

Feed intake capacity and production traits of growing bulls from different breeds

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Abstract

Feed intake capacity, growth performance and carcass composition were investigated on 210 progeny from 113-600 days of age in testing station from 1985 through 1990. The young bulls belonged to three breed types: 1) 162 German Friesian progeny derived from 16 sires, 2) 32 German Red and White bulls from 3 sires, 3) 16 crossbred sons of 2 Charolais sires out of German Friesian dams. The testing diet with a digestibility of organic matter of 69.4 % consisted of ad libitum feeding of NaOH-treated straw cobs and constant concentrate supply. Paternal half-sib heritability estimates, genetic, and phenotypic correlations were calculated by using enlarged data with 278 sons from 29 sires. German Friesian bulls reached the lowest roughage intake during the long-term testing on station. Because of feeding a test diet with a digestibility of organic matter below 70 %, it has to be concluded, that the rumen of German Friesian bulls has the smallest volume of the three breeds. Growth performance and carcass composition of the experimental animals clearly show that it is possible to achieve field fattening conditions with the investigated lowly digestible diet. The variability ($cv_g = 8.8 \%$) and heritability ($h^2 = 0.47$) of roughage intake is still high enough to ensure a sufficient selection response. The genetic correlation between roughage intake and daily gain is -0.06 and between roughage intake and net daily gain 0.15. To assess the relationship of roughage intake of A.I.-bulls and milk yield of their daughters, further investigations are due to be carried out. The influence of sires roughage intake on energy supply during early lactation in their high-yielding daughters has to be evaluated.

1. Introduction

The exploitation of testing station capacity should be orientated on traits which can not be measured in field testing. Especially, feed intake capacity is one of these traits, because in field fattening conditions roughage shows a broad variation in dry matter and nutrient content. The automation of roughage intake measurement in field fattening conditions is unrealistic to achieve.

From a dairy breeders point of view feed intake capacity is an important trait not only during first part of lactation. Especially, high-yielding cows are not able to meet nutrient requirements, which results in energy deficiency. During early lactation cows must be able to receive enough feed to keep body weight losses below 6 %

(Gravert, 1984). Higher losses in body weight are not in accordance with physiological requirements and can cause fertility problems, metabolic disorders and other health disturbances (Berglund and Danell, 1987). Consequently, sufficient feed intake capacity is the basis for maintaining health in high-yielding animals.

In beef cattle breeding feed intake capacity plays an important role as well. In extensified beef production systems roughage of low nutritional value has to be used. Each cow should breed a calf each year to meet costs in suckled calf production. For nutrient efficiency and ecological reasons concentrates should be given, if any, to calves. Suckler cows have to meet maintenance and performance requirements with roughage only. Thus feed intake

capacity of the nursing cows becomes one of the most important traits for the breeding strategy.

Based on data from progeny testing on station with low intensity testing diet, feed intake capacity of purebred German Friesian bulls is compared to dual purpose (German Red and White) and crossbred bulls. Further growth performance and carcass composition is described. Finally an assessment to consider feed intake capacity as selection trait is given on the basis of the variability and heritability calculated in the present study.

2. Material and methods

The material was derived from progeny testing on 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 278 progeny derived from 29 sires across 3 breeds and 3 different diets.

All progeny of a sire contemporaneously completed test period. Sires were assumed unrelated to each other.

Data were analyzed by using the following mixed model:

$$Y_{ijk} = \mu + K_i + v_j:K_i + e_{ijk}$$

with

Y_{ijk} = k-th observation in the ij-th subgroup,

μ = overall mean,

K_i = fixed combined effect consisting of breed (B) and diet (D), (i: 1 = B1 D1; 2 = B1 D2; 3 = B2 D2; 4 = B3 D2; 5 = B3 D3)

$v_j:K_i$ = random effect of the j-th sire within the i-th combined effect K (J: 1 - 29),

e_{ijk} = random error.

By using the program package LSMLMW (Harvey, 1987) a paternal half-sib analysis was completed. Breed differences were calculated as linear contrasts between the considered breed*diet effect: B1-B2 = K2-K3; B1-B3 = K2-K4; B2-B3 = K3-K4.

Paternal half-sib heritability estimates, genetic, and phenotypic correlations were computed from the appropriate estimates of sire and residual variances and covariances.

3. Results

3.1 Performance of different breeds

The following differences in feed intake capacity, growth performance and carcass composition between breeds were found within diet 2. Considering the complete test period each bull consumed 655 g digestible protein and 4225.9 starch units energy per day. Digestibility of organic matter considering the complete diet was 69.8 %.

The comparison of the three investigated breeds (table 2) reveals, that German Friesian bulls reach the lowest roughage and dry matter intake, with significant differences to German Red and White and crossbred bulls. Regarding growth performance there are no significant differences in daily gain between breeds. Net daily gain varies between breeds with highest values in crossbred and lowest in German Friesian bulls. The latter show the lowest efficiency of energy conversion and crossbred progeny reach the most efficient energy conversion.

In the present investigation the average carcass weight of all breeds is close up to those under field fattening conditions (table 3). German Friesian bulls reach the lowest carcass weight and crossbred bulls the highest.

Carcasses from German Friesian bulls have the highest kidney and pelvic fat content and crossbreds have an intermediate fat content. Regarding carcass grade of the different breeds, results are comparable to field

fattening conditions. The proportion of the hindquarter is nearly equal in the investigated breeds. The present results reveal that typical breed differences in carcass composition can be better differentiated at a low digestible diet.

3.2 Overall means and heritability estimates

Overall mean of roughage intake is 5.49 kg dry matter per day with a standard deviation of 0.7 (table 4). The calculated coefficient of variance is 12.75 % and has to be considered with respect to the digestibility of organic matter of the diets. German Friesians, which received diet 1 (table 1), reach 6.64 kg dry matter per day of roughage and digestibility of organic matter concerning the complete diet within these subgroup was 71.3%. Crossbred progeny which received concentrates according to diet 3 (table 1) eat 4.62 kg dry matter per day and the complete diet had a digestibility of organic matter of 67.6 %. Comparing German Friesian bulls feeding with diet 1 with bulls of the same breed feeding with diet 2, and additionally, comparing crossbred progeny in diet 2 with crossbred bulls in diet 3, it has to be concluded that an increasing digestibility of organic matter leads to a lower roughage intake.

Average daily gain, net daily gain and energy efficiency reach intermediate overall means and standard deviations, which are comparable to field fattening conditions (table 4).

Coefficient of variance in roughage intake was higher than estimates of the other traits, as table 4 points out.

Heritability of roughage intake was 0.47. Because of limited number of observations, standard error of the estimate is high ($sh^2=0.21$) (table 4). However, considering literature (Miller et al., 1972; Kennedy, 1984; Thiessen et al., 1984; Jensen et al., 1991; Brandt et al., 1985; Gravert, 1985; V. d. Werf et al., 1987; Andersen et al., 1987; Svendsen et al., 1990; Korver et al., 1991; V. Arendonk et al., 1991; Leuthold et al., 1991; Persaud et al., 1991) the calculated value in the present study is confirmed. An

intermediate heritability of feed intake capacity can be accepted. Also heritability estimates of the other three traits investigated were intermediate and in accordance with literature results (table 4).

3.3 Relationship between roughage intake and other traits

Because of lower digestibility of organic matter, a slightly positive genetic correlation between roughage intake and energy efficiency was found (table 5). Phenotypic correlation of roughage intake with daily gain, net daily gain and energy efficiency were calculated as $r_p=0.22$, $r_p=0.25$, and $r_p=0.23$. No genetic correlation was found between roughage intake and daily gain and a slightly positive correlation of roughage intake with net daily gain. A significant negative correlation was estimated between daily gain and energy efficiency. This relationship is desired and means decreasing energy intake per kg carcass weight if daily gain increases.

4. Discussion

The most important trait in german testing stations for cattle is daily gain (Wassmuth und Alps, 1995). In future, breeding values for growth performance will be estimated on the basis of progeny field testing based on the BLUP procedure with respect to an animal model as Kalm et al. (1995) pointed out. To justify costs of station testing, traits have to be included which are as important for the practical breeders but can not be measured in field testing.

Feed intake capacity is one of these traits, because under farm fattening conditions roughage utilization has a significant impact on the economic revenue. On the other hand there is no automation of measurement.

Feed intake capacity plays an important role in dairy and in beef cattle breeding. Dairy cattle selection with special regard on an appropriate feed intake capacity has the aim of taking care of animals health, especially, considering high-yielding cows. During early lactation cows have to be prevented from

energy deficiency. Considering beef cattle breeding, extensification of grassland leads to an increased impact of feed intake capacity on the weaning performance.

The present investigation is based on ad libitum feeding of NaOH-treated straw cobs and constant concentrate supply. These testing diet has the advantage of controlled dry matter and nutrient contents, which means high repeatability of feed intake measurements. Fattening intensity can be controlled by the amount of concentrates. Additionally, recording can be automated by using modified electronical feeding stations for dairy cows (Hartmann, 1989). Genotype by environment interactions for various diet intensities have not been evident (Potucek, 1990). Considering the investigated testing diet, digestibility of organic matter is below 70 % which leads to a physical restriction of feed intake where rumen fill restricts feed intake.

German Friesian bulls show the significantly lowest feed intake capacity, which allows the conclusion that their rumen has the smallest volume. Because of a change in body proportions during aging in favour of the cranial parts of the body, proportion of hindquarter can be regarded as an attribute of physiological age. There were no differences found in proportion of hindquarter between breeds. Therefore, physiological age very unlikely is responsible for differences in feed intake capacity of breeds.

According to Thies (1986) the present testing diet is suitable for simulating field fattening conditions on station. In the present study the lowly digestible diet results in an intermediate growth performance with about 1000 g daily gain across breeds. This growth performance is minorly below daily gain of bulls in field fattening conditions. Certainly the genetic growth potential is not exploited, but breed differences are evaluated at farm feeding level. In case of performance testing of A.I.-bulls, there is no fear of a negative influence on semen quality, else caused by high growth intensity during testing procedure.

If testing diet has a digestibility of organic

matter below 70 %, feed intake capacity has a higher heritability as physiologically determined feed intake, according to Potucek (1990). Variation in growth performance and feed intake capacity is higher when feeding a lowly digestible diet as Langholz (1982) and Potucek (1990) pointed out. In the present investigation the coefficient of variance of roughage intake nearly reaches 13 % and seems to be constant throughout a long-term test period (Thies et al., 1993).

Heritability of roughage intake was 0.47 in the present study. Literature estimates of heritability are between 0.16 and 0.5. Regarding dairy cows and heifers average estimates of heritability in literature is 0.22 and for growing bulls 0.35. Results of other studies confirm an intermediate value, which seems to be as high as heritability of daily gain, net daily gain and energy efficiency. The genetic coefficient of variance of roughage intake is about 9 % and guarantees sufficient selection response when treating roughage intake as separate selection criterion.

In case of ad libitum feeding of roughage and lowered nutritional value of testing diet, relationship of feed intake capacity with daily gain seems to be loose as several studies reveal (Thies, 1986, $r_p=0.25$; Thiessen, 1985, $r_p=0.48$; Thonney, 1987, $r_p=0.50$). The present results are in agreement with literature results. Phenotypic correlations of roughage intake with daily gain and net daily gain are slightly positive ($r_p=0.22$, $r_p=0.25$). Genetic correlation is $r_g=-0.06$ considering roughage intake and daily gain, and $r_g=0.15$ for roughage intake with net daily gain. Considering the relationship of roughage intake with energy efficiency genetic correlation is slightly higher ($r_g=0.34$) than the results of Andersen et al. (1987) ($r_g=-0.17$).

Because of low genetic relationship between roughage intake and growth performance and an intermediate genetic correlation of roughage intake with energy efficiency, it has to be concluded, that feed intake capacity has to be considered as separate

selection criterion. These suggestion is supported by the above mentioned high genetic variability and heritability. Correlated selection responses in feed intake capacity seem to be low, if selecting for daily gain, net daily gain and energy efficiency only.

The results of Persaud and Simm (1991) indicate that a shortening of the test period is possible because of close relationships between feed intake capacity of lactating cows in various stages. But Hartmann (1989) found low correlations between feed intake capacity of growing bulls in various stages. Further research is necessary because the test period of potential A.I.-bulls has to be finished with about 12 or 14 months of age. They are due to be sold with an age of slightly above one year on auction.

The aim of testing feed intake capacity on station, considering A.I.-bulls is to improve this trait in their lactating daughters to prevent energy deficiency during early lactation. This could result in a prolonged productive life and decreasing veterinary costs. Nieuwhof et al. (1992) found a close relationship of feed intake capacity in growing bulls with feed intake capacity in lactating daughters of $r_s = 0.77$ which means sufficient selection response.

An intermediate genetic correlation of $r_s = 0.55$ between feed intake capacity of lactating heifers and their milk yield (Van Arendonk et al., 1991) obviously does not lead to sufficient selection response in feed intake capacity by breeding towards a high milk yield. Otherwise cows must be able to meet nutrient requirements, especially during early lactation.

Although there seems to be no genetic relationship between feed intake capacity in growing bulls and milk yield of daughters (Nieuwhof et al., 1992), it would be an interesting task of research to study the relationship between feed intake capacity of sires and contents of milk and lifetime performance. Further studies on this topic are due to be carried out.

However, the variability of feed intake capacity and heritability is still high enough

to ensure a sufficient selection response. The lower correlations with growth performance traits are emphasising the importance of treating feed intake capacity as a separate selection criterion, considering performance testing of potential A.I.-bulls on station.

5. Conclusions

Performance testing on station has to be orientated on functional traits which can be measured in standardized environment only. Feed intake capacity is one of these traits and was measured by feeding of NaOH-treated straw cobs ad libitum and constant concentrates. This test diet has the following advantages: The dry matter and nutrient content is constant and fattening intensity can be controlled by the amount of concentrates. NaOH-treated straw cobs do not lead to any health problems which are likely caused by high sodium amounts animals receive. The bulls have an intermediate growth performance and carcass composition. In literature a higher genetic variability and heritability of growth performance and carcass composition caused by the low digestibility of organic matter of the diet was found. Genotype by environment interactions have not been evident considering different diet intensities. In the present investigation a loose relationship between roughage intake and growth performance was calculated.

German Friesian bulls have the lowest feed intake capacity in comparison to dual-purpose and crossbred bulls. The evaluation of feed intake capacity as separate selection criterion in breeding German Friesian A.I.-bulls has to base on the following future tasks: The correlation between feed intake capacity in A.I.-bulls and feed intake capacity of their lactating daughters has to be carried out. The relationship between milk yield and health disturbances should be investigated, esp., considering early lactation. The effect of feed intake capacity of A.I.-bulls on milk contents considering their daughters is another task of interest. The relationship of eating behaviour and feed intake capacity has to be carried out.

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

breeds (B)	diet (D)			total
	1	2	3	
digestible protein intake per day (g)	745	655	723	
energy intake per day (starch units)	4709.3	4225.9	4303.8	
digestibility of organic matter (%)	67.6	69.8	71.3	
1 German Friesian (GF) (sires with $\geq 87.5\%$ HF ¹ genes)	4, 37	16, 162	-	20, 199
2 German Red and White (GRW) (sires without RH ² genes)	-	3, 32	-	3, 32
3 Charolais*GF (CHA*GF) Charolais*GF, Fleckvieh*GF	-	2, 16	4, 31	6, 47
total	4, 37	21, 210	4, 31	29, 278

¹ HF = Holstein-Friesian, ² RH = Red-Holstein

Table 2: Least-squares means (standard errors) of feed intake, growth performance and energy efficiency for breeds

breed	GF	GRW	CHA*GF
number of sires, number of progeny	16, 162	3, 32	2, 16
concentrate intake (kg DM/day)	2.99a (0.01)	3.02b (0.03)	3.02b (0.04)
roughage intake (kg DM/day)	5.35a (0.05)	5.65b (0.12)	5.58a,b (0.16)
dry matter (DM) intake (kg/day)	8.34a (0.06)	8.67b (0.13)	8.59b (0.17)
daily gain (113-600 days of age) (g)	988.59a (9.49)	996.34a (21.55)	1014.88a (28.37)
net daily gain ¹ (g)	512.58a (4.92)	535.85a,b (11.19)	567.02b (14.57)
energy efficiency (starch units/kg slaughter wt.)	6672.3a (67.30)	6558.0a,b (153.1)	6134.3b (198.9)

Means with the same letters are not significantly different ($p \leq 0.05$) between breeds (Scheffé-test)

¹ slaughter weight divided by length of test period

Table 3: Least-squares means (standard errors) of carcass composition for breeds

trait	GF	GRW	CHA*GF
number of sires, number of progeny	16, 162	3, 32	2, 16
carcass weight (kg)	308.79a (2.99)	323.36b (6.80)	342.81b (8.85)
dressing-out percentage (%)	48.21a (2.77)	53.06b (6.34)	55.51b (6.34)
kidney and pelvic fat (%)	3.94a (0.13)	3.46b (0.31)	2.65c (0.39)
carcass grade (EUROP)	3.96a (0.05)	3.47b (0.11)	3.06c (0.14)
hindquarter ¹ (%)	52.59a (0.13)	52.74a (0.30)	52.31a (0.39)

Means with the same letters are not significantly different ($p \leq 0.05$) between breeds (Scheffé-test)

¹ hindquarter weight divided by carcass weight

Table 4: Overall mean, phenotypic standard deviation (st.dev.), heritability (h^2), standard error of heritability (s_{h^2}) and genetic coefficient of variance (cv_g) for roughage intake, growth performance and energy efficiency on 278 progeny from 29 sires

trait	mean	st. dev.	h^2	s_{h^2}	cv_g (%)
roughage intake (kg DM/day)	5.49	0.70	0.47	0.21	8.8
daily gain (113-600 days of age) (g)	998.41	89.31	0.40	0.20	5.7
net daily gain (g)	524.79	46.42	0.53	0.22	6.4
energy efficiency (starch units/kg slaughter wt.)	6677.4	667.3	0.57	0.22	7.5

Table 5: Phenotypic (above diagonal) and genetic (below diagonal) correlations between roughage intake, growth performance and energy efficiency

trait	1	2	3	4
1 roughage intake (113-600 days of age)	0.47	0.22	0.25	0.23
2 daily gain (113-600 days of age)	-0.06	0.40	0.82	-0.74
3 net daily gain (g/day)	0.15	0.47	0.53	-0.85
4 energy efficiency (starch units/ kg slaughter wt.)	0.34	-0.69	-0.83	0.57

¹: number refers to traits as listed in rows