Comparison of the feeding behaviour of primiparous and multiparous Jersey and Holstein cows kept under equal conditions throughout lactation

S. Gündel, L. Munksgaard, C. Looft and L. Foldager

Supplementary File

Supplementary Methods

Animals

A total of 334 cows (116 Danish Jersey and 218 Danish Holstein cows) housed in the same barn at the Danish Cattle Research Centre (Foulum, Denmark) were included in this study. Data were collected between 4 January, 2018 and 30 April, 2019. Because feed composition impacts the feeding behaviour of cows (Grant and Ferraretto 2018; Coons *et al.* 2019) and to keep environmental conditions as constant as possible, only data from cows fed the standard partially mixed ration (PMR) at the research facility were included in this analysis. Mean parity was 1.90 ± 1.16 for Holstein cows and 2.14 ± 1.32 for Jersey cows. For both breeds, parity ranged from one to eight lactations. The group composition was dynamic, with cows entering and leaving the experiment, depending on their expected calving dates. Cows that received veterinary treatment during lactation were not excluded from the study unless they were moved to a sick pen. Number of treatments per group was similar over the whole time period with 524, 546 and 437 for groups 1, 2 and 3, respectively. An ethical approval was not needed as the study was performed according to European and Danish laws and current guidelines for the ethical use of animals in research.

Feeding behaviour

All cows were allowed to feed on PMR ad libitum and were fed up to 3 kg of concentrate per day in the milking robot during milking. Silage and concentrate samples were collected every week. PMR samples were pooled over the course of the study to obtain the average. PMR was composed of an average of 6.51 ± 0.04 MJ /kg dry matter (DM), 26.81% corn silage, 28.67% grass–clover silage, 0.60%, horse beans, 6.87% barley, 0.50% spring barley straw, and 35.49% wheat and mineral mix. The concentrate contained an average of 18.2% crude protein and 10.2% crude fibre.

Time intervals between visits were calculated for each cow from the stop time of the previous visit and the start time of the subsequent visit. To determine if an interval was part of a meal, we used a simple approach to estimate a minimum interbout interval as the following. Time intervals measured in seconds were put in 1-min bins for the whole experimental period. Then, the average bin frequency was plotted against minutes. The x-axis was log-transformed to delineate the break point clearly for this curve and, consequently, the threshold for meals (i.e. minimum interbout interval). The minimum interbout interval criterion was set at the break point of 3 min, and time intervals shorter than this were deleted.

Data handling

To investigate the effect of breed and parity on feeding behaviour, a grand total of 69,398 feeding behaviour recordings were analysed utilising SAS 9.4 (SAS Institute Inc., Cary, NC, USA). The experimental unit was the individual cow with feeding behaviour records obtained from 218 individual Danish Holstein and 116 Danish Jersey cows consisting of a daily average of 108 and 57 cows, respectively. However, data from 15 Holstein cows (8 at first parity, 1 at second parity, 6 at higher parities) and 6 Jerseys cows (3 at first parity, 2 at second parity, 1 at a higher parity) were excluded from the analyses as less than 14 days of records were available within a parity. The cows were grouped according to breed and parity (first, second and later parity).

After visual inspection of the outcomes, data collected before day 15 after calving was not included in the analysis. To avoid decreasing numbers of animals, and to exclude any effects of special handling of cows at the end of pregnancy, any measurements exceeding 252 days from calving were omitted from the analysis. In addition, during a period of autumn of 2018, many cows were enrolled in other experiments. To retain reasonably high numbers of cows within days and similar levels across days, this led to the exclusion of 63 dates. After exclusions, data from 419 dates recorded from a total of 211 Holstein cows and 112 Jersey cows remained available for the analysis. Some cows were included from more than one parity. The total number of cows at first, second and later parities was 130, 79 and 83 for Holstein cows, respectively, and 68, 50 and 37 for Jersey cows, respectively.

Statistical analysis

The overall effects of breed and parity group, as well as their interaction, were analysed by linear mixed effects models using the MIXED procedure in SAS. Daily recordings of each variable and individual animal were averaged over lactation week. Week in lactation was included in the model as a covariate. These averages were then log-transformed (natural logarithm) to fulfil the assumption of normal distributed residuals. Based on Akaike's information criterion, first order autoregressive (**AR1**) residual covariance structure was chosen to account for correlation among repeated measurements from each cow within parity. The results are reported as least square means with 95% confidence intervals, both on the log-transformed and exponentially back-transformed scale. The confidence intervals and P values for differences were adjusted with the Tukey-Kramer method at a significance level of 5%, i.e., (adjusted) $P < 0.05$ was considered statistically significant.

Model 1 to analyse the effect of breed and parity on eating time per visit as well as eating rate was the following:

$$Y_{ijkl} = B_i + P_j + BP_{ij} + (\beta_{B_i} + \beta_{P_j})w_{ijkl} + \varepsilon_{ijkl}$$

Here, Y_{ijkl} is the natural logarithm of the response variable, B_i is Breed effect (i = Holstein, Jersey), P_j is the Parity effect (j = 1, 2, 3), BP_{ij} is the interaction effect of breed and parity, β_{B_i} is the breed-specific slope parameter for weeks in lactation, β_{P_j} is the parity-specific slope parameter for weeks in lactation, w_{ijkl} and $\varepsilon_{ijkl} \sim N(0, \sigma^2)$ are the random residuals where l index the repeated measures over weeks for cow $k = 1, \dots, n_{ij}$. The AR(1) covariance means that $cov(\varepsilon_{ijkl}, \varepsilon_{ijkm}) = \sigma^2 \rho^{|l-m|}$.

To analyse the effect of breed and parity on between meal intervals, model 1 was used although excluding the weeks in lactation covariate as it was not significant (P > 0.05).

To analyse the effect of breed and parity on eating time per day and number of visits per day, a second order polynomial was used for weeks in milk to better fit nonlinear changes during lactation. This resulted in the following model 2:

$$Y_{ijkl} = B_i + P_j + BP_{ij} + (\beta_{B_i} + \beta_{P_j})w_{ijkl} + (\gamma_{B_i} + \gamma_{P_j})w_{ijkl}^2 + \varepsilon_{ijkl}$$

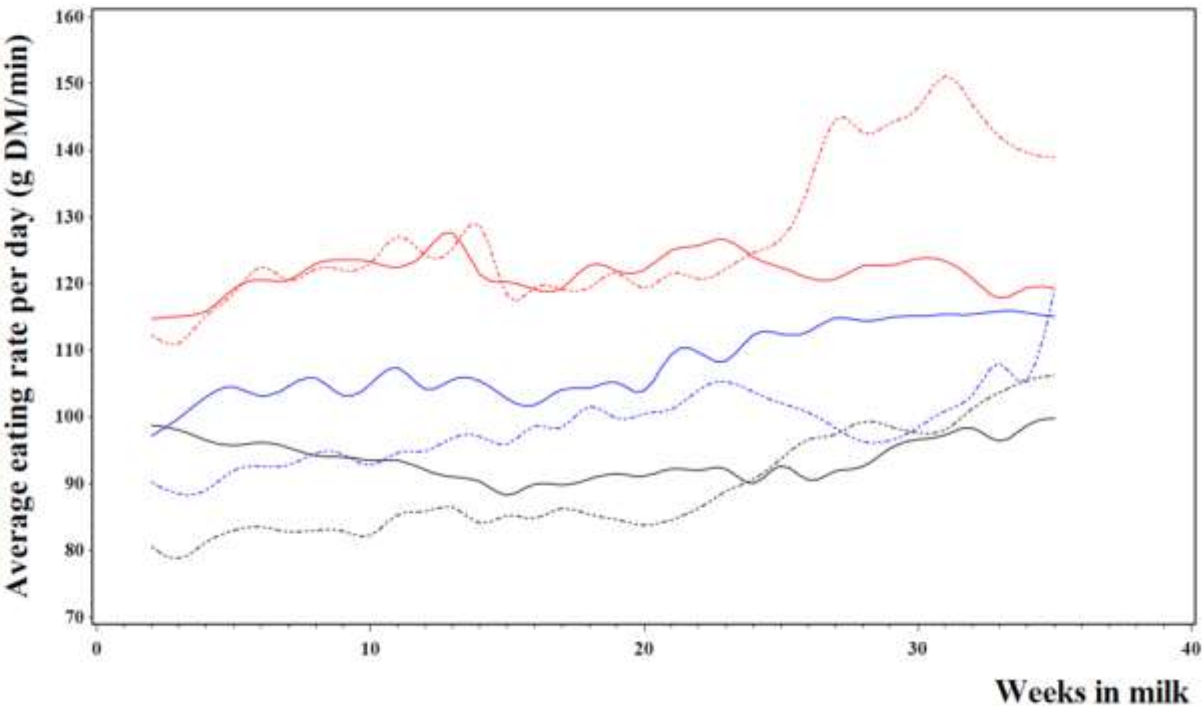
In addition to the parameters described for model 1, γ_{B_i} and γ_{P_j} are the breed- and parity-specific parameters for weeks in lactation squared, w_{ijkl}^2.

Supplemental Figures

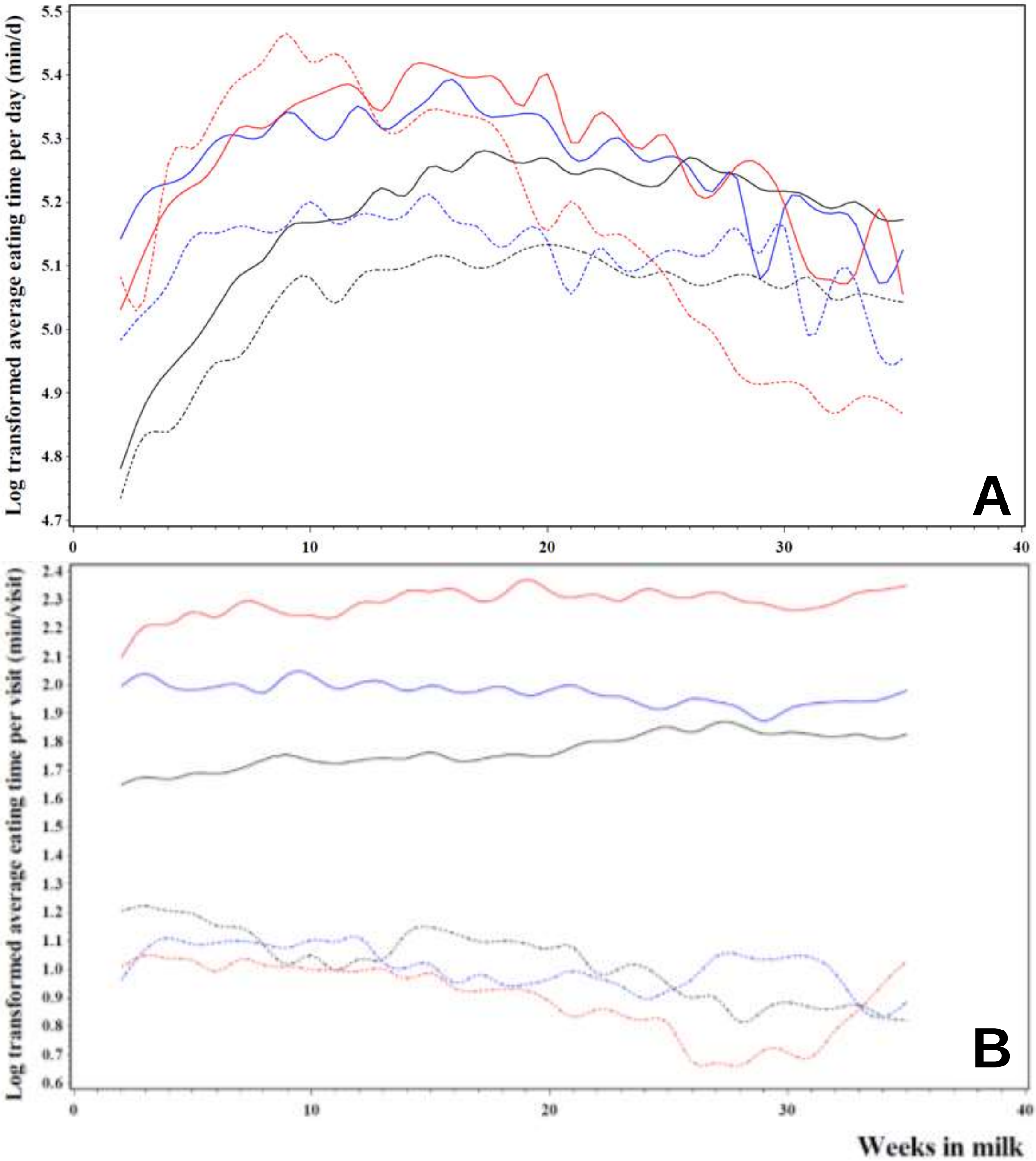
Supplemental Figure S1 Average eating rate vs. weeks in milk for Jersey and Holstein cows at each parity. Daily records were averaged for each week in milk and each animal, and smoothed lines were drawn through the scatter of points against weeks in milk.

Supplemental Figure S2 Average eating time per day (A) and average eating time per visit (B), vs. weeks in milk for Jersey and Holstein cows at each parity. Daily records were averaged for each week in milk and each animal. These averages were then log-transformed (natural logarithm), and smoothed lines were drawn through the scatter of points against weeks in milk.

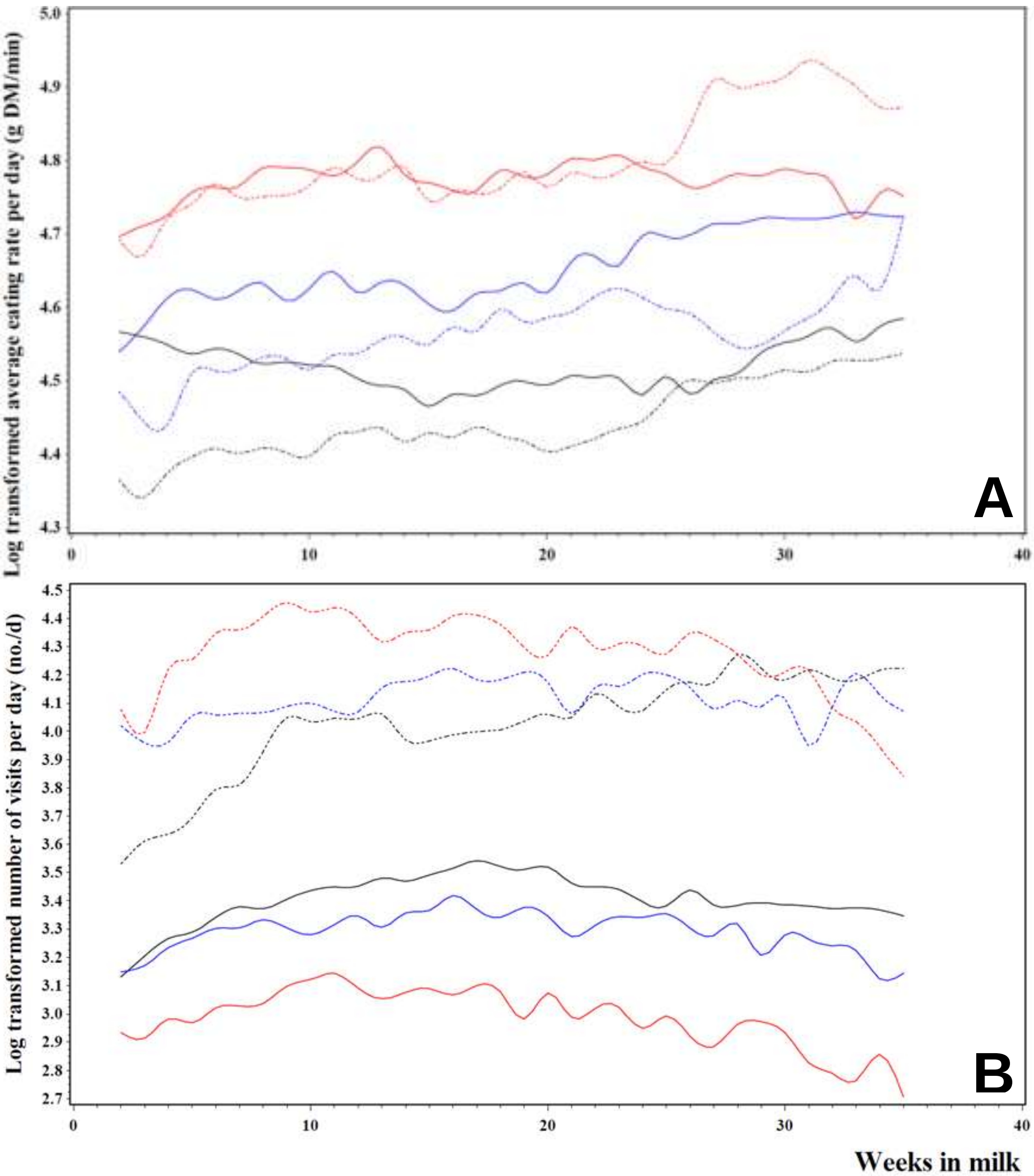
Supplemental Figure S3 Average eating rate (A) and average number of visits per day (B), vs. weeks in milk for Jersey and Holstein cows at each parity. Daily records were averaged for each week in milk and each animal. These averages were then log-transformed (natural logarithm), and smoothed lines were drawn through the scatter of points against weeks in milk.



Supplemental figure S1



Supplemental figure S2



Supplemental figure S3

Supplementary references

Coons, E. M., Fredin, S. M., Cotanch, K. W., Dann, H. M., Ballard, C. S., Brouillette, J. P., and Grant, R. J. (2019). "Influence of a novel bm3 corn silage hybrid with floury kernel genetics on lactational performance and feed efficiency of Holstein cows." *Journal of Dairy Science*, 102(11), 9814-9826.

Grant, R. J., and Ferraretto, L. F. (2018). "Silage review: Silage feeding management: Silage characteristics and dairy cow feeding behavior." *Journal of Dairy Science*, 101(5), 4111-4121.