# Grazing behaviour of dairy cattle in relation to genetic selection for milk production

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# Einfluß der Selektion auf Milchleistung auf das Graseverhalten von Rindern

## 1. Introduction

In recent years there has been considerable progress in selection of dairy cows for increased milk production. While the physiological basis for this progress is increasingly understood, relatively little is known about its behavioural consequences. Increased milk production leads to higher food intake (e. g. LÖBER et al., 1993), but little work has been done on the effects of higher milk yield or higher genetic merit for milk production on the control and expression of feeding behaviour. Under summer grazing conditions there are different possibilities for dairy cows to gain higher food intake. One of them is to change the time budget for various activities, especially for grazing and lying. Since feed intake is not only related to the time spent grazing but also to the number of bites per unit of time and the average size of each bite (SPEDDING et al., 1966) other possibilities are to increase bite rate or the amount of feed obtained per bite. Many factors have an influence on grazing behaviour. First, there are environmental factors such as climate (ARNOLD and DUDZINSKY, 1978), pasture quality (HANCOCK, 1954), grazing management (HART et al., 1993) or amount of supplementary feed (PHILLIPS and LEAVER, 1986). Second, there are animal specific factors, which are subject of this study, like age (HODGSON and WILKINSON, 1967), breed (LATHROP et al., 1988), stage of pregnancy (VANZANT et al., 1991) or level of milk production (BAO et al., 1992). Stage of pregnancy might affect grazing behaviour, since the capacity of the rumen decreases with advanced pregnancy (BURGSTALLER, 1986) and hence might lead to a change in

**Zusammenfassung**

Ausgehend von der Frage, inwieweit die Selektion auf Milchleistung eine Änderung des Graseverhaltens von Rindern bewirkt, wurden Verhaltensbeobachtungen an insgesamt 43 Tieren der Langhill Herde in Edinburgh durchgeführt. Die Herde besteht aus zwei genetischen Linien, die sich im Zuchtwert für Milchleistung unterscheiden. Zusätzlich zu den Verhaltensbeobachtungen wurde auch die Futteraufnahme auf der Weide erhoben. Weder Milchleistung noch Zuchtwert zeigten einen Einfluß auf die Dauer der Verhaltensweisen auf der Weide. Der Einfluß der Trächtigkeit war stärker, jedoch gegensätzlich für Kalbinnen und Kühe. Die Ermittlung der Futteraufnahme zeigte, daß Tiere mit hohem Zuchtwert sowohl als Kalbinnen als auch als trockenstehende Kühe signifikant mehr Futter aufnahmen.

**Schlagworte:** Milchrinder, Selektion, Milchleistung, Graseverhalten, Futteraufnahme.

**Summary**

The present study was designed to examine effects of selection for milk production on the grazing behaviour of dairy cattle. Subjects were 43 Holstein Friesian cows from the Langhill Dairy Herd in Edinburgh which consists of two genetic lines: one selected for high milk solids yield and a control line of average genetic index for milk solids yield. Their behaviour was recorded in various observation periods, additionally herbage intake on pasture was investigated. No significant influence was found of either milk yield or breeding value on time spent grazing, lying, ruminating or standing or on bite rate. The influence of stage of pregnancy was stronger, however, results for heifers and cows were contrary. Heifers and cows of the selected line had higher herbage intakes than animals of the control line.

**Key words:** Dairy cattle, genetic selection, milk production, grazing behaviour, herbage intake.

the pattern of grazing. A positive relationship between milk production and grazing time has been reported by some researchers (BRUMBY, 1959; LATHROP et al., 1988; BAO et al., 1992). However, other studies failed to find any relationship between milk yield and grazing time (JOHNSTONE-WALLACE, 1951; PHILLIPS and LEAVER, 1986; PHILLIPS and HECHEIMI, 1989). Results for the relationship between bite rate and milk yield are not uniform either (PHILLIPS and HECHEIMI, 1989; BAO et al., 1992).

The present study was designed to examine effects of genetic selection for milk production on the grazing behaviour of dairy cattle. Mainly nonlactating animals of a dairy herd consisting of two genetic lines with different selection history were observed to investigate the effects of the disposition for milk production rather than of the actual milk yield. Preliminary observations (STAACK, 1991) showed differences in feeding and lying time between dairy cows with high and low genetic merit for milk production. Results of more detailed observations including measurements of bite rate as well as results of herbage intake investigations of animals of the same herd before and after their first lactation are presented in this paper.

## 2. Materials and methods

Subjects were 43 Holstein Friesian cows from the Langhill Dairy Herd in Edinburgh. The herd, which is owned by the University of Edinburgh, consists of two genetic lines, selected and control. The selected line cows are bred by AI to the best available bulls on the basis of their estimated Predicted Transmitting Abilities (PTAs) for kg fat plus protein; the control line cows, which have been maintained at Langhill since the late 1970s, were bred to bulls of around average PTA for kg fat plus protein (LANGHILL FARM REPORT, 1994).

Animals of both genetic lines were observed as nonlactating heifers in 4 observation periods during the day and one period during the night in 1992, in 1993 as first lactating cows in one period during the day and one during the night, and as dry cows in two periods during the day (Table 1). Only animals observed as heifers were later observed as cows. However, not all heifers could be observed as cows since some had been sold or culled while others were not lactating or dry during the respective observation periods.

Observations took place on a leased 18 hectare pasture in the south of Edinburgh (periods 1 to 3), and on 4–10 hectare pastures at Langhill Farm. Heifers and dry cows grazed on permanent pastures which were of comparable quality while lactating cows rotationally grazed a series of large paddocks with sizes of approximately 3 to 4 hectares, where they were on average kept 2 days. Predominant plants were ryegrasses on all pastures, growing seasons in 1992 and 1993 were similar. Time of observation, number of observed animals of both lines, their average breeding value index and 305 day ECM (energy corrected milk) lactation of 1992/93 are shown in Table 1. The breeding value index PI (Pedigree index) for kg fat plus protein was predicted from PTA ancestor records. Animals of the two genetic lines did not differ in liveweight in periods 1 to 6, in period 7 animals of the control line were lighter but an additional analysis showed that weight did not have a significant influence on herbage intake. Animals of both lines did not differ in condition score.

Heifers and dry cows had access only to pasture: no other food was provided. In addition to pasture lactating cows also had a concentrate allowance of 2 kg for all cows offered in the milking parlour and silage ad libitum after milking.

Table 1: Details of observations and of experimental animals of both genetic lines, Selected (SL) and Control (CL)
Tabelle 1: Einzelheiten zu Beobachtungsperioden und den Versuchstieren beider genetischer Linien (SL, CL)

| Period | Date of observation | No. of days | Sample intervals in min. | No. of animals | | PI for kg fat plus protein | | 305 day ECM yield (kg) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | SL | CL | SL | CL | SL | CL |
| 1 | 24.06.-06.07.1992 | 12 | 30 | 22 | 20 | 28.7 | -11.0 | 6520 | 5318 |
| 2 | 21.07.-01.08.1992 | 12 | 30 | 22 | 19 | 28.7 | -10.8 | 6520 | 5306 |
| 2n[1] | 02.08.-06.08.1992 | 4 | 30 | 22 | 19 | 28.7 | -10.8 | 6520 | 5306 |
| 3 | 11.08.-22.08.1992 | 12 | 15 | 9 | 6 | 30.2 | -13.6 | 5822 | 5370 |
| 4 | 14.09.-24.09.1992 | 8 | 10 | 6 | 4 | 25.5 | -8.7 | 7053 | 5133 |
| 5 | 06.07.-16.07.1993 | 10 | 15 | 11 | 11 | 27.0 | -10.5 | 6802 | 5320 |
| 5n[1] | 02.08.-06.08.1993 | 4 | 15 | 11 | 9 | 27.0 | -11.6 | 6802 | 5213 |
| 6 | 20.08.-25.08.1993 | 6 | 10 | 9 | 4 | 28.1 | -6.5 | 6575 | 5311 |
| 7 | 06.09.-17.09.1993 | 10 | 5 | 6 | 3 | 28.7 | -9.8 | 6830 | 5533 |

[1] Night time observations

### 2.1 Behaviour

Behaviour was recorded alternately from 7.30 to 13.30 h one day and from 13.30 to 19.30 h the following day during daytime observations in periods 1-4 and 6-7. In period 5 observations were conducted for a period of 6 h between morning and evening milking from 8.30 to 14.30 h. Night time observations were made once a year to ascertain that there was no negative correlation between levels of behaviour observed during the day and those performed at night. In 1992 (period 2n) the animals were observed on two days from 19.30 to 1.30 h and from 1.30 to 7.30 h, respectively; in 1993 (period 5n) night time observations were on two days from 18.00 to 23.00 h and from 23.00 to 4.00 h, respectively. The different observation time in 1993 was due to the milking regime of the cows. However, the main observation time between 7.30 and 19.30 h includes the main grazing periods and should give a representative picture over the behaviour of two groups (PHILLIPS and LEAVER, 1985). Night grazing during summer months is little except when temperatures are very high or quantity or quality of pasture is poor (JAMIESON and HODGSON, 1979; ARNOLD, 1981).

The behaviour of all animals was recorded using 'scan-sampling' procedures (MARTIN and BATESON, 1986). Every 30, 15, 10 or 5 minutes (Table 1), depending on the number of animals and size of pasture, behaviour was recorded in one of the following exclusive categories: Grazing, Lying, Lying Ruminating, Standing, Standing Ruminating, Walking or Others (Lying total = Lying + Lying Ruminating, Ruminating total = Lying Ruminating + Standing Ruminating, Standing total = Standing + Standing Ruminating).

For identification freeze brand numbers and colored ear tags were used; in period 5 and 5n animals were additionally marked with colored chains since separation from the whole herd was not possible. Daytime observation was aided by binoculars, night time observation by a torch. Before formal records started, heifers and cows were habituated to the observers presence by an additional period between 2 and 8 (heifers prior to period 1) days. All records were made by the same person, at night a second person was at the pasture for safety reasons.

Bite rate was measured for all animals during the breaks between scan-sampling (HODGSON, 1982) in periods 4 to 7 and was obtained by recording the time taken for 100 uninterrupted bites (ILLIUS, 1989), with pauses no longer than 15s. To take diurnal variation into account, bite rate was recorded on at least 5 occasions for each animal at different times during the day.

### 2.2 Herbage intake

Food intake on pasture was estimated for 10 heifers shortly before their first parturition (average stage of pregnancy 260 d) in period 4 and for 9 dry cows before their second parturition (average stage of pregnancy 258 d) in period 7 using n-alkanes as indicators. For 6 of the 9 cows food intake was also investigated as heifers. When using n-alkanes, herbage intake can be directly determined using those dosed alkanes and alkanes which are present in the cuticular wax without the need for estimation of faecal output (MAYES et al., 1986). In this study, herbage intake was estimated from the simultaneous use of dosed $C_{32}$ and herbage $C_{33}$ n-alkanes as markers.

During the first 11 of 12 experimental days, animals were dosed with $C_{32}$ n-alkane impregnated paper capsules (approx. 5 g) once a day with the help of a dosing gun. Herbage samples were taken on days 1-11, faecal samples on days 7–12 once daily, respectively. Herbage and faecal samples were first stored in a deep-freezer, then freeze-dried and milled.

Analysis of alkanes was performed according to the method of MAYES et al. (1986). For calculation of the herbage intake the following formula was used:

$$IH = \frac{D32}{\left(\frac{F32}{Fi} \times Hi\right) - H32}$$

where

| | |
|---|---|
| IH | = Herbage dry matter intake (kg/d) |
| D32 | = Dose rate of artificial alkane $C_{32}$ (mg/d) |
| F32 | = Faecal alkane content for $C_{32}$ (mg/kg DM) |
| Fi | = Faecal alkane content for $C_{33}$ (mg/kg DM) |
| Hi | = Herbage alkane content for $C_{33}$ (mg/kg DM) |
| H32 | = Herbage alkane content for $C_{32}$ (mg/kg DM) |

### 2.3 Statistical analysis

All calculations were carried out using different procedures of SAS (STATISTICAL ANALYSIS SYSTEMS INSTITUTE, 1988).

In period 5 data were expressed as percentages of 6 h, in period 5n of 10 h and in all other periods of 12 h of observation. Except for period 5 two consecutive half days were treated as one full day.

After testing for normal distribution the categorized behaviour was analysed by the General Linear Models (GLM) procedure. The following statistical models were used (more detailed explanation is given below):

$$Y_{ijkl} = \mu + D_i + G_j + A_{jk} + (D*G)_{ij} + \varepsilon_{ijkl} \qquad [1]$$

where $Y_{ijkl}$ = an individual observation, $\mu$ = the overall mean, $D_i$ = the fixed effect of the $i^{th}$ day, $G_j$ = the fixed effect of the $j^{th}$ group, $A_{jk}$ = the random effect of the $k^{th}$ animal within the $j^{th}$ group, $(D*G)_{ij}$ = the interaction between $D_i$ and $G_j$, and $\varepsilon_{ijkl}$ = the random residual.

$$Y_{ijklm} = \mu + P_i + D_{ij} + G_k + A_{kl} + (P*G)_{ik} + \varepsilon_{ijklm} \qquad [2]$$

where $Y_{ijklm}$ = an individual observation, $\mu$ = the overall mean, $P_i$ = the fixed effect of the $i^{th}$ period, $D_{ij}$ = the random effect of the $j^{th}$ day within the $i^{th}$ period, $G_k$ = the fixed effect of the $k^{th}$ group, $A_{kl}$ = the random effect of the $l^{th}$ animal within the $k^{th}$ group, $(P*G)_{ik}$ the interaction between $P_i$ and $G_k$, and $\varepsilon_{ijklm}$= the random residual.

Animals were grouped in classes with respect to milk production in two alternative ways: First, by their first lactation 305 day ECM yield to investigate differences due to actual production; second, by line (selected or control) to account for different selection history.

Model [1] was used for analysis within period. For periods 1 to 3, 5 and 5n animals were additionally grouped by stage of pregnancy. Model [2] was used for analysis within year, animals were divided into two groups, depending on their PI for kg fat plus protein or 305 day ECM yield, respectively. For model [2] records were weighted according to the frequency of scans per animal and day. Medians were used for grouping animals with respect to 305 day ECM yield and stage of pregnancy. The random effect of animal within group was used as the error term to test the fixed effect of group (models [1] and [2]); the random effect of day was used as the error term to test the fixed effect of period (model [2]).

Correlation analysis was carried out to investigate the relationships between the duration of main activities during the day and at night (periods 2/2n and 5/5n) and between daily milk yield and the duration of main activities in period 5. For analysis of bite rate model [1] was used, day as fixed effect being included in periods 4 and 7 only.

Herbage intake results were tested using a t-test. Additionally regression analysis was performed between herbage intake and grazing time, bite rate, PI and 305 day ECM yield.

## 3. Results

### 3.1 Behaviour

#### *3.1.1 Effects of 305 day ECM yield and breeding value*

In Tables 2 and 3 the LS-Means of main activities are shown for groups with high or low milk yield and with high or low PI (model [1]). No significant differences were found between high and low yielders in any of the observation periods. Differences were generally small, with slight, non-significant trends for high yielders to graze longer from shortly before their first parturition (period 4) and, from the same time, to spend less time lying.

Table 2: LS-Means and residual standard deviation (r.s.d.) of time spent in different behaviour (%) and average 305 day ECM yield (kg) for groups with low (LY) and high (HY) milk yield

Tabelle 2: LS-Mittel und Residualstandardabweichung (r.s.d.) der Hauptaktivitäten in % für die Gruppen mit niedriger (LY) und hoher (HY) Milchleistung

| | Grazing [1] | | | Lying total [1] | | | Ruminating total | | | Standing total [1] | | | ECM (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Period | LY | HY | r.s.d. | LY | HY | r.s.d. | LY | HY | r.s.d. | LY | HY | r.s.d. | LY | HY |
| 1 | 44.3 | 43.4 | 7.0 | 40.0 | 40.2 | 5.9 | 29.4 | 29.3 | 6.4 | 11.2 | 12.9 | 5.9 | 5123 | 6855 |
| 2 | 54.5 | 53.1 | 6.4 | 30.6 | 30.3 | 5.6 | 24.8 | 25.7 | 5.8 | 12.6 | 13.9 | 5.3 | 5136 | 6908 |
| 2n | 20.6 | 20.8 | 3.6[2] | 62.1 | 62.2 | 4.9 | 46.3 | 44.4 | 7.0 | 16.2 | 16.3 | 5.4 | 5136 | 6908 |
| 3 | 57.6 | 56.5 | 6.3 | 26.6 | 26.4 | 5.1 | 16.7 | 18.2 | 4.2 | 11.4 | 13.3 | 4.4 | 5234 | 6206 |
| 4 | 52.5 | 54.6 | 3.3 | 16.5 | 14.6 | 3.6 | 12.9 | 12.0 | 2.7 | 23.6 | 23.4 | 3.6 | 5343 | 7327 |
| 5 | 54.9 | 56.1 | 6.9 | 38.4 | 37.1 | 6.9[2] | 20.3 | 21.1 | 6.0 | 4.0 | 4.5 | 4.5 | 5141 | 6837 |
| 5n | 36.9 | 40.2 | 6.8 | 55.7 | 53.6 | 7.4 | 33.3 | 36.7 | 6.6 | 5.2 | 5.2 | 3.7 | 4952 | 6982 |
| 6 | 63.2 | 64.7 | 4.9 | 24.8 | 22.9 | 4.9 | 21.8 | 22.5 | 3.6 | 8.5 | 9.6 | 3.7 | 5410 | 7092 |
| 7 | 68.7 | 69.4 | 4.5 | 14.1 | 12.6 | 2.5 | 15.5 | 14.4 | 3.2 | 12.7 | 13.1 | 4.0 | 5710 | 7257 |

[1] Grazing and Lying total not normally distributed in period 2n, Standing total in periods 1, 2 and 5

[2] Significant interaction ($P < 0.05$) between day and group

Table 3: LS-Means and residual standard deviation (r.s.d.) of time spent in different behaviour (%) and average Pedigree Index (PI) for animals of the Control (CL) and Selected (SL) line

Tabelle 3: LS-Mittel und Residualstandardabweichung (r.s.d.) der Hauptaktivitäten in % für die Gruppen mit niedrigem (CL) und hohem (SL) Zuchtwert (Pedigree Index, PI)

| | Grazing [1] | | | Lying total [1] | | | Ruminating total | | | Standing total [1] | | | PI for kg fat plus protein | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Period | CL | SL | r.s.d. | CL | SL | r.s.d. | CL | SL | r.s.d. | CL | SL | r.s.d. | CL | SL |
| 1 | 43.1 | 44.5 | 7.0 | 40.6 | 39.6 | 5.9 | 29.1 | 29.7 | 6.4 | 12.0 | 12.1 | 5.9[3] | -11.0 | 28.7 |
| 2 | 53.2 | 54.5 | 6.4 | 30.7 | 30.2 | 5.6 | 24.9 | 25.3 | 5.8 | 13.6 | 12.9 | 5.3 | -10.8 | 28.7 |
| 2n | 20.7 | 20.8 | 3.6[3] | 61.2 | 62.7 | 4.9 | 43.6 | 47.2 | 7.0[2] | 16.8 | 15.8 | 5.4 | -10.8 | 28.7 |
| 3 | 58.5 | 57.3 | 6.3 | 25.7 | 26.9 | 5.1 | 17.8 | 17.7 | 4.2 | 12.4 | 11.4 | 4.4 | -13.6 | 30.2 |
| 4 | 51.7 | 54.8 | 3.3 | 16.1 | 15.2 | 3.6 | 12.2 | 12.6 | 2.7 | 24.6 | 22.8 | 3.6 | -8.7 | 25.5 |
| 5 | 55.9 | 53.9 | 6.9 | 37.0 | 40.3 | 6.9 | 21.1 | 20.4 | 6.0 | 4.5 | 3.6 | 4.5 | -10.5 | 27.0 |
| 5n | 36.7 | 40.0 | 6.8 | 55.2 | 55.1 | 7.4 | 36.5 | 33.0 | 6.6 | 6.6 | 3.6 | 3.7 | -11.6 | 27.0 |
| 6 | 60.4 | 65.4 | 4.9 | 25.6 | 23.2 | 4.9 | 22.0 | 22.2 | 3.6 | 10.4 | 8.4 | 3.7 | -6.5 | 28.1 |
| 7 | 67.5 | 69.8 | 4.5 | 13.4 | 13.5 | 2.5[3] | 15.8 | 14.6 | 3.2 | 14.5 | 12.1 | 4.0 | -9.8 | 28.7 |

[1] Grazing and Lying total not normally distributed in period 2n, Standing total in periods 1, 2 and 5

[2] $P < 0.05$

[3] Significant interaction ($P < 0.05$) between day and group

The results for groups with high or low PI were not uniform and no significant differences were found between the two genetic lines for time spent grazing, lying or standing. In period 2n heifers of the selected line spent significantly more time ruminating than heifers of the control line (+ 3.6 %, $P < 0.05$).

The fixed effect of day was significant for main activities in all periods except ruminating total in period 5n and on standing total in period 6. The random effect of animal was found to have a significant influence on time spent grazing except in period 5n and also had a significant influence on the other main activities in most periods.

When using model [2] no significant differences between the two groups with high or low milk yield and high or low PI were found.

### *3.1.2 Correlation between daily milk yield and duration of main activities*

For period 5, when lactating cows were observed, correlation analysis showed no significant relationship between daily milk yield and duration of main activities. Correlations were between -0.02 (milk yield and ruminating total) and 0.07 (milk yield and lying total).

### *3.1.3 Effects of pregnancy*

Stage of pregnancy had a stronger influence on grazing time than milk yield or breeding value (Table 4). Heifers which were closer to parturition showed a trend to spend less time grazing in periods 1 and 2 (– 2.7 % and $P < 0.10$, respectively), spent significantly more time lying in period

Table 4: LS-Means and probabilities (P) of time spent in different behaviour ( %) and average stage of pregnancy (d) for groups in early (E) and late (L) stage of pregnancy (residual standard deviation is shown in Tables 2 and 3)

Tabelle 4: LS-Mittel und P-Werte für die Dauer der Hauptaktivitäten in % für die Gruppen mit niedriger (E) bzw. hoher (L) Trächtigkeitsdauer zum Zeitpunkt der Beobachtung (Residualstandardabweichung aus Tabellen 2 und 3 ersichtlich)

| | Grazing [1] | | | Lying total [1] | | | Ruminating total | | | Standing total [1] | | | Stage of pregnancy | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Period | E | L | P | E | L | P | E | L | P | E | L | P | E | L |
| 1 | 45.1 | 42.4 | 0.056[2] | 38.9 | 41.2 | 0.028 | 28.3 | 30.4 | 0.070 | 12.0 | 12.1 | 0.959 | 136 | 201 |
| 2 | 55.2 | 52.5 | 0.092 | 29.8 | 31.2 | 0.330 | 24.7 | 25.8 | 0.398 | 12.4 | 14.1 | 0.204 | 166 | 229 |
| 2n | 20.2 | 21.1 | 0.528 | 62.8 | 61.7 | 0.418 | 45.4 | 45.3 | 0.997 | 15.5 | 17.1 | 0.281 | 174 | 237 |
| 3 | 58.0 | 56.2 | 0.380 | 26.2 | 26.8 | 0.753 | 17.5 | 17.5 | 0.984 | 12.2 | 12.5 | 0.744 | 159 | 190 |
| 5 | 53.0 | 58.0 | 0.008 | 40.0 | 35.5 | 0.063[2] | 21.7 | 19.7 | 0.090 | 4.8 | 3.8 | 0.318 | 112 | 203 |
| 5n | 37.6 | 39.5 | 0.458 | 55.7 | 53.6 | 0.445 | 36.6 | 33.4 | 0.236 | 5.7 | 4.7 | 0.580 | 102 | 216 |

[1] Grazing and Lying total not normally distributed in period 2n, Standing total in periods 1, 2 and 5

[2] Significant interaction ($P < 0.05$) between day and group

1 (+ 2.3 %, P < 0.05) and tended to ruminate a greater proportion of time in period 1 (+2.1 %, P < 0.10). The results recorded for heifers were contrary to those recorded for lactating cows. Cows, which were closer to parturition spent significantly more time grazing (+ 5.0 %, P < 0.01) and tended to spend less time lying and ruminating (– 4.5 % and -2.0 %, respectively, P < 0.10) in period 5. Results recorded at night (period 5n) were not significant but in accordance to the observations made during the day.

### *3.1.4 Effects of period*

In 1992 the period had a significant influence on the main activities grazing (P < 0.05), lying (P < 0.01) and ruminating (P < 0.001, Table 5). Time spent grazing increased during the day until period 3, then decreased. Lying and rumination time decreased constantly. For the time spent standing a trend could be observed (P < 0.10) which was due to the distinct increase of standing between periods 3 and 4. Similar, but non significant tendencies were found for cows in 1993: grazing time increased, time spent lying and ruminating decreased. Period 5 was not included in the analysis since lactating cows got silage and concentrate in addition to pasture.

### *3.1.5 Correlation between duration of main activities during the day and their duration at night*

No significant correlation could be found for time spent grazing (r = 0.10), lying (r = 0.09), ruminating (r = 0.00) and standing (r = 0.24) between periods 2 and 2n (P > 0.10, respectively). Significant positive correlations were found for time spent lying (r = 0.55) and standing (r = 0.50) between periods 5 and 5n (P < 0.05, respectively), correlations for time spent grazing (r = 0.32) and ruminating (r = 0.00) were not significant though (P > 0.10).

### *3.1.6 Bite rate*

No significant differences were found in bite rate between the two groups with high and low 305 day ECM yield or with high and low breeding value, respectively (Table 6). The random effect of animal had a significant influence on bite rate in periods 4, 6 and 7 (P < 0.05); in period 5 a trend could be observed (P < 0.10). The fixed effect of day, which was included in periods 4 and 7 only, had no significant influence on bite rate in either of these periods.

Table 6: LS-Means, residual standard deviation (r.s.d.) and probabilities (P) of bite rate (bites/min) for groups with low (LY) and high (HY) 305 day ECM yield and for animals of the Control (CL) and Selected (SL) line

Tabelle 6: Vergleich der Bißrate (Anzahl Bisse pro Minute) der Gruppen mit niedriger und hoher Milchleistung (LY, HY) sowie niedrigem und hohem Zuchtwert (CL, SL)

| Period | LY | HY | P | CL | SL | P | r.s.d. |
|---|---|---|---|---|---|---|---|
| 4 | 55.4 | 52.8 | 0.511 | 54.2 | 53.9 | 0.956 | 8.8 |
| 5 | 55.0 | 55.1 | 0.963 | 54.9 | 55.2 | 0.888 | 11.8 |
| 6 | 57.0 | 55.9 | 0.786 | 59.4 | 55.2 | 0.392 | 8.5 |
| 7 | 62.8 | 62.0 | 0.746 | 63.9 | 61.7 | 0.409 | 8.6 |

## 3.2 Herbage intake

Animals with high 305 day ECM yield had higher herbage intakes in both years (Table 7); for heifers in period 4 this result was significant (+ 2.02 kg, P < 0.01). Animals with a high PI had significantly higher herbage intakes than those with a low one in both years: in period 4 +1.85 kg (P < 0.01) and in period 7 + 3.13 kg (P < 0.05).

Regression analysis showed that there was no significant relationship between herbage intake and grazing time in either of the two periods. Significant relationships were found between herbage intake and 305 day ECM yield in period 4 (Figure 1, coefficient of determination $r^2 = 0.921$),

Table 5: LS-Means, residual standard deviation (r.s.d.) and probabilities (P) of time spent in different behaviour ( %) for periods within years

Tabelle 5: LS-Mittel, Residualstandardabweichung (r.s.d.) und P-Werte für die Dauer der Hauptaktivitäten in % innerhalb der Beobachtungsjahre

| Activity in % | Periods in 1992 | | | | | | Periods in 1993 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | r.s.d. | P | 6 | 7 | r.s.d. | P |
| Grazing | 43.7 | 53.7 | 55.4 | 52.3 | 5.0 | 0.020[2] | 62.5 | 69.0 | 7.2 | 0.424 |
| Lying total | 40.2 | 30.5 | 28.4 | 15.2 | 4.4 | 0.002 | 23.5 | 14.1 | 5.6 | 0.527 |
| Ruminating total | 29.4 | 25.1 | 18.2 | 13.1 | 4.4 | < 0.001 | 22.9 | 14.6 | 5.2 | 0.192 |
| Standing total [1] | 12.1 | 13.3 | 12.1 | 24.9 | 4.1 | 0.085[2] | 10.7 | 12.5 | 5.9 | 0.791 |

[1] Grazing and Lying total not normally distributed in period 2n, Standing total in periods 1, 2 and 5

[2] Significant interaction (P < 0.05) between day and group

Table 7: Mean values and standard deviation of herbage intake (kg DM/day) for groups with low (LY) and high (HY) 305 day ECM yield and for animals of the Control (CL) and Selected (SL) line

Tabelle 7: Mittelwerte und Standardabweichung der durchschnittlichen Futteraufnahme auf der Weide (kg Trockenmasse pro Tag) der Gruppen mit niedriger und hoher Milchleistung (LY, HY) sowie niedrigem und hohem Zuchtwert (CL, SL)

| Period | $\bar{x}$ | s.d. | $\bar{x}$ | s.d. | P |
|---|---|---|---|---|---|
| | LY | | HY | | |
| 4 | 7.53 | 0.34 | 9.55 | 0.89 | 0.002 |
| 7 | 11.14 | 1.83 | 13.29 | 2.88 | 0.220 |
| | CL | | SL | | |
| 4 | 7.43 | 0.29 | 9.28 | 1.04 | 0.009 |
| 7 | 10.25 | 0.43 | 13.38 | 2.59 | 0.031 |

between herbage intake and PI in periods 4 and 7 (Figures 2 and 3, $r^2$ = 0.637 and 0.375, $P < 0.10$, respectively) and between herbage intake and bite rate in periods 4 and 7 (Figures 4 and 5, $r^2$ = 0.470 and 0.592, respectively). The PI had

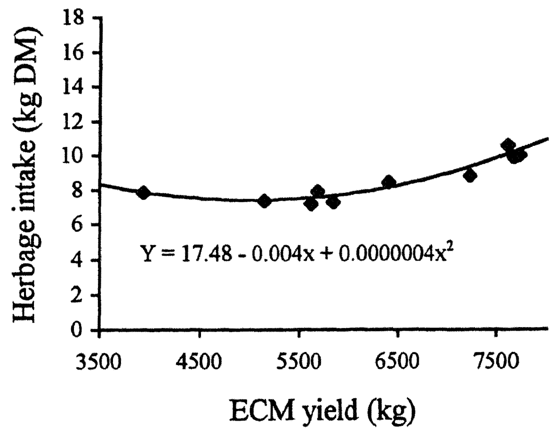


Figure 1: Relationship between average daily herbage intake and 305 day ECM yield in period 4

Abbildung 1: Beziehung zwischen durchschnittlicher täglicher Futteraufnahme und 305 Tage ECM Leistung in Periode 4

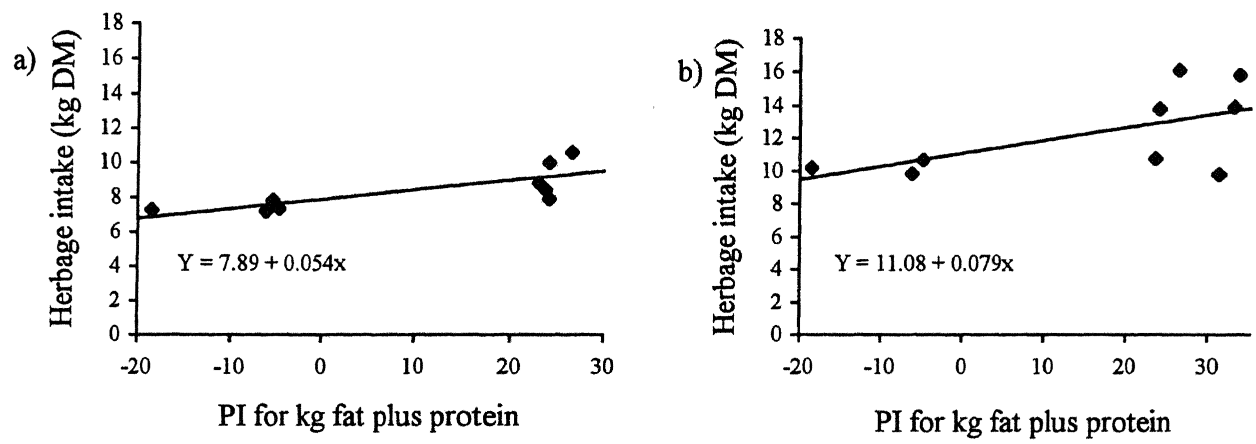


Figure 2: Relationship between average daily herbage intake and PI a) in period 4, b) in period 7

Abbildung 2: Beziehung zwischen durchschnittlicher täglicher Futteraufnahme und PI in a) Periode 4, b) Periode 7

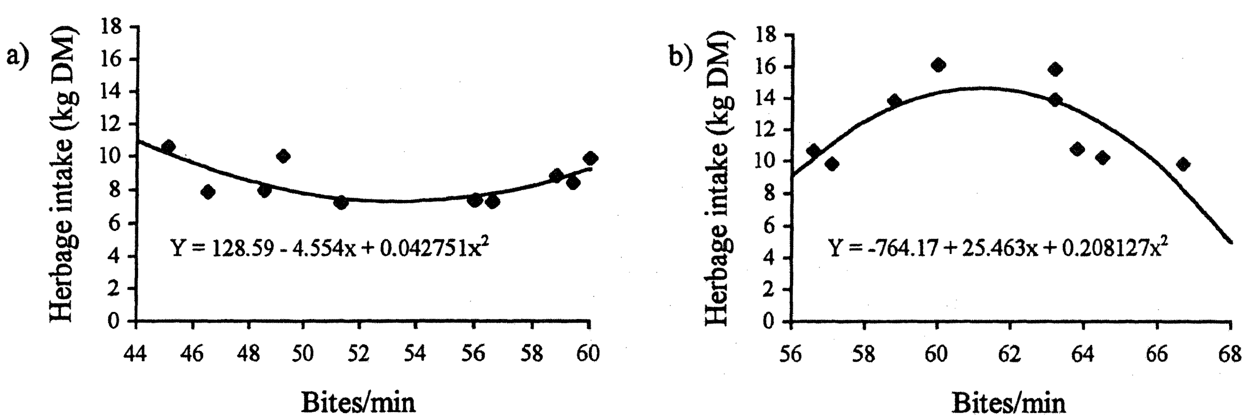


Figure 3: Relationship between average daily herbage intake and bite rate a) in period 4, b) in period 7

Abbildung 3: Beziehung zwischen durchschnittlicher täglicher Futteraufnahme und Bißrate in a) Periode 4, b) Periode 7 a positive linear influence on herbage intake in both years, 305 day ECM yield in heifers only. Different tendencies were found for bite rate – animals with medium bite rate showed the lowest intake in period 4, the highest in period 7.

## 4. Discussion

### 4.1 Behaviour

No significant effect of 305 day ECM yield or PI for kg fat plus protein was found on the duration of main activities in dairy heifers and first lactating or dry cows. In other studies when the relationship between milk yield and grazing behaviour was investigated mainly lactating cows were observed (e.g. BRUMBY, 1959; PHILLIPS and LEAVER, 1986; BAO et al., 1992). In the present study heifers before their first parturition and dry cows were also studied. This was done deliberately to examine whether the milk production potential apart from actual milk yield leads to a different behaviour at pasture. Results for the groups with high and low PI were not uniform, but there were some slight, not significant tendencies for groups differing in 305 day ECM yield. High yielders tended to graze longer from shortly before their first parturition and to spend less time lying. In a similar study by STAACK (1991), who observed dry animals of the same dairy herd in Langhill, animals of the selected line grazed for longer ($P < 0.10$) than those of the control line. Additional observations of lactating cows during winter supported the results found at pasture, but were significant for older cows only (STAACK, 1991).

From the observations of lactating cows (period 5) it can not be concluded that grazing behaviour is related to daily milk yield either. The absence of a significant relationship between grazing time and milk yield is in accordance with the works of PHILLIPS and LEAVER (1986) and PHILLIPS and HECHEIMI (1989). A possible explanation for the lack of difference between high and low yielders may be that high yielders were not prepared to graze much longer than low yielders (PHILLIPS and LEAVER, 1986). Where positive effects of milk production on grazing time have been reported (e.g. BRUMBY, 1959; LATHROP et al., 1988; BAO et al., 1992) magnitudes were also relatively small. This might suggest that there could be differences in grazing or metabolic efficiency between high and low yielders. PHILLIPS and HECHEIMI (1989) who only found longer rumination times for high yielders suggested that the longer time spent ruminating may have been an intrinsic reason for increased milk yield as ruminating could have increased the digestibility of the feed.

The stage of pregnancy had a stronger influence on grazing time than milk yield or genetic line. However, contrary results were found for heifers and cows. Heifers which were closer to parturition spent less time grazing and more time lying whereas lactating cows in late pregnancy spent more time grazing and less time lying. The results for heifers are in accordance with the study of VANZANT et al. (1991), who found that pregnant heifers spent less time grazing than non-pregnant heifers of the same age. An explanation for that could be the decreasing rumen capacity with advanced pregnancy (BURGSTALLER, 1986) which might be a limiting factor for heifers, leading to lower herbage intake and grazing time, but not for cows in their first lacatation. Hypothetically cows might differ because they will have a greater need to replenish diminished tissue reserves than heifers. However, it should be noted that other neural and hormonal controls beside physical restriction are in operation over food ingestion.

The period had a significant effect on the duration of main activities in the year 1992: as the season progressed time spent grazing increased, time spent lying and ruminating decreased. The increase of grazing time is in agreement with previous studies (e.g. PHILLIPS and LEAVER, 1986) and may be due to the fact that under declining forage availability animals spend more time grazing because they can obtain less per bite (ARNOLD and DUDZINSKY, 1978). Another explanation is that as nights get longer the remaining daylight is increasingly used for grazing. This idea is supported by the results of PHILLIPS and SCHOFIELD (1989) which indicate that cows prefer to feed in the light. The decrease of grazing time between periods 3 and 4 is probably related to the above mentioned fact of decreasing rumen capacity with advanced pregnancy since heifers were shortly before parturition in period 4. It should also be noted that weather conditions were poor in period 4: it was raining on 5 of 8 days of observation. This often caused heifers to stop grazing and to seek shelter, also leading to a distinct increase of time spent standing. In 1993 similar, but not significant trends could be observed as in 1992.

Correlations between duration of main activities during the day and at night were zero for time spent ruminating and positive, though not significant in all cases, for time spent grazing, lying and standing which indicates that behaviour at night was not in contrast with the behaviour observed during the day.

Feed intake is not only determined by grazing time but also by bite rate and bite size (HANCOCK, 1953; SPEDDING et al., 1966). Therefore one might postulate that if grazing time is equal animals with higher milk production would graze faster to obtain more feed in the same time. The results of the present study are in contrast to this expectation; no significant differences were found between the groups with high and low milk yield or with high and low PI, respectively. In the study of BAO et al. (1992) different results were found; high merit cows had greater bite rates than low merit cows. The fixed effect of day being included in model [1] in periods 4 and 7 had no significant effect on bite rate in either period which might suggest that bite rate is not affected by changing weather conditions as much as grazing time. In the study of BAO et al. (1992) no significant effect of day was found either. The increase of bite rate within the year 1993 (periods 5 to 7) may be explained by the inverse relationship between bite rate and herbage height (ZOBY and HOLMES, 1983).

### 4.2 Herbage intake

Heifers and cows of the selected line had significantly higher herbage intakes than animals of the control line ($P < 0.01$ and $P < 0.05$, repectively). Results for animals with high and low 305 day ECM yield were similar but significant for heifers only ($P < 0.01$). These results are in accordance with the view that animals with higher milk production level have higher feed intakes (KORVER, 1988; LÖBER et al., 1993). One reason for the clearer result on breeding value than on yield for dry cows might be that the 305 day ECM yield of the first lactation was used. Data of the second lactation, which could have lead to more distinct results, were not available for all animals. The most interesting, and novel, finding here, however, was that heifers with high PI for kg fat plus protein before their first lactation and in the dry period after it ate more DM than their lower PI contemporaries. The reasons for these differences are not clear. It would appear that they are not simply due to the groups being different in body weight or condition score. Analysis of the relationships between pedigree index, milk yield and dry matter in milking animals in the herd suggests that high PI animals mobilise more body tissue during lactation than their lower PI contemporaries (VEERKAMP et al., 1995). However, there does not appear to be a difference in fatness (as measured by body condition score) at the start of lactation, which might suggest that this additional tissue mobilisation is associated with a greater body fat mass at the start of lactation in high PI animals. While the extra DM intake observed in high PI animals here, before lactation starts, might be expected to lead to increased size or fatness, this does not seem to be consistent with other observations in the herd. The underlying reasons for, and consequences of, the extra DM intake of high PI animals during late pregnancy therefore remains to be established.

Regression analysis supported the former results but also showed that herbage intake was not related to grazing time either for heifers or for cows. The relationship between bite rate and feed intake was significant in both years but contrary and difficult to explain since it would have been expected that feed intake increases with increasing bite rate (e.g. ALLDEN and WHITTAKER, 1970). However, animals with medium bite rate had the highest herbage intakes as heifers, the lowest as cows. Feed intake by grazing animals is not only related to time spent grazing and number of bites per unit of time but also to the average size of each bite (SPEDDING et al., 1966). The lack of relationship between herbage intake and grazing time and the indifferent relationship between herbage intake and bite rate at the same time suggest that higher feed intakes were achieved by higher bite sizes.

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