows, (n=32) were used to determine the effects of maintenance energy requirement (MR) on rumen temperature (RuT), and concentrations of thyroxine (T4) and triiodothyronine (T3) in plasma. Cows (4 to 7 yr of age) with an initial BCS of 4.4 ± 0.1 and BW of 556 ±5.9 kg were individually fed a complete ration for 17 wk during 4-8 mo of gestation. After 2 wk on a diet calculated to supply MR (Model 1, NRC 1996) the diet was adjusted weekly until constant BW was achieved (regression analyses). BW was maintained for 31 d for 25 cows and the amount of feed consumed was actual MR. Blood samples were collected before and after consumption of feed on 2 d when cows consumed MR. Cows were classified based on MR as low (> 0.5 SD less than mean, LMR), mod (± 0.5 SD of the mean, MMR) and high (> 0.5 SD greater than mean, HMR). Average MR was 84.04 (SD=7.13) $Kcal \cdot kg^{-0.75} \cdot day^{-1}$. The difference in MR between the least efficient and the most efficient cow was 32%. When cows were exposed to warmer temperatures (15°C) plasma T4 was not influenced by MR (P = 0.92). When exposed to cooler temperatures (-5°C), LMR cows had greater plasma T4 (P = 0.003) compared with HMR. Plasma T3 was not influenced by MR when cows were exposed cooler ambient temperatures (P = 0.64). When exposed to warmer temperatures HMR cows had greater plasma T3 (P = 0.007) compared with LMR cows. During late gestation MR were associated with plasma concentrations of T4 and T3. Thyroid hormone may be involved in the regulation of MR of beef cows during late gestation. Identification of cows with lower MR and greater efficiency could improve the profitability of beef production.

(University of Illinois) Residual feed intake (RFI) is a measured feed efficiency trait independent of level of production, such as size and growth rate in cattle, making it comparable across animals at different levels of production (Herd, 2009). Being independent of production traits, some authors suggest that RFI may represent inherent variation in the basic metabolic processes or other physiological mechanisms. The current research project measured individual RFI values on Angus and Simmental sired steers. These individual RFI values then classified the animal into one of three groups: low (3), medium (2), and high (1) based on their distance from the mean RFI value. The data being collected in this trial are unique since it is a large data set without dietary treatment effects present. This is because all steers have been fed a common grain diet allowing for the collection of a grain RFI. The project is currently in its third year and will be complete this fall. The third year data set will include both heifer and steer mates with measurement of both forage and grain RFIs. Steer data will not only include grain RFI values but both performance and carcass traits. Heifer data will include forage and grain RFIs as well as performance traits allowing for a comparison between grain and forage RFI.

(University of California-Davis) Initial results of our work to model the cow-calf production system shows some management strategy by animal efficiency interactions. For example, selecting replacements on phenotypic weaning weight improves subsequent system efficiency over selection on genetic breeding value for weaning weight alone. This information can be used to improve genetics or to determine the appropriate management system for different genotypes, or animals with varying energetic efficiencies. Useful for this ongoing effort are our previously published analytical results of production and economic relationships between genetics, management, and beef quality. We have also initiated work to link digestion, metabolism, and composition models of ruminant growth.

(The Ohio State University) Objective 1: To understand biological sources of variation in efficiency of feed utilization as quantified by traits like RFI

A study was conducted to investigate the effect of divergent selection for serum insulin-like growth factor I (IGF-I) concentration on mature weight as estimated using growth curve functions in Angus cattle. The average of multiple serum IGF-I measurements taken at d 28, d 42, and d 56 of the 140-d postweaning period (denoted as mean IGF-I) from a total of 2,182 animals and weight records from birth to at least 3 yr of age from a total of 172 animals were collected from an ongoing divergent selection experiment involving IGF-I that was initiated in 1989. Four growth curve functions (Brody, Logistic, Gompertz, Von Bertalanffy) were used to estimate mature weight (A) and maturing rate (k) using the NLIN procedure in SAS (SAS Inst. Inc., Cary, NC). Based on the criteria of R^2, MSE, AIC, and Log Likelihood, the Brody function fitted the weight-age data best, followed by the Von Bertalanffy function. The heritability estimates for growth curve parameters from each function were obtained using a multiple-trait, derivative-free, REML program (MTDFREML). The direct heritability (h_d^2) estimates for A from the 4 growth functions ranged from 0.77 to 1.00 in single-trait analyses. In 2-trait analyses, however, such estimates ranged from 0.26 to 0.41. The h_d^2 estimates for k ranged from 0.10 to 0.41 in both single-trait and 2-trait analyses. Genetic correlations between mean IGF-I and A within each growth curve function ranged from -0.38 to -0.06. Growth curves for the low IGF-I selection line exceeded those for the high IGF-I selection line with an average difference of 10 kg after approximately 3 yr of age. This result suggests that selection for postweaning IGF-I affected mature weight in the Angus cattle used in this study and that the cows from the high IGF-I selection line had lighter mature weights and perhaps lower maintenance requirements than those from the low line.

The Brody function was the most appropriate function in fitting the weight-age data based on the criteria of R^2, MSE, AIC, and Log Likelihood. Because there is considerable variation in estimates from different growth functions, and no growth model is superior to other models in all cases, it is recommended that growth curve approaches be utilized in studies involving mature weight, and that more than one growth curve function be applied to datasets to choose the most appropriate function.

The genetic correlations between mean IGF-I and A within each growth curve function ranged from -0.38 to -0.06. Although serum IGF-I was negatively genetically correlated with mature weight, the phenotypic correlation between these 2 traits was moderately positive (from 0.50 to 0.59) due to highly positive environmental correlations (most converged to 1.00). The growth curves for the low IGF-I selection line exceeded those for the high IGF-I selection line with an average difference of 10 kg after approximately 3 yr of age. Results suggest that selection for serum IGF concentration may affect mature weights in cattle and that heifers selected for high IGF-I concentration may have lighter mature weights and lower maintenance requirements as cows than those selected for low IGF-I concentration.

(University of Missouri) A herd of Simmental x Angus cows was established for the purpose of divergent selection for RFI. The second calf crop has been weaned and is being phenotyped for RFI. This herd is being used to determine impact of RFI phenotype on progeny performance and cow efficiency. To date progeny generated from dams and/or sires mirror parent RFI phenotype. The first year progeny from efficient dams and sires had improved feed efficiencies of 10 and 14%, respectively. We concluded that selection for efficient dams and sires (negative RFI) would improve progeny feed efficiency. These cows are also being used to measure forage intake by negative and positive RFI phenotypes. Negative RFI cows consumed less forage daily than inefficient cows with no difference in progeny performance. We hypothesized that mitochondrial function was in part responsible for RFI differences among animals. We have measured greater complex I to complex III ratios and greater complex I concentrations in negative RFI than positive RFI cows. We conclude that mitochondrial function explains at least in part RFI differences among cattle. We also collaborated with a cow-calf producer that has been phenotyping heifers for RFI the past several years. We used his records on approximately 800 head of females to generate RFI, intake and ADG EPDs with Dr. Denny Crews at Colorado State University. This herd is being used to study effects of selecting for RFI on progeny performance and cow efficiency.

Outputs

1. Researchers participating in this committee have generated data and information on residual feed intake that is in use by genetic suppliers in the beef industry.
2. Feeding behavior equations have been developed that will allow wider application of RFI phenotyping into the beef industry.
3. Heritability estimates for progeny RFI was shown to agree with published expected values.

Impact Statement

Participants of this committee are engaged in generating RFI data calculations for genetic evaluation of breeding cattle. Most of the impact of RFI selection on beef production can be traced to activities between committee members and sire test facilities. Likewise, a preponderance of research information that has been generated regarding RFI in the US has come for researchers and discussions originating from the W1010 committee.

Publications

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