Variation in Ultrasonically Determined Intramuscular Fat in Brangus Cattle

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Story in Brief

The objectives of this research were to determine: 1) the effects of sire on the expression of intramuscular fat, and 2) the relationship of intramuscular fat to selected performance traits. Purebred Brangus cattle were subjected to Real-time ultrasound evaluation of body composition, and traits recorded were the 12th and 13th rib subcutaneous fat thickness (FT), longissimus muscle area (LMA), and percentage intramuscular fat (IMF). Performance data provided by the International Brangus Breeder's Association (IBBA) included: birth weight (BRW), weaning weight (WWT), yearling weight (YWT), and scrotal circumference (SC). Data were analyzed to determine genetic relationships with the animal model using multiple trait restricted maximum likelihood (MTDFREML) procedures. Contemporary group was included in the model as a fixed effect, and age of days was included as a covariate. Analyses of covariant models were examined to determine the relative importance of sire and carcass traits to percentage IMF. Genetic correlations of IMF with LMA, FT, and YWT were –0.25, 0.36, and 0.31, respectively, indicating that as LMA increased IMF decreased. Sire, FT, and LMA were important ($P < 0.05$) sources of variation in percentage of IMF; BRW, WWT, YWT, SC, and age did not ($P > 0.05$) influence percentage IMF. These data suggest that percentage of IMF is under genetic control of a quantitative nature, and therefore should be considered when selecting for increased quality grade.

Introduction

Percentage intramuscular fat (IMF) is an important trait in the cattle industry for several reasons. It is economically important because it influences discounts and premiums in grid marketing and is the primary factor used to determine quality grade for carcasses of cattle. Because of its influence on quality grade, it is implicated in palatability and product consistency. Consumers associate U.S.D.A. quality grade with eating quality of meat. In the production segment, as pressure increases to produce a higher quality, consistent product, intramuscular fat will become of increasing importance to seedstock and commercial beef producers.

There is currently some debate whether percentage IMF is under more of an environmental or genetic control, and which factors have an impact on the phenotypic expression of IMF. It is well known that if a trait is heritable, the quickest way to affect the trait is through selection of the parental generation, and especially selection of the sire (Falconer and MacKay, 1996). Recently, there has been much interest in effectively evaluating IMF using ultrasound technology (Brethour, 2000; and Hassen et al., 2001). Hassen et al. (2001) reported that Critical Vision Software is the more accurate predictor of IMF, and a correlation of about 0.61 has been reported for actual carcass to live animal ultrasonically predicted IMF (Herring et al., 1998).

Considering the relative importance of IMF to the industry, Wilson et al., (1994) concluded that evaluation of IMF should be included in seedstock performance programs. The recent advances in ultrasonic image processing technology make this more practical; therefore, the objectives of this study were to determine the effects of sire on the expression of IMF and to determine the relationship of intramuscular fat to selected performance traits.

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Experimental Procedures

Purebred Brangus cattle were subjected to Real-time ultrasound evaluation for estimation of body composition. Ultrasound measurements were taken in accordance to Beef Improvement Federation guidelines (BIF, 1996) for percent intramuscular fat (IMF), longissimus muscle area (LMA), and 12-13th-rib fat thickness (FT). In addition to ultrasound data, birth weight (BRW), weaning weight (WWT), yearling weight (YWT), scrotal circumference (SC), ranch location, sex of animal, age of animal, and animal registration number in accordance with the International Brangus Breeders Association (IBBA, San Antonio, TX) were also collected. All animals included in the study had pedigrees traceable to paternal and maternal grandparents.
The Real-time ultrasound equipment utilized for data collection was an Aloka 500V system (distributed by Aloka USA, Inc., Wallingford, CT) along with a superflab to ensure proper fit of the transducer to the curvature of the animal's natural body shape. Image visualization and data capture were accomplished using Critical Vision Software (Critical Vision, Inc., Atlanta, GA), which predicts the percentage of IMF (ether extractable equivalent) from the LMA image.

Images were collected on the left side of the chute and transducer placement was first determined by palpating the animal between the 12th and 13th ribs. Once the scanning area was determined, the location was oiled, curried free of dirt and debris, and oiled again before transducer placement. The ultrasound probe was placed toward the midline, between and parallel to the 12th and 13th rib bones and moved laterally until the longissimus muscle came into full view on the screen (Perkins et al., 1992). All 12th-rib FT and LMA images were captured and down loaded on a computer to be viewed later. The technician traced the outline of the muscle image then counted pixels to determine LMA. Fat thickness was estimated at the 3/4 position from the chine bone end of the longissimus muscle (U.S.D.A. beef carcass grade standards) using the cross sectional longissimus muscle image. A single longitudinal image of the longissimus muscle was taken (included the 11-12-13th ribs) for calculation of IMF.

In this study, data were edited to ensure uniformity of the equipment, software, and guidelines of the IBBA. Only purebred Brangus bulls and heifers intended to be used in the future as seedstock or replacement animals were in the data set. According to IBBA guidelines, yearling animals are considered 365 ± 45 days of age. Therefore, yearling weights were only considered from those animals weighed within 45 days of a year of age. Animals must have also had a measurement recorded for IMF to be included in the data set. Animals remaining in the data set were divided into contemporary groups based on sex, breeding season, and environment for restricted maximum likelihood analysis. Contemporary groups containing only one sire were eliminated from the data set. Represented in 21 contemporary groups were the progenies of 297 sires. Descriptive statistics for the edited data set used for analysis are shown in Table 1.

Single-trait animal models were used to estimate starting variances for subsequent multiple-trait analysis. All possible combinations of multiple-trait analysis were performed two traits at a time. This procedure fits an additive genetic effect for animals with records as well as all parents analyzed in the pedigree database. Genetic parameters were estimated for LMA, FT, IMF, and YWT. There were not enough data points for the traits of BRW, WWT, and SC for MTDFREML to converge on permissible heritabilities and correlations. Prior to variance component estimation, the MIXED procedure of SAS (SAS Inst., Inc., Cary, NC) was used to determine the significance of fixed effects for contemporary group, days of age, and the interaction of contemporary group x days of age for inclusion into the final animal model. In addition, starting variance components for the Multiple Trait Restricted Maximum Likelihood program of Boldman et al. (1993) and Boldman and Van Vleck (1991) were also estimated using MIXED procedures. Contemporary group was significant ($P < 0.001$), the linear effect of days of age was significant ($P < 0.001$), but the interaction of contemporary group x days of age was not significant ($P > 0.05$). Therefore, contemporary group was included in single and multiple-trait animal models as a fixed effect, and days of age was included in the models as a covariate. Analyses of covariance models were examined using GLM procedures of SAS (SAS Inst., Inc., Cary, NC) to determine significant effects of LMA, FT, BRW, WWT, SC, days of age, and sire on IMF. Sire was considered as a random variable, and the test option was used to ensure that proper F-tests were computed. Days of age was included in the model as a covariate. Interactions and main effects were tested, however interactions were not significant and therefore not included in the final model.

Results and Discussion

Sire effects. Sire had a significant effect on the expression of IMF ($P = 0.0004$). Approximately 32% of the variation for IMF was accounted for by the sire term of the model used in the analysis. The Brangus sires represented in these data produced progeny that averaged about 3.5% IMF. Mean and coefficients of variation for IMF of 10 bulls with 10 or more progeny are presented in Table 2. Some of the sires represented produced progeny that averaged up to 6.9% IMF. There is sufficient variation in IMF to support artificial selection for genetic change in the trait.

Carcass Traits. Longissimus muscle area had a significant effect on the expression of IMF ($P = 0.03$). The genetic correlation between these two traits was –0.25. This correlation is in agreement with the –0.21 between LMA and marbling score reported by Koots et al. (1994), in a review of published literature. However, Wilson et al. (1993) found a much lower correlation of –0.04 between LMA and marbling score. The moderately low, negative correlation found in this study indicates that as LMA increases IMF will tend to decrease. This relationship is not fully understood, but could be due in part to the position on the growth curve of the animals involved. Breeding cattle are usually managed for growth. At one year of age, Brangus cattle in this study were likely still growing with little impetus for fattening. Twelfth-rib fat thickness was also found to have a significant effect on the expression of IMF ($P < 0.0001$), and a moderately positive genetic correlation of 0.36 (Table 3). The correlation found in this study is in agreement with both Wilson et al. (1993) and Koots et al. (1994) who found correlations of 0.38 and 0.35, respectively, for FT and marbling score. This relationship is however antagonistic on a value based pricing system. Brethour (2000) reported that when feeding cattle to achieve a desired quality grade, yield grade would most likely suffer. It was found that external fat increases at a much quicker rate than IMF during the fattening period. Selection of the proper sires, ones that have high breeding value for IMF and percentage retail product, could possibly allow the progeny to achieve a high quality grade without having to sacrifice yield grade.

Growth Traits. Birth weight, WWT and YWT did not ($P > 0.05$) have a significant effect on the variation found in IMF. As SC increased, IMF slightly decreased, indicating that selection for increased SC might have an antagonistic effect on IMF. This relationship could be explained by the fact that bulls that are not castrated will produce testosterone and have a longer growth curve, therefore causing them to deposit muscle longer, and deposit fat at a later stage in the life. Days of age also approached significance on the expression of IMF ($P = 0.11$). Brethour (2000) demonstrated that as days on feed increased so did the amount of IMF that was deposited. This is likely a response to the fact that as an animal matures, muscle accretion decreased and fat deposition increases.

Implications

Percent intramuscular fat is under quantitative influence, and there are many traits that may affect it. In this study approximately one-third of the variation of IMF was accounted for by variation due to sire. Therefore, selection for sires could be the best way to cause an increase in the amount of IMF. However, in the real world of animal breeding, selection for a single trait is rare, because breeders typically are interested in improving a number of traits.

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Table 1. Descriptive statistics for edited data

Trait	Number of Records	Mean	Standard Deviation
PFAT[a], %EE	1,215	3.27	0.92
LMA[a], in^2	1,214	11.10	2.28
FT[a], in	1,214	0.22	0.11
BW[b], lb	323	84.04	10.23
WW[b], lb	328	641.32	59.27
YW[a], lb	1,087	1,028.52	191.27
SC[b], in	329	15.01	1.04

[a]LMA = 12th-rib longissimus muscle area, ultrasonically measured on live yearling bulls and heifers; FT = 12th to 13th-rib fat thickness, ultrasonically measured on live yearling bulls and heifers; PFAT = percent intramuscular fat from 12th-rib longissimus muscle area, ultrasonically measured on live yearling bulls and heifers; YW = live weight of yearling bulls and heifers taken at time of ultrasound.
[b]Measurement was recorded by producer and obtained from sale catalogs for: BW = birth weight; WW = weaning weight; SC = scrotal circumference.

Table 2. Variation in intramuscular fat by sire progeny group

Sire No.	1	2	3	4	5	6	7	8	9	10
N	21	38	11	26	13	10	15	25	12	29
Mean, %	3.72	3.00	2.80	3.42	3.36	3.35	2.58	3.21	2.90	3.58
CV	15.1	34.0	26.7	16.3	18.7	13.7	62.0	17.9	39.6	19.3

Table 3. Heritabilities estimated from two-trait models and correlationsfor estimates of ultrasonic carcass characteristics

Trait[b]	LMA	FT	IMF	YW
LM[A]	0.31	-0.09	-0.25	0.44
FT	0.16	0.27	0.36	0.42
IMF	-0.08	0.17	0.15	0.31
YW	0.44	0.33	0.03	0.53

[a]Heritability estimates on diagonal, genetic correlations above diagonal, phenotypic correlations below diagonal.
[b]LMA = 12th-rib longissimus muscle area, ultrasonically measured on live yearling bulls and heifers, in cm2; FT = 12th to 13th-rib back fat thickness, ultrasonically measured on live yearling bulls and heifers, in cm; IMF = Percent intramuscular fat from 12th-rib longissimus muscle area, ultrasonically measured on live yearling bulls and heifers; YW = Live weight of yearling bulls and heifers taken at time of ultrasound, in kg.