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Variations in cow behaviour after regrouping in a conventional Swedish dairy herd

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A R T I C L E I N F O

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A B S T R A C T

A common management practice of commercial dairy farms is grouping cows according to their nutritional needs. Having different lactation groups also implies the regrouping of animals during their lactation period. Real-time locating systems based on ultra-wideband devices provide information about the cow's position inside barns. This information can be used to infer time budgets and animal locations on a continuous basis. The present study aimed to evaluate the behavioural changes that could be induced in dairy cows when regrouping between lactation groups by using location data obtained from real-time locating systems technology. This study is based on observational data from a commercial dairy farm, where 12 regrouping events, each involving between 3 and 15 cows, were recorded without any experimental intervention. The analyses included six months of data from two lactation groups with around 100 cows in each group. The effects of regrouping on time budgets and home range were analysed by comparing changes in regrouped cows before and after the process, and by comparing regrouped cows with their matched controls. The results showed that regrouping had a slight impact on the feeding and resting times of dairy cows. In contrast, parity was associated with opposing effects on feeding and resting times. Furthermore, regrouped cows tended to cover a larger area of the barn. The extent to which regrouped cows increased their use of barn space was also affected by the number of cows regrouped simultaneously. Our analysis of location data from a commercial dairy herd provides new insights into the impact of regrouping events on cow behaviour and welfare in commercial settings.

1. Introduction

Most commercial dairy farms manage to group cows based on their specific nutritional demands, usually only considering the lactation stage (Hu et al., 2023). Nutritionally homogeneous cow groups facilitate proper adjustment of feed ration composition, improving milk production performance and reducing nutrient excretion and carbon dioxide and methane emissions (Hu et al., 2023; St-Pierre and Thraen, 1999). Having different lactation groups also implies regrouping animals during their lactation period (Grant and Albright, 2001).

The effects of regrouping are variable and may promote physical agonistic interactions (e.g., displacements, threats, and butting) (Kondo et al., 1984; Raussi et al., 2005), disrupting their normal behavioural routines (von Keyserlingk et al., 2011), and reducing feeding and lying time, dry matter intake and milk production (Hasegawa et al., 1997; Kjæstad and Myren, 2001; von Keyserlingk et al., 2008). These studies were conducted by observation in small groups (the group size range 2–28 cows/group), where the cows were regrouped within free-stall barns or from tie-stall to free-stall groups. However, in larger groups on commercial dairy farms, constant regrouping may dilute the effects

Abbreviations: DIM, days in milk; edf, estimated degrees of freedom; G1, group 1; G2, group 2; GAMM, Generalized additive mixed models; HR, home range; PLF, precision livestock farming; RTLS, real-time locating systems; UWB, ultra-wideband.

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observed in smaller, experimental settings, making it necessary to use more than visual observations to detect changes.

Behavioural studies with direct human observations are time-consuming, thus often limited in duration and number of animals. The use of precision livestock farming (PLF) technologies that allow the continuous monitoring of a large number of animals could solve these limitations, providing continuous data that could help to better understand animal behaviour (Lovarelli et al., 2020). Real-time locating systems (RTLS) based on ultra-wideband (UWB) devices can provide information about the cow's position inside barns. This information can be used to infer activity patterns and animal behaviour on a continuous basis (Wagner et al., 2021). For example, a previous study implemented RTLS to study how time budgets of dairy cows change throughout the lactation cycle (Hut et al., 2022). However, animal regrouping effects studied on commercial farms is still a rather uncharted area of research especially for large group sizes (e.g., over 50 cows).

The aim of this study was to evaluate the behavioural changes that could be induced by regrouping events in dairy cows on a commercial farm. Differences in daily time budgets for three activities, such as feeding, standing-walking and resting, and the area covered after a regrouping event were investigated using RTLS information. The data from our commercial farm are purely observational, in the sense that regrouping was not experimentally designed; we accounted for this in our analysis by applying propensity score matching.

2. Materials and methods

2.1. Ethical considerations

The authors declare that, according to the Swedish animal welfare act, this type of study does not need to be submitted to an Animal Ethics Committee for ethical approval.

2.2. Animals and housing

The study used data from a commercial dairy farm in Sweden, previously described by Churakov et al. (2021). During the study period from October 2020 to March 2021, the farm had 280 milking cows (Holstein Friesian, Swedish Red, and crossbreds), with around 200 lactating cows being in the barn at the same time. Cows were housed in a non-insulated free-stall barn with a rectangular plan of 74 m x 33 m, which is divided in the middle to accommodate two lactation groups (Fig. 1). Lactating cows had access to 205 cubicles with mattresses, and fresh sawdust added manually twice daily. After calving, lactating cows are introduced to Group 1 (G1), where they stay until approximately 150 days in milk (DIM). Mid-lactation, cows are moved from G1 to Group 2 (G2) until they are dried off. Cows were milked twice daily (around 4:30 and 16:30) in a herringbone milking parlour, with G1 being milked first. Feeding tables were towards the outer walls, and feed (total mixed ration) was distributed with an automatic feeding system 12 times a day.

2.3. Data collection

All cows were equipped with a collar embedded with an active tag for the CowView positioning system (CowView, GEA Farm Technologies, Bönen, Germany) that had been installed and actively used for health surveillance, heat detection, and cow identification by the farmer for around ten years (Ren et al., 2021). The CowView system was a RTLS that recorded the position of each cow approximately every second through a triangulation (Sloth and Frederiksen, 2019) with an accuracy of about 78 cm (Hansson et al., 2023). It can monitor animal behaviour based on an individual's spatial coordinate through a zone-related virtual barn map (for example, being at the feeding table corresponds to feeding behaviour). Using the position information, the CowView system achieves a 95 % accuracy in detecting zone-related behavioural activities based on the floor plans of the barn (Tullo et al., 2016).

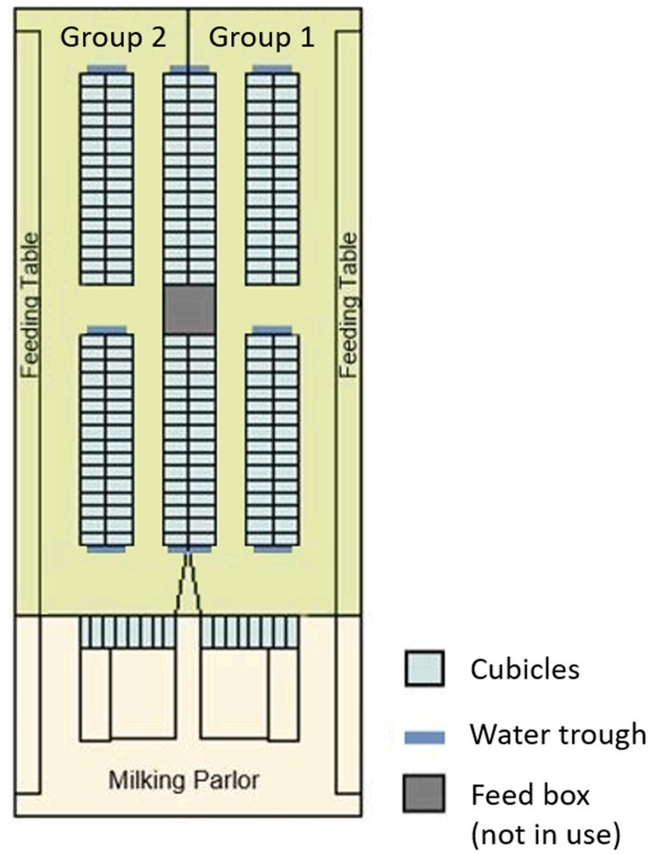

Fig. 1. Schematic map of the commercial Swedish farm, where cubicles (blue areas) are located in the middle of the barn and the feeding tables along the sides. The barn was divided into two different milking groups. The beige area was out of reach of the dairy cows, except for transport between the pen area and the milking parlour.

We extracted two datasets from September 2020 to April 2021 that were pre-processed through a chain of built-in data-processing modules in the CowView system (Sloth and Frederiksen, 2019). The first dataset (activity dataset) included the following information: cows' tag identification, position in the barn, activity (standing in the alleys, walking in the alleys, resting/being in a cubicle, and being at the feeding table) and distance moved. Each activity was logged with start and end times at one-second intervals, capturing its duration until the cow transitioned to a new behaviour. The second dataset (aggregated activity dataset) further aggregated activity in 10-minute intervals. This dataset contained tag identifications, start of the interval, activity type, distance moved, the number of times the activity appeared in the interval, and the total activity duration in seconds. For the aggregated activity dataset, we further summarised the data to a daily level by summing the durations of each activity (standing, walking, resting, and feeding). The activities 'standing' and 'walking' were combined into a single category, referred to as 'alleys', following Veissier et al. (2017). The activity 'resting/being in a cubicle' is hereafter referred to as 'resting'. Additionally, individual cow data such as parity, calving dates, and tag ID were provided by the farm.

2.4. Data pre-processing

As the tags were usually removed from cows at dry-off and re-used on other cows after calving, we first linked individual cow data such as cow ID and parity (categorized to 1, 2, and 3 +) to the CowView data by the lists provided by the farm. Then we calculated lactation group affiliation (G1 or G2) for each cow on each day, using the coordinates provided in the first dataset. To calculate group affiliation for G1, cows had to have x-coordinates that belonged to the feeding tables on the right side of the barn. Similarly, for G2, they had to have x-coordinates belonging to the feeding tables on the left side of the barn. Furthermore, we added a third group (group 0, G0) when cows had x-coordinates throughout the entire barn (i.e., for feeding tables on both the left and the right side) on the same day. This group was used to identify cows on the day they were regrouped.

Subsequently, we identified all cows that switched lactation groups from G1 to G2 at some point between October 2020 and March 2021. Cows were moved between lactation groups on 12 different dates in the study period (Table 1). In most cases, on the day they switch from G1 to G2, cows will belong to G0. In case of group affiliation switched directly from G1 to G2, in which case we decided on taking the first day in G2 as the 'regrouping day'. We then calculated the time difference between each cow's observation day and its regrouping day (negative/positive number of days before/after the regrouping day, 0 if the cow was in the same group throughout the whole study period) and marked all observations of cows that were within five days before or after their regrouping day as 'cases'. All other observations were marked as 'controls'.

To account for missing data in this dataset (due to, for example, system error or the individual cow being out of reach), we converted each activity duration into the proportion of time spent in the respective activity relative to the amount of data available on each day. The missing data patterns of positional information on this farm were previously evaluated by Ren et al. (2021), who reported an average data loss of 31.29 % (~7.5 h/day), with the most common scenario being a single second missing. Typically, missing data were dispersed throughout the day, with interruptions lasting less than five seconds and showing no bias toward specific individuals or areas. No RTLS outages were reported during the study period.

Because the activity dataset provided representative coordinates for each activity period, linear interpolation was used to generate estimated position data for each individual at one second intervals. This procedure was necessary to accurately estimate the barn areas where each animal was most likely to be located each day. As the area used by each individual had to be estimated over a specific period of time, we opted to calculate the area covered on a daily basis, using a 24-hour period from midnight to midnight. To maintain consistency in the analysis, the activity durations described above were also aggregated into daily values, hereafter referred to as dairy cows' time budgets.

Furthermore, since the cows were housed in a free-stall barn, an enclosed space with no access to external land, we implemented constraints for the external boundaries of both lactation groups (G1 and G2) in the analyses to estimate the area covered by each individual, following (Paterson, 2019). Implementing the boundaries corrects the overestimation bias of the unused side by setting the probability of the quadrats outside the boundaries to zero and re-estimating the quadrats lying on the internal land (Benhamou and Cornélis, 2010). In addition, Melzer et al., (2021) stressed the importance of extending the boundaries of the pen as tags may be found outside the pen area when a cow puts its head through the rails in the feeding area. Therefore, the boundaries of both lactation groups were extended by 50 cm in all directions.

2.5. Statistical analyses

All analyses were carried out in R (R Core Team, 2024), using the additional packages adehabitatHR (Calenge, 2006), MatchIt (Ho et al., 2011), mgcv (Wood, 2011), nlme (Pinheiro et al., 2022), sp (Pebesma and Bivand, 2005) and tidyverse (Wickham et al., 2019).

We fitted generalized additive mixed models (GAMMs) for the three time budgets: 'alleys', 'feeding', and 'resting', using data from all cows that switched from G1 to G2 during the study period (Eq. 1).

$$Y_{ijklm} = \mu + \beta_1 \ days\_to\_move_i + \beta_2 \ parity_j + \beta_3 \ regrouped_k + \beta_4 \ removed_l + b \ cow_m + \varepsilon_{ijklm} \quad (1)$$

$$b \sim N(0, \sigma^2_{cow}), \quad \varepsilon_{ijklm} \sim N(0, \sigma^2_e)$$

In Eq.1, for every observation i, the proportion of time spent in the given activity is given by Y_{ijklm}. The fixed effects included $days\_to\_move_i$ (the number of days before and after the regrouping event, ranging from −5–5), $parity_j$ ($j = 1, 2, \ldots, 6$), and $regrouped_k$ and $removed_l$, representing the number of individuals regrouped from G1 to G2, and the number that left G2, respectively, in each event (see Table 1). The variable $days\_to\_move_i$ was fitted as a non-linear dependent variable using thin plate regression splines, with the aim of detecting variations in activities in the days before and after the regrouping event. The variable cow_k was regarded as a random effect ($k = 1, 2, \ldots, 108$). The random effect (cow_k) and the residual error term (ε_{ijklm}) were both assumed to be normally distributed with mean zero and variances σ^2_{cow} and σ^2_e, respectively. A total of 108 cows with information on 122 different days (5 days before to 5 days after regrouping) were included in this analysis. The number of pen mates regrouped simultaneously, and the number of individuals removed from G2 were included in the model to estimate their impact on the response variables.

To compare activities from cows that just switched to G2 with those of cows not subjected to a regrouping event, we applied a propensity score matching method (Rosenbaum and Rubin, 1983). This method estimates the conditional probability of being a 'case' (regrouped cow) given observed covariates, using logistic regression. Hence, using the nearest neighbour matching method, each 'case' observation was matched to a 'control' observation (cows not subjected to a regrouping event at the time) based on parity and DIM, with exact matching on the date. The propensity score method was chosen to reduce potential selection bias by matching the cases with control cows that exhibited similar characteristics but were not subjected to a regrouping event. Propensity score matching is an effective way to achieve covariate balance between the case and control groups. Subsequently, we fitted GAMMs for the same response variables using the matched case-control data (Eq. 2).

$$Y_{ijkl} = \mu + \beta_1 \ case_i + \beta_2 \ parity_j + \beta_3 \ \mathrm{dim}_k + b \ pair_l + \varepsilon_{ijkl} \quad (2)$$

$$b \sim N\left(0, \sigma^2_{pair}\right), \quad \varepsilon_{ijkl} \sim N(0, \sigma^2_e)$$

In Eq. 2, the observations i ranged from one day to five days after the regrouping day. The variables Y_{ijkl} and $parity_j$ were as described above, while $case_i$ was a binary variable describing whether the observation belonged to a cow that was regrouped to G2 (case) or not (control), and dim_k represented the cow's days in milk on the respective days. The

Table 1
Number of cows moved from Group 1 to Group 2 on 12 regrouping days from October 2020 to March 2021, as well as the number of cows entering Group 1 and leaving Group 2 between regrouping days.

Regrouping day	Oct 13	Oct 23	Nov 03	Nov 16	Nov 26	Dec 04	Dec 16	Jan 08	Jan 19	Feb 03	Feb 19	Mar 15
G1→ G2	9	7	10	8	10	7	10	15	9	10	10	3
Entering G1	7	8	9	7	4	9	11	20	13	14	12	15
Leaving G2	16	5	7	6	6	6	10	14	12	7	10	13

variable $pair_l$, added as a random effect ($l = 1, 2, \ldots, 524$), indicated the case-control pair matched using the propensity score. The variable dim_k was fitted as a non-linear dependent variable using thin plate regression splines. The random effect ($pair_l$) and the residual error term (ε_{ijklm}) were both assumed to be normally distributed with mean zero and variances σ^2_{pair} and σ^2_e, respectively. A total of 135 cows with information from 59 different days were included in this second analysis (some cows were used as both a case and control at different points during the study period).

Furthermore, the activity data were used to estimate the home range, area traversed by an animal during its normal activities (Burt, 1943), for each dairy cow and date considered in this study using the kernel-based utilization distribution approach (Benhamou and Cornélis, 2010) implemented in the R package adehabitatHR (Calenge, 2006). The 50 % and 95 % home ranges were calculated to evaluate changes in space use by all cows, both 'cases' before and after regrouping, and 'controls', following Frondelius et al. (2022). Home range percentages correspond to the probability of locating the animal within the area (e.g., a 50 % home range corresponds to a probability of 0.5).

Finally, the surface areas of the estimated home ranges (m^2) were used as response variables in the GAMMs described above, rather than the time budget variables (Y_{ijklm} in Eq. 1 and Y_{ijkl} in Eq. 2), to compare the 50 % and 95 % home ranges before and after cows switched groups (Eq. 1), and to compare the home ranges of 'case' and 'control' cows (Eq. 2).

3. Results

Differences in the distribution of time budgets and home range variables by day relative to regrouping, and between case and control animals, are shown in Figure S1. An initial visual inspection of the data revealed no discernible pattern of behavioural changes in the cows. Means and standard deviations of the time budgets (alleys, feeding, and resting) and home ranges (50 % and 95 %) before and after regrouping are shown in Table 2, along with the estimated regression coefficients from the GAMMs in the regrouping scenario (Eq. 1). Table 3 presents the corresponding values for cases and controls, together with the estimated regression coefficients from the GAMMs in the propensity score scenario (Eq. 2).

3.1. Effects of regrouping events on dairy cows' time budgets

The predicted effects of *days_to_move* estimated in the regrouping scenario indicated a positive association with alleys and feeding time budgets, and a negative association with resting (Fig. 2). Furthermore, these results revealed a significant non-linear association between *days_to_move* (indicating the effect of regrouping) and both feeding and resting time budgets (Table 2). The models also showed a significant effect of parity on feeding and resting times (P-values < 0.01). For feeding time, regrouping led to an increase, while cows in higher parities exhibited decreased feeding time. This was the opposite for resting, where regrouping led to a decrease, while a higher parity led to an increase in resting time. For both activities, the estimated effect sizes of regrouping ranged between 1 % and 2 %, a small but non-negligible effect on these specific behaviours. The number of individuals entering or leaving a group simultaneously did not have a significant effect on the time budgets of the regrouped cows.

The propensity score scenario showed that regrouped cows (cases) had significantly higher feeding time budgets than control cows (Table 3). Additionally, the effect of parity in this scenario was significant for alleys and feeding (both negative; P-value < 0.05) and resting (positive; P-value < 0.001) time budgets, in line with the results obtained from the regrouping scenario. The predicted effects of DIM indicated a significant association with alleys and feeding time budgets (Fig. 3), revealing variability in these time budgets throughout lactation.

3.2. Effects of regrouping events on dairy cows' home ranges

The regrouping and propensity score scenarios revealed significant increases in the 95 % home range of regrouped cows, both when comparing their behaviour before and after the regrouping event (P-values < 0.001) and when comparing cases versus controls (P-values < 0.001). The regrouping scenario also revealed a significant positive effect of *days_to_move* on both the 50 % and 95 % home ranges (Table 2). Fig. 4 represents the increase in the 50 % and 95 % home ranges of an arbitrary cow, five days before and after regrouping. Parity did not show consistent effects across scenarios, providing no evidence of a statistical association with either home range measure. The number of cows regrouped simultaneously had a significant positive effect on both the 50 % and 95 % home range areas (P-values < 0.05; Table 2). In contrast, the number of individuals removed from G2 had a significant negative effect on both home range measures (P-values < 0.01). Finally, DIM revealed a significant positive effect on both the 50 % and 95 % home ranges throughout lactation (P-values < 0.001).

4. Discussion

In this study, we investigated changes in cows' time budgets and home ranges associated with regrouping in a commercial setting. We did this in two ways: first, by comparing cows shortly before and after regrouping, and second, by comparing cows after regrouping with similar cows that remained in the same lactation group during the regrouping event. Similar cows were chosen by propensity score matching. In contrast to the regrouping scenario, the exact match of the day in the propensity score scenario should be able to account for any unknown irregularities on the farm that may have occurred on specific

Table 2
Descriptive statistics and estimated regression coefficients for the regrouping scenario of time budget and home range variables. The regrouping scenario evaluated changes by comparing values before and after the regrouping event. The five-day period on either side of the regrouping (Days to move) was included in the model as a non-linear effect.

	Descriptive statistics		Parametric terms			Smooth term (Days to move)	
	Before	After	Parity	Animals regrouped	Animals leaving	edf	F-value
Alleys	0.26 (0.08)	0.27 (0.08)	−0.001 (0.004)$^{n.s.}$	0.004 (0.002)$^{n.s.}$	0.002 (0.002)$^{n.s.}$	1.000	1.942 $^{n.s.}$
Feeding	0.22 (0.05)	0.22 (0.04)	−0.012 (0.002)***	−0.000 (0.001)$^{n.s.}$	0.000 (0.001)$^{n.s.}$	2.424	6.429***
Resting	0.51 (0.09)	0.51 (0.09)	0.013 (0.004)**	−0.004 (0.003)$^{n.s.}$	0.001 (0.002)$^{n.s.}$	2.039	5.564**
Home range 50 % (m^2)	64.67 (30.05)	71.77 (31.37)	−0.458 (1.396)$^{n.s.}$	1.895 (0.845)*	−1.784 (0.607)**	1.000	20.948***
Home range 95 % (m^2)	365.89 (128.60)	417.13 (127.99)	−3.687 (6.096)$^{n.s.}$	9.891 (3.688)**	−8.706 (2.649)**	3.752	19.151***

Alleys, Feeding, and Resting represent the average of the daily time budgets for standing/walking, feeding, and resting activities, respectively. Home range variables represent the average area within which an animal is expected to be located with a given probability (50 % or 95 %). Parametric terms indicate the estimated regression coefficients of the fixed effects included in the model. The estimated degrees of freedom (edf) reflect the complexity of the smooth term (i.e. Days to move); values greater than one suggest a non-linear relationship. Values in brackets indicate standard deviations for descriptive statistics (left) and standard errors for estimated regression coefficients (right). Statistical significance is indicated as follows: *** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$, and 'n.s.' denotes non-significant results.

Table 3
Descriptive statistics and estimated regression coefficients for the propensity score scenario of time budget and home range variables. The propensity score scenario evaluated changes in activity time proportions and home range variables by comparing regrouped cows (cases) with cows not subjected to a regrouping event at the time (controls). Days in milk was included in the model as a non-linear effect.

	Descriptive statistics		Parametric terms		Smooth term (Days in milk)	
	Control	Case	Parity	Case	edf	F-value
Alleys	0.27 (0.08)	0.27 (0.08)	−0.005 (0.002)*	−0.005 (0.005)$^{n.s.}$	4.794	2.805*
Feeding	0.22 (0.05)	0.22 (0.04)	−0.008 (0.001)***	0.005 (0.003)*	3.121	3.377*
Resting	0.51 (0.10)	0.51 (0.09)	0.012 (0.002)***	0.000 (0.005)$^{n.s.}$	1.000	0.048 $^{n.s.}$
Home range 50 % (m^2)	68.90 (35.20)	72.18 (31.36)	−1.389 (0.806)$^{n.s.}$	2.579 (1.925)$^{n.s.}$	2.950	9.439***
Home range 95 % (m^2)	369.56 (132.16)	419.41 (127.70)	−11.886 (3.144)***	47.366 (7.728)***	3.371	12.139***

Alleys, Feeding, and Resting represent the average of the daily time budgets for standing/walking, feeding, and resting activities, respectively. Home range variables represent the average area within which an animal is expected to be located with a given probability (50 % or 95 %). The estimated degrees of freedom (edf) reflect the complexity of the smooth term (i.e. Days in milk); values greater than one suggest a non-linear relationship. Values in brackets denote standard deviations for descriptive statistics (left) and standard errors for estimated regression coefficients (right). Statistical significance is indicated as follows: *** for $p < 0.001$, ** for $p < 0.01$, * for $p < 0.05$, and 'n.s.' denotes non-significant results.

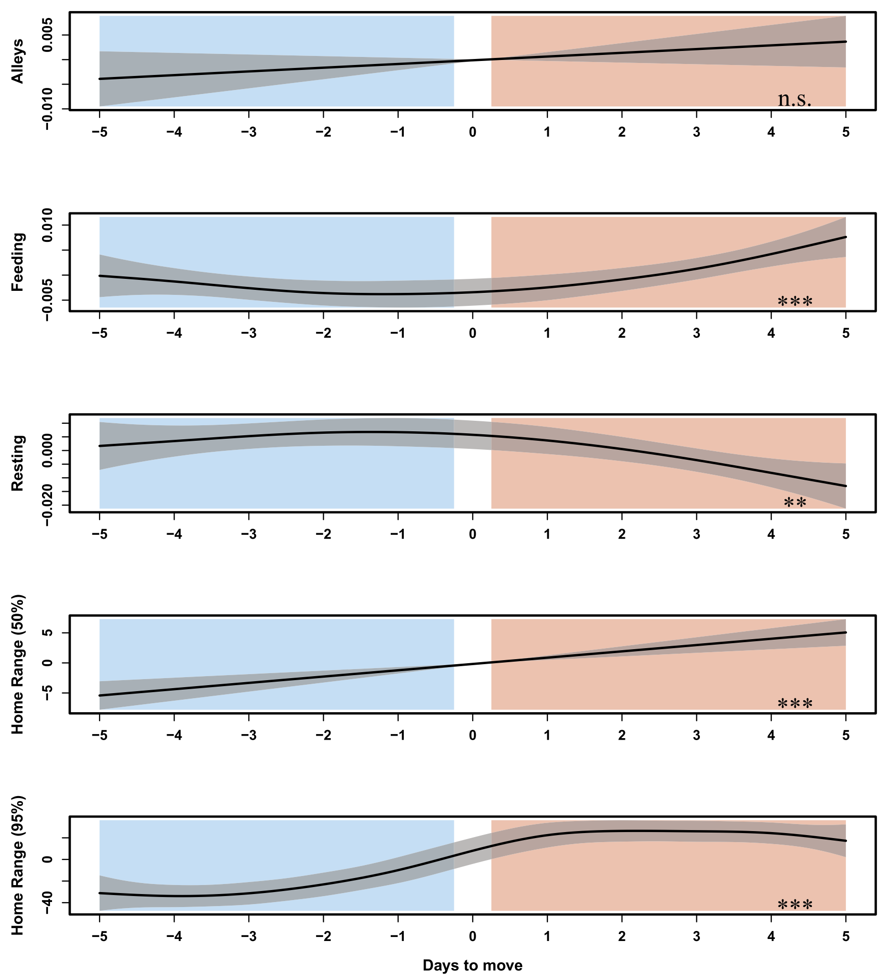

Fig. 2. Fitted effects of *days_to_move* on time budget and home range variables. Statistical significance is denoted by asterisks: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, and 'n.s.' indicates non-significant results.

days. Matching on parity and DIM ensures that parity and lactation stage distributions are similar for cases and controls and thus do not skew the outcome for the case variable. Although control cows could also have been indirectly affected by regrouping events, as changes in group composition affect animal behaviour, this effect was considered relatively limited due to the large group size (~100 cows) and the routine nature of regrouping in commercial dairy farms.

Previous studies have shown that regrouping disrupts a cow's normal behavioural routines and time budgets; however, most of these studies have been carried out in research settings with smaller group sizes (Gygax et al., 2009; Kjæstad and Myren, 2001; Soonberg et al., 2021; von Keyserlingk et al., 2011). Our study used RTLS data from a commercial Swedish dairy farm with group sizes of about 100 cows. The results revealed significant but marginal differences in feeding and resting time budgets for individual cows before and after a regrouping event. This finding is consistent with our hypothesis that constant regrouping in larger groups on dairy farms may dilute the effect of these events on time budgets. The frequent regrouping events typical of commercial settings may lead animals to become accustomed to these changes and familiar with all herd members, reducing the impact of

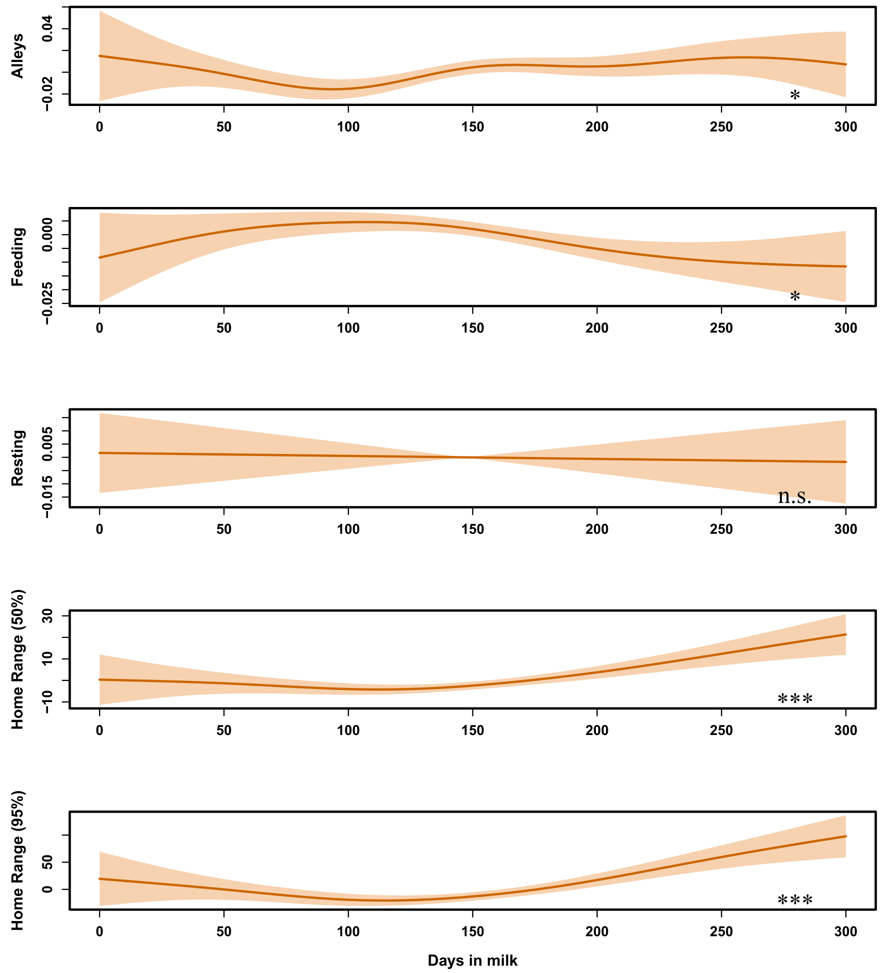

Fig. 3. Fitted effects of *days in milk* on time budget and home range variables. Statistical significance is denoted by asterisks: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, and 'n.s.' indicates non-significant results.

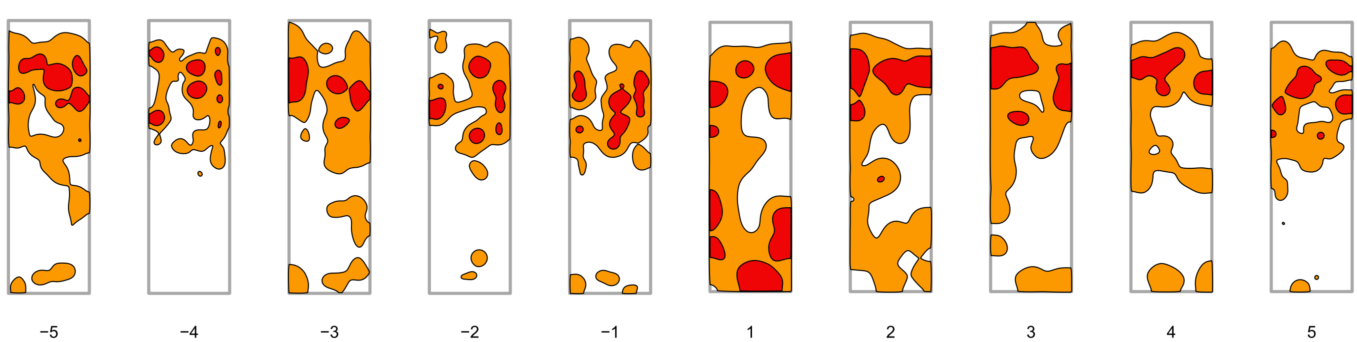

Fig. 4. Representations of the 50 % (red) and 95 % (orange) home ranges of an arbitrary individual, five days before and five days after regrouping.

regrouping on their daily time budgets. Additionally, the observed effects of the number of individuals regrouped at each event on cows' area coverage could indicate that group size may influence the behavioural response, with smaller groups potentially having more pronounced effects than larger groups. However, it could also be that the commercial setting with large groups already introduced an amount of stress to the animals, so regrouping does not lead to a significant difference. On top of that, using RTLS data is different to using more detailed observed behavioural data, so information could have been lost due to study design. Moreover, our results showed that parity had a significant effect on feeding (decreased) and resting time (increased), which agrees with previous studies (Azizi et al., 2010; Løvendahl and Munksgaard, 2016; Solano et al., 2016; Stone et al., 2017). The estimated effects of parity with those of regrouping events on feeding and resting time budgets, suggesting that higher-parity cows might be less sensitive to regrouping than their lower-parity counterparts. Our results also indicated that DIM was associated with alleys and feeding time budgets, as well as with cows' area coverage, suggesting that these behavioural variables are influenced not only by parity but also by the animals' physiological demands throughout lactation.

The biggest difference in behaviour before and after regrouping, we found in our study, was concerning home ranges. In both groups, cows had access to an area of about the same square meters. However, the home range of a cow (area covered in the barn) increased significantly after a regrouping event, and was also significantly larger than the home range of a control animal. This implies that the cow moves more in the new area, possibly exploring the unfamiliar environment and/or competing for resources with new group members. Kondo et al. (1984) described that the mean area occupied by the animals after regrouping decreased in the first week, which would fit with this explanation. Furthermore, the home ranges of the cows were influenced by the number of individuals regrouped simultaneously. Our results indicated that regrouping a larger number of familiar cows simultaneously, ranging from 3 to 15 across the different events, increased the area occupied by these animals. This may reflect enhanced area exploration, possibly facilitated by the presence of familiar peers. Conversely, the number of individuals leaving G2 was negatively associated with home range size. Taken together, these findings may reflect fluctuations in the availability of lying cubicles, which alter the pressure to find available resting spaces when stock density changes. The latter hypothesis is consistent with previous studies, which have shown that the number of lying bouts increases after regrouping events (Schirmann et al., 2011), which could help to explain the significant increase observed in the area covered by this study. Moreover, increased area exploration after regrouping may elevate the risk of disease transmission involving environmental pathogens within dairy herds.

5. Conclusions

Our study leveraged data from a real-time locating system to estimate the impact of regrouping events on cows' time budgets and home ranges in a commercial dairy herd. In commercial farms, where cows are frequently moved between groups according to lactation stage, the effects of regrouping on cows' time budgets appear to be limited. Nevertheless, regrouped cows occupied significantly larger areas following a regrouping event, likely reflecting the need to explore their new surroundings. For both the cows' time budgets and home ranges, parity showed an opposite effect to the regrouping event. Furthermore, the number of cows regrouped simultaneously and that were removed from the destination group also influenced the extent of area covered by the regrouped cows.

CRediT authorship contribution statement

Maya Gussmann: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Hector Marina:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation. **Keni Ren:** Writing – review & editing, Supervision, Resources, Investigation. **Lars Rönnegård:** Writing – review & editing, Validation, Supervision, Software, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Per Peetz Nielsen:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.applanim.2025.106790.

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