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RELATIONSHIP OF MAINTENANCE ENERGY REQUIREMENTS TO BEEF FEMALE PRODUCTION EFFICIENCY

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Summary

Thirty-three Hereford x Angus first-calf females were used to determine the relationship between production efficiency (PE = calf weaning weight/12 month dam + calf ME intake) and nonlactating dam maintenance ME requirements (ME_m) and its components k_m and FHP. Substantial variation existed in PE and energy parameters among individuals. However, maintenance metabolism of the dam contributed little to explaining PE variation ($r^2 \leq .04$). This may have been due to the high plane of nutrition provided. Additionally, FHP was closely related to ME_m ($r^2 = .69$), suggesting it could be used as an indicator of fed maintenance requirements.

(Key Words: Cattle, Production Efficiency, Energy, Maintenance.)

Introduction

Improving production efficiency (PE) is a constant necessity for the beef cattle industry. PE has generally been expressed as weaning weight divided by feed energy consumed when considering the cow-calf segment of production. Factors that affect the output or input side of the relationship could be expected to affect PE.

Energy requirements can be divided into two components, maintenance and production. It has been estimated that 60% to 75% of the total energy needed for beef production is required by the cow herd. Cow maintenance energy accounts for 70% to 75% of this. Additionally, maintenance energy requirements in cattle may vary by 20% to 30% due to genetic differences and have been shown by previous research to be moderately to highly heritable. For these reasons, it has been suggested that PE might be improved by selection for low maintenance energy requirements. Efforts have been made to develop indicators of maintenance requirements that may make selection practical. Improvement in PE by selection for low maintenance, however, may not be an inevitable result. Genetic potential for milk production and growth rate are positively correlated with maintenance requirements when evaluated across breeds. It is unclear if the same relationship applies to individuals within a single breed type.

The objective of this study was to determine the relationship between maintenance energy requirements and PE through weaning in beef females of similar breeding.

Materials and Methods

Animals: Production efficiency and energy balance measurements were made on 33 first-calf Hereford x Angus females (12 in year 1, 21 in year 2). Females used in the study were the result of a two-way rotational breeding system. This cross was chosen because the two breeds have been shown to have similar maintenance energy requirements and crosses between the two should likewise be similar.

Production Efficiency Procedure: Starting in October, the females were placed in drylot as bred heifers (approximately 20 months of age and 150 days of gestation) and individually fed for 1 year. They were

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fed an amount calculated to meet maintenance, lactation and fetal requirements, which was additionally adjusted as necessary to maintain a relatively constant body condition. Milk production was determined six times during the study using the weigh-suckle-weigh technique following a 14-hour separation from the dam and was expressed as the sum of the six measurements.

The calves were born during March and April of each year. They were allowed access to the dams twice daily for 1 hour during the feeding period to suckle. During the rest of the day, calves were maintained separately from the dams to prevent cross nursing. At night the calves were allowed individual access to a high-roughage creep feed.

PE in this study was defined as weaning weight of the calf (g) divided by the total ME (Mcal) consumed by the female and her calf during the year. Metabolizable energy intake (MEI) of the dam was adjusted to zero maternal body weight change during the PE period using initial and final PE weights and relationships from NRC (1984).

Calorimetry Procedure: Following weaning of the calves in October, the females were halter broken and moved to the metabolism facilities. The females were limit fed an experimental diet (Table 1), at 119.8 and 117.1 kcal ME*wt$^{-.75}$*d^{-1} in years 1 and 2, respectively. This included an allowance for conceptus growth. The diet ME content had been previously determined using Hereford steers during two 7-day collection periods. Females were adapted to the experimental diet and environmental conditions in the building a minimum of 21 days prior to metabolism measurements. During that time they were familiarized with the calorimetry system and procedures.

Heat production was determined by indirect respiration calorimetry using two modified hood calorimeters. The females were confined to the calorimeters for two consecutive 23-hour periods for fed measurements, during which gaseous exchange was measured. Samples of air entering and leaving the calorimeters were analyzed for O_2, CO_2 and CH_4 content. They were then fasted for 5 days with measurements taken on days 4 and 5. During all measurements, animals were allowed free access to water.

TABLE 1. EXPERIMENTAL DIETS FED TO COWS DURING METABOLIC MEASUREMENTS

Ingredient[a]	Year 1	Year 2
Ground hay	73.7	61.0
Rolled corn	25.3	35.9
Trace mineralized salt[b]	.8	1.4
Molasses	.2	1.4
Vitamin A[c]	.03	.30
Energy digestibility, %[d]	65.0	73.4
Energy metabolizability, %[d]	55.6	61.5

[a] Percent dry matter basis.

[b] Contained 97% NaCl, .007% I, .24% Mn, .24% Fe, .05% Mg, .032% Cu, .11% Co, .032% Zn and .5% Ca.

[c] Diets formulated to provide >30,000 IU of vitamin A daily.

[d] Years differ ($P<.001$).

Fed and fasted heat productions and MEI were mathematically adjusted to zero energy gain of the gravid uterus, taking into account day of gestation during the calorimetry measurements and subsequent calf birth weight, assuming an efficiency of ME utilization of 14% for gravid uterine growth. ME requirement for maintenance (ME_m) was calculated from a semilog regression of heat production on MEI and solving iteratively for the point at which heat production was equal to MEI. Partial efficiency of using ME for maintenance (k_m) was calculated by dividing fast heat production (FHP) by ME_m.

Data were analyzed with the General Linear Models procedures of SAS (1988). Relationships between the metabolic parameters and PE were determined by using the pooled data from both years and including year and PE calf sex in the model.

Results and Discussion

Selected characteristics of the females and their calves during the PE phase of the study are presented by year in Table 2. Females in years 1 and 2 were from the same herd and, as a result, were genetically

TABLE 2. SELECTED COW AND CALF TRAITS DURING PRODUCTION EFFICIENCY (PE) PHASE OF THE STUDY

Item	Year 1	Year 2
No. of cows	12	21
Average cow weight, lb[a]	926	1030
Range	862-1030	941-1138
SD[b]	58.0	50.9
Weight change, lb	106	249
Range	32-194	134-281
SD	44.1	59.9
Calf birth weight, lb	86	89
Range	70-106	77-105
SD	11.6	7.5
Weaning age of calf, days	222	217
Range	211-230	185-232
SD	6.0	13.6
Weaning weight of calf, lb	551	556
Range	461-628	485-626
SD	56.4	50.3
Milk production, lb[c]	59	56
Range	42-81	29-72
SD	12.7	11.2
Calf MEI[d]	445.1	477.6
Range	388.4-522.7	231.9-701.9
SD	41.0	124.8
Female MEI, Mcal[ade]	7535.7	8393.8
Range	6980.8-8501.0	7696.7-9553.2
SD	518.8	487.7
Production efficiency[aef]	31.2	28.4
Range	27.8-34.5	25.2-32.0
SD	2.3	1.8

[a] Years differ ($P<.001$).
[b] Standard deviation.
[c] Sum of six measurements following 14-hour separation from dam.
[d] MEI = metabolizable energy intake.
[e] Adjusted to maternal body weight maintenance.
[f] Expressed as grams of calf weaned/Mcal MEI of dam and calf.

similar. Reproductive performance, as indicated by weaning age of the calves with a constant weaning date, and general productivity (milk production and calf weaning weights) did not differ significantly by year ($P>.10$). Average weights were greater and PE lower in year 2 than 1 ($P<.001$), likely due to the 12% greater overall $MEI*wt^{-.75}$ and winter environmental differences. Most interesting are the ranges and standard deviations (SD) in PE. Comparison of females more than 1 SD above the mean (HIGH) to those at least 1 SD below (LOW) would represent the differences possible if culling the lower 15% of the herd and replacing them with a comparable number of the best individuals. By such comparison, PE of HIGH females were at least 14.9% and 13.2% greater than LOW in years 1 and 2, respectively. At the extremes, the most efficient female was 24.1% and 27.0% more efficient than the least in each year.

Energy metabolism data collected after the PE phase of the study are presented in Table 3. Fasting heat production did not differ between years 1 and 2 ($P>.10$) and are in good agreement with previously published results for similar cattle. Partial efficiency was greater in year 2, undoubtedly due to increased grain content of the diet ($P<.05$). Numerical differences in ME_m also indicated an expected diet effect but were not significant ($P>.10$). As with PE, sizable animal variation was found in measures of energy metabolism. HIGH females FHPs were at least 23.0% and 18.6% greater than LOW in years 1 and 2, respectively. Comparison of extreme animals indicated maximum differences of 36.2% and 41.9%. Similar results were found for ME_m (years 1 and 2 HIGH greater than LOW, 19.2% and 21.0%; extremes 32.3% and 47.1%). Partial efficiency was somewhat less variable within year, with the HIGH females at least 14.7% and 8.2% greater than LOW and maximum individual differences of 29.7% and 21.7% for years 1 and 2, respectively.

Variation in ME_m was due more to FHP ($r^2 = .69$) than k_m ($r^2 = .12$) which is contrary to the conclusions of previous research.

Despite the variation present, ME_m and FHP only approached significance ($P=.16$) when evaluated separately and contributed little to explaining the variation in PE ($r^2 = .04$ and .04, respectively). Partial efficiency (k_m) was not significant ($r^2 = .00$; $P>.20$).

TABLE 3. ENERGY METABOLISM DATA FOR COWS COLLECTED AFTER THE PRODUCTION EFFICIENCY (PE) PHASE OF THE STUDY[a]

Item	Year 1	Year 2
FHP, $Kcal*wt^{-.75}*d^{-1}$ [b]	76.7	76.3
Range	65.8-89.7	63.0-89.4
SD[c]	7.91	6.50
k_m [d]	.73	.76
Range	.64-.83	.69-.84
SD	.05	.03
ME_m, $Kcal*wt^{-.75}*d^{-1}$ [b]	104.9	100.5
Range	90.7-120.0	83.7-123.2
SD	9.17	9.56

[a] Data adjusted to day zero of gestation.

[b] Weight (kg).

[c] Standard deviation.

[d] Years differ ($P<.001$).

The poor relationship between energy parameters and PE may have been due to the level of nutrition during the PE phase which was adequate for an average maternal weight gain of .53 $lb \cdot d^{-1}$. It has been previously suggested that some degree of energy restriction would place higher producing genotypes at a disadvantage because of higher and less adaptable maintenance requirements. The data from our study would tend to support the implied counterpart to this statement that no advantage is conferred on genotypes (or in this case, individual animals within a genotype) by virtue of having a lower maintenance requirement if nutrition is not limiting. This could be true if milk production differed in proportion to ME_m, although this cannot be confirmed in this study due to the high variability of the milk data (cv = 20.6%). As a result, selection for such an attribute in these circumstances would be of little benefit. However, this says nothing about the possible role of maintenance in determining PE with restricted nutrition.

An additional point to consider is that the energy metabolism measurements were made on females that were pregnant but not lactating. To relate these to PE requires making the assumption that animal differences in metabolism would also be expressed while lactating, at least in relative terms. Such an assumption may not be appropriate. While maintenance estimates for nonlactating Holstein cows have been consistently higher than for Herefords or Angus, recent research reported no difference when estimated during lactation. If lactation alters maintenance relationships between genotypes, this may also occur within genotype. In this case, the energy metabolism data would only reflect differences present during 4 to 6 months of the production cycle and its role in determining PE would be diminished.

If maintenance energy metabolism of the dam is unrelated to PE, then other factors must be responsible for the variation seen in this study. PE consists of three components: dam MEI, calf MEI from creep and calf weaning weight. Multiple regression analysis indicates that 66.6% of the variation in PE is accounted for by calf weaning weight, 31.1% by dam MEI and only 1.8% by calf cree MEI ($P<.01$). Factors associated with the calf such as relative weaning age (a reflection of reproductive performance) and perhaps growth rate and efficiency of growth as affected by calf sex and sire deserve consideration.

In conclusion, variability great enough to be of economic importance does exist for PE as well as ME_m and its components k_m and FHP in beef females that are likely representative of those found in many commercial herds in the United States. While not conclusive, the data suggest that variation in maintenance requirements of the breeding female have, at best, a minor effect on PE when nutrition level is adequate to meet maintenance and lactation requirements. Additionally, if maintenance requirements are found to be an important determinant of PE with restricted nutrition, indicators of FHP would be appropriate for selection since FHP is the primary determinant of maintenance.