57. EAAP Annual Meeting, Antalya, Turkey

Session C33.3

Feed intake and energy balance – investigations with intent to integrate the energy status of bull dams into the performance test on station

H. Hüttmann, E. Stamer, W. Junge, G. Thaller, E. Kalm*

Christian-Albrechts-Universität of Kiel
Institute of Animal Breeding and Husbandry
24098 Kiel, Germany

*email: hhuettmann@tierzucht.uni-kiel.de

Abstract

Since 1st of September 2005 the individual roughage intake has been measured with a computerized scale system at the dairy research farm Karkendamm, where the individual performance test of the bull dams of a German breeding company is located. In conjunction with the routinely collected data of the established individual performance test the daily energy balance has been calculated as the difference between energy intake and calculated energy requirements for lactation and maintenance.
Several criteria of energy balance have been defined over different lactation stages: mean daily energy balance during the first 50 and 100 days of lactation, duration of negative energy balance and total energy deficits in the early stage of lactation. The dataset is not yet great enough for a calculation of genetic parameters. The present data set has been used preliminary to estimate repeatabilities and correlations between cow effects and to show tendential differences in energy balance traits between heifers with or without medical treatments.

Introduction

Milk yield has been the dominating selecting criterion in the last decades. The genetic correlation between milk yield and feed intake is reported to be in a range from 0.46 to 0.65 (VEERKAMP, 1998). This suggests that correlated response in feed intake cannot compensate the increased energy requirements at the beginning of the lactation. As the resulting enlargement of the negative energy balance *post partum* is assumed to be the reason for the increase in fertility and health problems (VEERKAMP, 1998, COLLARD et al., 2000, DE VRIES and VEERKAMP, 2000), aspects of feed intake or energy balance should be included into breeding programs as a selection criterion (VEERKAMP et al., 2000, COFFEY et al., 2001, 2002, 2003).
The opportunity of measuring the feed intake of bull dams is only practicable in a nucleus breeding scheme (SIMM et al., 1991), because the sampling of individual feed intake data is expensive and cannot be achieved on commercial farms. Therefore, a scales system weighing

the individual roughage intake has been installed at the dairy research farm Karkendamm where the individual performance test of the bull dams of a German breeding company is located. The dataset will be used for further examinations regarding to the relationships between milk yield, feed intake, energy balance and disease liability of the potential bull dams.

Material and methods

The cows on the test station Karkendamm are fed a total mixed ration (TMR) *ad libitum* given twice daily. This total mixed ration consists of corn silage, grass silage, concentrates, soybean meal and minerals. Additionally, the cows have the possibility to take in a fixed amount of concentrates at the concentrate feeders.

Table1. Data collection on the test station Karkendamm

Parameter	Recording frequency
Milk yield (marketable)	each milking
Milk solids	weekly
- fat-%, protein-%	
- SCC and urea content	
Live weight	each milking
Concentrate intake	each visit at the concentrate feeder
Total mixed ration (TMR) intake	each visit at the feeding trough
Animal event data	permanently
- animal activities (calving, insemination)	
- treatments of diseases	
Body condition score	monthly

The *ad libitum* individual feed intake has been measured automatically since 1^{st} September 2005 in addition to the routinely recorded data (Table 1). In consideration of the bull dam breeding program only the records of first lactating cows between the 11^{th} and 180^{th} day of lactation have been taken into account when these heifers additionally had nearly complete datasets. Therefore, two conditions have been defined: the first observation must be before the 20^{th} and the last observation after the 120^{th} day of lactation. The analyzed data of the 76 heifers fulfilling these two conditions are shown in Table 2.

Table 2. Number of records, mean, standard deviation, minimum and maximum values of analysed data

Trait	n	Mean	Std. dev.	Minimum	Maximum
Day of lactation	12440	93	48	11	180
Milk yield kg	11641	35.1	5.4	9.8	58.3
Fat-%	1688	3.53	0.66	1.64	7.76
Protein-%	1695	3.25	0.23	2.53	3.87
Somatic cell count	1695	77	237	3	5887
ECM kg	11641	3.5	4.9	11.0	53.4
Total mixed ration DMI kg	11360	18.4	4.5	2.0	37.5
Concentr. DMI kg	12440	2.2	0.6	0.0	4.2
Total DMI kg	11360	20.7	4.5	3.2	39.7

ECM = energy corrected milk (4% milk fat), DMI = dry matter intake

The daily energy balance has been defined as the difference between energy intake and estimated energy requirements for lactation and maintenance costs as a function of live weight. Lactation curves of total daily feed intake, daily milk yield and daily energy balance have been calculated using the following model:

$$y_{ijk} = \mu + T_i + b_1 (D/c) + b_2 (D/c)^2 + b_3 \ln(c/D) + b_4 [\ln(c/D)]^2 + a_j + e_{ijk}$$

where: y_{ijk} = observed total dry matter intake (DMI), energy corrected milk yield (ECM) or daily energy balance (EB), μ = mean, T_i = fixed effect of herd test day (i = 1-172), a_j = random effect of the cow, e_{ijk} = random error. The regression coefficients $b_{1\text{-}4}$ are according to ALI and SCHAEFFER (1987), where b_1 and b_2 are regression coefficients on the linear and quadratic effect of the ratio D/c, where D is the day of lactation and c is a constant (c = 190). b_3 and b_4 are regression coefficients on the linear and quadratic effect of ln(c/D).

Four energy balance traits are defined according to COLLARD et al. (2000). As these traits are derived from the daily measures of energy balance, complete datasets are needed. Hence, gaps have been filled using moving average methods. Missing values have been replaced with the mean value of the prior or following three-day-period. In total, 1279 and 1560, respectively, missing values have been replaced in the traits energy corrected milk yield and dry matter intake. Based on this completed dataset the mean daily energy balance during days 11 to 50 and 11 to 100 (MEB50, MEB100) have been calculated. The number of days with a negative daily energy balance at the beginning of lactation (DAYS) were defined as the period between parturition and the end of days with negative daily energy balances. This end was determined as the 10^{th} day of the earliest 20 days period during which the cow was in positive energy balance for at least 10 days. The total energy deficit (TED) has been defined as the cumulative sum of daily energy balances from the 11^{th} day of lactation to the end of negative energy balance determined by DAYS.
Repeatabilities and correlations between cow effects (Table 3) of the three daily traits dry matter intake, energy corrected milk yield and energy balance have been estimated multivariately by REML using the VCE 4 package (NEUMAIER and GROENEVELD, 1998). Phenotypic correlations were calculated between traits of energy balance and performance, where ΣDMI180 and ΣECM180 are the cumulative totals of the daily values of DMI and ECM between the 11^{th} and 180^{th} day of lactation (Table 4).
The first lactating cows have been divided into two groups without and with at least one medical treatment within the first 100 days of lactation in the three categories mastitis, metabolic diseases and claw and leg problems to show tendential differences in the traits of performance and energy balance between fragile and robust heifers.

Results and discussion

The computed lactation curves (Figure 1) demonstrate the expected delay in the increase of feed intake at the beginning of lactation. The energy corrected milk yield reaches the climax around the 25^{th} day of lactation while the total dry matter intake still increases till the 70^{th} day of lactation. Energy requirements are not met by the energy intake resulting in a negative energy balance until the 65^{th} day of lactation.

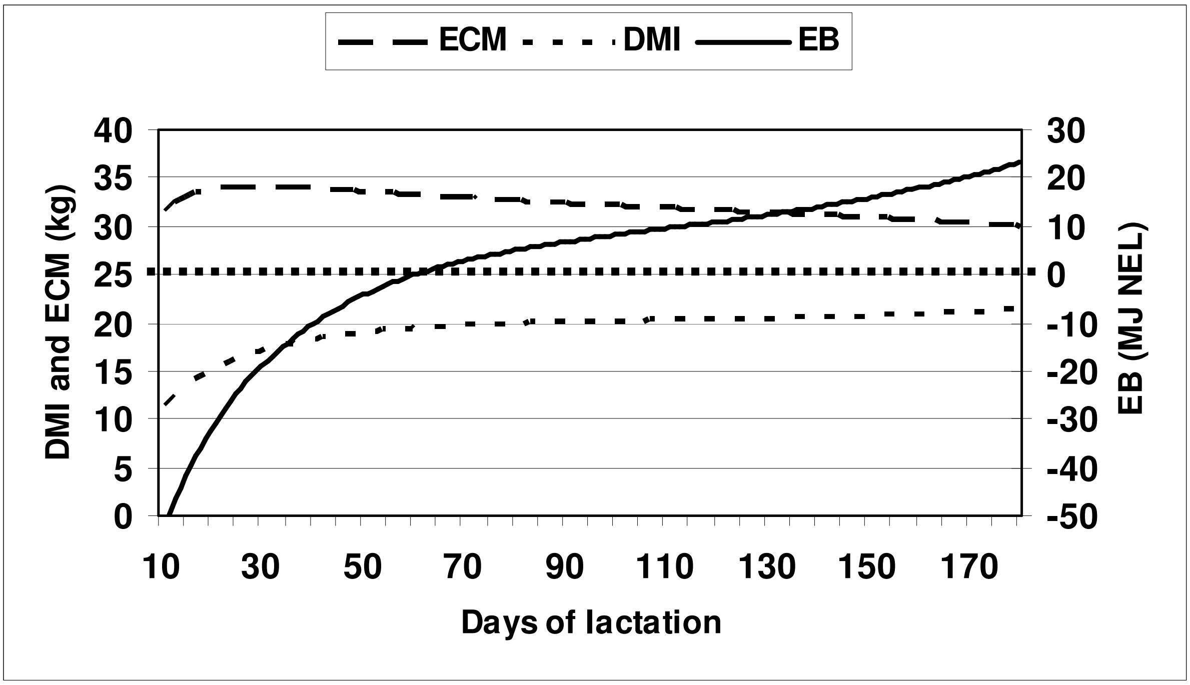

Figure 1. Lactation curves of the traits energy corrected milk (ECM), dry matter intake (DMI) and energy balance (EB)

The repeatabilities of 0.37, 0.77 and 0.50 for the daily traits DMI, ECM and EB respectively are in a range we expected. The correlation coefficient of -0.11 between cow effects between ECM and DMI with the increased standard error is probably due to the shortened observation period. The correlation coefficients between EB and DMI and accordingly EB and ECM of 0.80 and -0.69, respectively, show that the EB depends more on the DMI than on the ECM, but there is an autocorrelation that has to be considered. The variations in energy balance are largely due to variations of energy intake (ZUREK et al., 1995, VEERKAMP et al., 2000).

Table 3. Repeatabilities and correlations between cow effects between the daily traits DMI, ECM and EB

	DMI	ECM	EB
DMI (kg)	0.37 $_{(.03)}$	-0.11 $_{(.10)}$	0.80 $_{(.04)}$
ECM (kg)		0.77 $_{(.02)}$	-0.69 $_{(.05)}$
EB (MJ NEL)			0.50 $_{(.04)}$

DMI = dry matter intake, ECM = energy corrected milk, EB = energy balance

As expected, the phenotypic correlations between the accumulated DMI until the 180th day of lactation and the energy balance traits show that an increase in the feed intake improves all energy balance traits. Heifers with a higher dry matter intake realize higher mean energy balances, need less days until they are in an equilibrated daily energy balance, and their total energy deficit at the beginning of lactation is decreasing. There are reciprocal relationships between the milk yield performance and the energy balance traits. The phenotypic correlations have similar absolute values but the direction changes. The absolute values of the phenotypic correlations between the energy balance traits are in a range from 0.75 and 0.91. Hence, it could be assumed that the four energy balance traits are describing nearly the same parameter.

Table 4. Phenotypic correlations between traits of energy balance and performance

	ΣECM180	mEB50	mEB100	DAYS	TED
ΣDMI180	0.23 *	0.52 ***	0.64 ***	-0.46 ***	0.50 ***
ΣECM180		-0.57 ***	-0.55 ***	0.55 ***	-0.52 ***
mEB50			0.94 ***	-0.75 ***	0.86 ***
mEB100				-0.80 ***	0.86 ***
DAYS					-0.91 ***

ΣDMI180 = accumulated dry matter intake until the 180th day of lactation, ΣECM180 = accumulated energy corrected milk yield until the 180th day of lactation, mEB = mean energy balance until the 50th or 100th day of lactation, DAYS = days from calving to the return to positive daily energy balance, TED = total energy deficit until return to positive daily energy balance

*** $P < 0.001$, * $P < 0.05$

Tendential differences in energy balance and performance traits between the 52 untreated and the 24 heifers with at least one treatment within the first 100 days of lactation are shown in Table 5. Although there are only small differences in the total feed intake and the energy corrected milk yield during the 11th and 180th day of lactation between the two groups, there are distinctive differences in the energy balance traits. The treated heifers are in a more severe negative energy balance at the beginning of lactation and need 16 days longer to reach an equalized daily energy balance than the untreated heifers.

Table 5. Differences in performance and energy balance traits between treated and untreated heifers

	Treated heifers	Untreated heifers
mEB50	-24.7	-14.0
mEB100	-8.3	-0.6
DAYS	70	54
TED	-1582.5	-1102.7
ΣDMI180	3494	3509
ΣECM180	5796	5660

ΣDMI180 = accumulated dry matter intake until the 180th day of lactation, ΣECM180 = accumulated energy corrected milk yield until the 180th day of lactation, mEB = mean energy balance until the 50th or 100th day of lactation, DAYS = days from calving to the return to positive daily energy balance, TED = total energy deficit until return to positive daily energy balance

Conclusions

Preliminary results show that the complex energy balance should be included into breeding programs. In general, heifers are in a negative energy balance till the 65th day of lactation, and the duration and severity of the energy deficit are decreasing with higher intakes. Heifers with a higher disease liability seem to be in a more distinctive energy deficit. The correlations indicate that the energy balance depends more on the dry matter intake than on the energy corrected milk yield. Hence, the dry matter intake probably could be used as a substitute for the energy balance traits. However, further data have to be recorded to enlarge the database for a following estimation of genetic parameters. Thereafter, it can be decided which trait of energy intake or balance should be considered in breeding programs to avoid the corresponding deterioration in health traits when selecting on milk yield alone.

References

ALI, T.E., L.R. SCHAEFFER, 1987. Accounting for covariances among test day milk yields in dairy cows. Can. J. Anim. Sci. 67: 637-644.

COFFEY, M.P., G.C. EMMANS, S. BROTHERSTONE, 2001. Genetic evaluation of dairy bulls for energy balance traits using random regression. Anim. Sci. 73: 29-40.

COFFEY, M.P., G. SIMM, S. BROTHERSTONE, 2002. Energy balance profiles for the first three lactations of dairy cows estimated using random regression. J. Dairy Sci. 85: 2669-2678.

COFFEY, M.P., G. SIMM, W.G. HILL, S. BROTHERSTONE, 2003. Genetic evaluations of dairy bulls for daughter energy balance profiles using linear type scores and body condition score analyzed using random regression. J. Dairy Sci. 86: 2205-2212.

COLLARD, B.L., P.J. BOETTCHER, J.C.M. DEKKERS, D. PETITCLERC, L.R. SCHAEFFER, 2000. Relationships between energy balance and health traits of dairy cattle in early lactation. J. Dairy Sci. 83: 2683-2690.

DE VRIES, M.J., R.F. VEERKAMP, 2000. Energy balance of dairy cattle in relation to milk production variables and fertility. J. Dairy Sci. 83: 62-69.

NEUMAIER, A., E. GROENEVELD, 1998. Restricted Maximum Likelihood estimation of covariances in sparse linear models. Genet. Sel. Evol. 30: 3-26.

SIMM, G., P. PERSAUD, D.R. NEILSON, H. PARKINSON, B.J. McGUIRK, 1991. Predicting food intake in dairy heifers from early lactation records. Anim. Prod. 52: 421-434.

VEERKAMP, R.F., 1998. Selection for economic efficiency of dairy cattle using information on live weight and feed intake: a review. J. Dairy Sci. 81: 1109-1119.

VEERKAMP, R.F., J.K. OLDENBROEK, H.J. VAN DER GAAST, J.H.J. VAN DER WERF, 2000. Genetic correlation between days until start of luteal activity and milk yield, energy balance, and live weights. J. Dairy Sci. 83: 577-583.

ZUREK, E., G.R. FOXCROFT, J.J. KENNELLY, 1995. Metabolic status and interval to first ovulation in postpartum dairy cows. J. Dairy Sci. 78: 1909-1920.