Genetic Relationships Between Feed Intake Capacity in Growing Bulls and Production Traits in Lactating Heifers

Dr. Ralf Wassmuth

Institute of Animal Husbandry and Genetics, University of Göttingen
Albrecht-Thaer-Weg 3, D 37075 Göttingen,

Abstract

Feed intake capacity was measured on 231 progeny from 113-600 days of age in testing station from 1985 through 1990. The young bulls belonged to 23 sires. BLUP breeding values for feed intake capacity were estimated with the PEST programme package and an animal model. Estimated breeding values for milk yield, milk fat content and yield and protein content and yield were obtained from the routine evaluation as published 3/96 by the agricultural computing center (VIT), Verden. An estimation of the genetic relationship between milk performance and feed intake capacity was calculated by using Spearman rank correlation coefficients. Breeding values for milk yield, milk fat content or milk protein content were classified in three classes and were considered as fixed effect in 3 different analysis of variance.

A high variation in breeding values could be observed. When selecting a small proportion of tested sires a high selection differential can be reached. To ensure a repeatability of breeding value estimation of 0.42 11 progeny have to be tested. The Spearman rank correlation coefficients reveal that there is no correlation between ranks of breeding values for feed intake capacity and ranks of breeding values for the different milk performance traits. Hence, there is no correlated selection response in feed intake capacity when selecting on high milk performance. Considering the analysis of variance the effect consisting of 3 breeding value classes had no significant influence on the variation of feed intake capacity considering the three different models for milk yield, milk fat content or milk protein content.

Feed intake capacity has to be considered as separate selection criterion to ensure low feed costs and lower energy deficiencies at the beginning of the lactation. The improvement of feed intake capacity in dairy cows can be achieved by selecting sires in a testing station. But station test regimes have to be adapted and standardized test diets have to be included.

Introduction

During the early part of lactation higher feed intake can reduce the feed costs, increase the protein content in milk and improve the conception rate in dairy cows (Gravert, 1985). Olsson et al. (1995) found that cows reaching a high milk performance on the basis of high proportions of roughage are healthier than others.

In a first analysis of data from the central performance testing station in Echem/Lower Saxony (Wassmuth, 1996), it could be concluded that German Friesian bulls had the lowest feed intake capacity compared to German Red and White (dual purpose) and to crossbred bulls (Charolais*German Friesian). Especially crossbred progeny were expected to have the lowest feed intake capacity because of breeding for higher killing-out percentages (Ørskov et al., 1988).

The German "Ausschuß für genetisch-statistische Methoden in der Tierzucht" (1990) recommends the improvement of feed intake capacity in dairy cattle to reduce the feed costs and to lower the energy deficiency at the beginning of the lactation. The use of highly standardizable test diets is necessary to ensure highly repeatable measurements which can not be achieved under field conditions.

The aim of the present study was to calculate an estimate of the genetic relationship between production traits in lactating heifers and feed intake capacity in growing bulls.

Material and Methods

Feed intake capacity

Data was taken from the progeny testing station in Echem/Lower Saxony from 1985 through 1990. The test period lasted from 113-600 days of age. During the test period, bulls were housed in a tie stall and fed a diet of NaOH-treated straw cobs ad libitum and a restricted amount of concentrates, according to age. Three different levels of protein and energy content were fed (Table 1). Feed was given by hand and feed intake was recorded once a week. Table 1 shows the distribution of 231 progeny derived from 23 sires across 2 breeds and 2 different diets.

Breeding values for feed intake capacity (straw cob intake in kg dry matter per day and animal) were estimated by using the BLUP method and the PEST programme package (Groeneveld et al., 1990). The following animal model was performed:

$$Y_{ijk} = \mu + K_i + a_j + e_{ijk}$$

with

Y_{ijk} = k-th observation
μ = overall mean
K_i = fixed combined effect of breed (B) and diet (D), (i: 1 = B1 D1; 2 = B1 D2; 3 = B2 D2)
a_j = random additiv genetic effect of the j-th animal,
e_{ijk} = random error.

The liveweight at the end of the testing period (600 days) was included as covariable. The heritability was assumed as $h^2 = 0.3$ (Jensen et al., 1991; Bishop, 1992; Jähne u. Schwark, 1987; Schäfer und Trappmann, 1995; Nieuwhof et al., 1992; Fan et al., 1995). The following variance components were used: $V_p = 0.4154$, $V_g = 0.1246$, $V_e = 0.2908$.

Milk performance

Estimated breeding values for milk yield, milk fat content and yield and milk protein content and yield were obtained from the routine evaluation as published 3/96 by the agricultural computing center (VIT), Verden.

Spearman rank correlation coefficients between breeding values for feed intake capacity and breeding values for milk yield traits of the 23 sires were calculated by using the SAS programme package (SAS Institute, 1990).

A further analysis consisted of an analysis of variance:

Progeny were classified in three groups, according to the breeding values of their sires for milk yield, milk fat content or milk protein content. According to the following model three different analysis of variance were performed:

$$Y_{ijkl} = \mu + K_i + M_j + V_j(K_i{*}M_j) + e_{ijkl}$$

with

Y_{ijkl} = l-th observation
μ = overall mean
K_i = fixed combined effect of breed (B) and diet (D), (i: 1 = B1 D1; 2 = B1 D2; 3 = B2 D2)
M_j = fixed effect of milk yield, milk fat content or milk protein content
(j: 1 = highest 33% of breeding values; 2 = middle 33% of breeding values; lowest 33% of breeding values)

$V_k(K_i*M_j)$ = fixed effect of the k-th sire within the ij-th subgroup,

e_{ijkl} = random error.

Results and discussion

Estimation of breeding values for feed intake capacity

23 German Friesian sires and German Red and White sires with different proportions of Red Holstein genes were included in the estimation of breeding values for feed intake capacity, measured as straw cob intake in kg per day and animal (Table 2). The repeatability of the estimation of breeding values (r_{ti}^2) varies between 0.2455 and 0.4410, due to the variation in number of progeny per sire from 5 to 13. Additionally, the rank of each sire was calculated.

The high variation in breeding values ensures high selection differentials when selecting only a small proportion of tested sires according to feed intake capacity. This result supports an earlier investigation (Wassmuth, 1996), which led to the conclusion that feed intake capacity should be considered as separate selection criterion. To reach an repeatability of breeding value estimation of 0.42, about 11 progeny of a sire have to be tested.

Relationship between feed intake capacity and milk performance

An estimation of the genetic relationship between milk performance and feed intake capacity was calculated by using Spearman rank correlation coefficients (Table 3).

A high, negative relationship was found between rank of breeding values for milk yield and fat content and between rank of breeding values for milk yield and protein content. Between fat content and protein content there is a positive relationship. The correlation between protein yield and milk or fat yield is positive. Fat content and fat yield are also positively correlated, as expected.

Considering relationships between milk traits and feed intake capacity, it could be concluded that no significant correlation exists. This is in good accordance with Nieuwhof et al. (1992). The authors found no relationship between fat and protein corrected milk yield (105 days and 305 days) of lactating heifers and feed intake capacity of young bulls. Hence, there is no correlated selection response in feed intake, when selecting lactating heifers for higher milk yield.

Breeding values for milk yield, milk fat content or milk protein content were classified in three classes and were considered as fixed effect in 3 different analysis of variance (Table 4). The effect consisting of 3 breeding value classes had no significant influence on the variation of feed intake capacity, considering the three different models for milk yield, milk fat content or milk protein content. But it has to be mentioned that there is a tendency towards lower feed intake capacities in progeny from sires with high breeding values for protein content (Table 4).

It has to be concluded that feed intake capacity has to be considered as separate selection criterion because there is no higher feed intake capacity of progeny from sires which have a high breeding value in milk yield, fat content or protein content of milk.

Similar conclusions were published by Korver (1988). He suggests in his review that selection on milk yield would not automatically increase feed intake of dairy cows in the first part of the lactation. Nieuwhof et al. (1992) come to a similar conclusion and they put forward the low genetic correlation between feed intake capacity and fat and protein corrected milk yield, both measured in lactating heifers, of $r_g = 0.61$.

When considering feed intake as separate selection criterion, station test regimes have to be adapted because of difficulties in measuring roughage intake under field conditions.

It seems to be possible to improve feed intake capacity in cows by selecting sires on high feed intake capacity (Nieuwhof et al., 1992), because of a close relationship between feed intake capacity in lactating heifers and the same trait in young bulls of $r_g = 0.77$.

Conclusions

Breeding for milk performance does not lead to a higher feed intake capacity because there are no genetic relationships between the traits. Therefore feed intake has to be considered as separate selection criterion. Selection of potential A.I. bulls in a testing station leads to an improvement of feed intake in dairy cows. Cows with a high feed intake are able to meet nutrition requirements during early part of lactation and reach higher conception rates. Breeding for healthier, high yielding cows should be an important aim for the future.

References

Ausschuß für genetisch-statistische Methoden in der Tierzucht der Deutschen Gesellschaft für Züchtungskunde, 1990. Stellungnahme zur Futteraufnahme und Futterverwertung bei Milchkühen. Züchtungskunde, 62, 165-166.

Bishop, S.C. 1992. Phenotypic and genetic variation in body weight, food intake and energy utilisation in Hereford cattle. 1. Performance test results. Livest. Prod. Sci. 30, 1-18.

Fan, L.Q., Bailey, D.R.C. and Shannon, N.H. 1995. Genetic parameter estimation of postweaning gain, feed intake and feed efficiency for Hereford and Angus bulls fed two different diets. J. Anim. Sci. 73, 365-372.

Gravert, H.O. 1985. Genetic factors controlling feed efficiency in dairy cows. Livest. Prod. Sci. 13, 87-99.

Groeneveld, E., Kovac, M. and Wang, T. 1990. PEST, a general purpose BLUP package for multivariate prediction and estimation. 4th World Congress on Genetics Applied to Livestock Production, Edinburgh, Vol. XIII: 488-491.

Jähne, M. and Schwark, H.J. 1987. Züchterische Aspekte der Verbesserung des Futteraufnahmevermögens und des Futterenergieaufwandes beim Rind. Tierzucht 41, 35-37.

Jensen, J., Mao, I.L., Andersen, B.B. and Madson, P. 1991. Genetic parameters of growth, feed intake, feed conversion and carcass composition of dual-purpose bulls in performance testing. J. Anim. Sci. 69, 931-939.

Korver, S. 1988. Genetic aspects of feed intake and feed efficiency in dairy cattle: a review. Livest. Prod. Sci. 20, 1-13.

Nieuwhof, G.J., Van Arendonk, J.A.M., Vos, H. and Korver, S. 1992. Genetic relationships between feed intake, efficiency and production traits in growing bulls, growing heifers and lactating heifers. Livest. Prod. Sci. 32, 189-202.

Olsson, G., Emanuelson, M., Wiktorsson, H., Ahlin, K.-Å. and Holtenius, P. 1995. Effects of different dietary composition at calving on production, health and fertility in dairy cattle. 46th EAAP-meeting, Prague, Czech Republic, September 4-7, 1995. Commissions on Animal Nutrition and Cattle Production, Session I. Management, health and feeding issues in the dry period and early lactation of the dairy cow.

Ørskov, E.V., Ojwang, I. and Reid, G.W. 1988. A study on consistency of differences between cows in rumen outflow rate of fibrous particles and other substrates and consequences for digestibility and intake of roughages. Anim. Prod. 47, 45-51.

SAS Institute Inc. 1990. User's guide. Statistics. Version 5.

Van Arendonk, J.A.M., Nieuwhof, G.J., Vos, H. and Korver, S. 1991. Genetic aspects of feed intake and efficiency in lactating dairy heifers. Livest. Prod. Sci. 29, 263-275.

Schäfer, C.-St. and Trappmann, W. 1995. Schätzung genetischer Populationsparameter für Merkmale der Mastleistung bei Fleischrindern. Polykopie, DGfZ/GfT-Tagung, Hannover.

VIT, 1996. Zuchtwertschätzung Bullen -März 1996-. Vereinigte Informationssysteme Tierhaltung w.V., Verden/Aller.

Wassmuth, R. 1996. Feed intake capacity and production traits of growing bulls from different breeds. Proceedings international workshop on genetic improvement of functional traits in cattle, Gembloux, Belgium, January 21-23, 1996, Bulletin No. 12 1996, 181-188.

Table 1. Distribution of progeny across breeds and diets (number of sires, number of progeny)

Breed (B)		Diet (D) 1	2	Total
1	German Friesian sires and German Red and White sires with different proportions of Red Holstein (RH) genes	4, 37	16, 162	20, 199
2	German Red and White		3, 32	3, 32
Total		4, 37	19, 194	23, 231

Table 2. Estimated breeding values for feed intake capacity of German Friesian (GF) sires and German Red and White (GRW) sires with different proportions of Red Holstein (RH) genes

Name of sire	Herd book no.	Breed (% HF or RH)	Breeding value	r_{ti}^2	Rank
Fundus	373588	GF (88)	302.05	0.4368	1
Ramon	455056	GRW (100)	176.71	0.4090	2
Etta	503264	GF (100)	136.87	0.3874	3
Erz	382185	GRW (94)	123.49	0.4171	4
Chanti	373498	GF (88)	103.80	0.4371	5
Schmo	503212	GF (100)	102.91	0.3475	6
Jakute	379083	GF (94)	85.85	0.3515	7
Eagle	503240	GF (100)	63.99	0.3647	8
Eitel	17785	GRW (0)	56.32	0.2785	9
Corri	503232	GF (100)	24.75	0.3133	10
Stony	503243	GF (100)	17.13	0.4082	11
Runte	17789	GRW (0)	16.27	0.3082	12
Brett	502405	GF (100)	-46.55	0.2455	13
Vitus	375571	GF (100)	-71.20	0.4352	14
Hira	17250	GRW (0)	-76.18	0.2777	15
Voya	503242	GF (100)	-91.83	0.3728	16
Pank	375528	GF (88)	-113.33	0.4016	17
Astor	373851	GF (94)	-132.49	0.4398	18
Vetter	376945	GF (94)	-139.21	0.3769	19
Choko	375429	GF (88)	-175.80	0.4230	20
Mando	503306	GF (100)	-203.12	0.4410	21
Vandale	379084	GF (94)	-208.46	0.3582	22
Joerg	375577	GF (100)	-289.30	0.3694	23

Table 3. Spearman rank correlation coefficients between ranks of feed intake capacity and milk yield traits

Rank for	2[1]	3	4	5	Feed intake capacity
1 Milk yield	-0.04 ns	0.53 **	-0.86 ***	-0.87 ***	0.03 ns
2 Fat yield		0.42 *	0.42 *	0.23 ns	0.13 ns
3 Protein yield			-0.27 ns	-0.11 ns	-0.06 ns
4 Fat content				0.86 ***	0.05 ns
5 Protein content					0.00 ns

[1]Numbers refers to traits as listed in rows.

Table 4. Least-squares means (standard errors) of feed intake capacity for 3 different classes of breeding values calculated in 3 different runs of analysis of variance

Fixed effect (apart from others)	Class of breeding values		
	1[1]	2[1]	3[1]
Milk yield breeding values	6.01 (0.09)	6.03 (0.06)	6.01 (0.06)
Milk fat content breeding values	6.01 (0.06)	6.03 (0.06)	6.00 (0.09)
Milk protein content breeding values	5.95 (0.07)	5.98 (0.06)	6.04 (0.06)

[1] 1 = 33% of the highest breeding values; [2]: 2 = 33% of the middle breeding values;
[3] 3 = 33% of the lowest breeding values.