

Brief Report

Comparison of Activity Levels Around Disbudding Between Individually and Pair-Housed Dairy Calves

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Abstract: Use of pair housing for preweaning calves has shown positive benefits in terms of health and production, with it also being thought to offer social support in times of stress such as when calves are disbudded. Calf disbudding through thermal cautery is a common procedure, with recognized physiological and behavioral implications. This study's objective was to utilize continuous monitoring accelerometers to compare the impact of disbudding on the behavior of pair and individually housed calves. Data from an all-year-round dairy herd in the southwest of England were collected via an accelerometer (ABS breeder tag, Genus, Cheshire, UK) fitted to a forelimb of a convenience subset of calves ($n = 265$) within two weeks of age. Data were collected between March and December 2020 and covered the period 7 days prior to disbudding until 30 days post disbudding. Calves underwent thermal cautery disbudding by farm staff using local anesthesia and a systemic nonsteroidal anti-inflammatory drug. Data from 205 calves (125 pair-housed and 80 individually housed) were included in analysis through generalized estimating equations models. The calf activity ($p = 0.98$), number of lying bouts ($p = 0.40$), and lying time per day ($p = 0.75$) were not associated with the housing treatment of the calves. Calf activity was associated with the day compared to disbudding ($p < 0.001$), with both housing treatments having decreased activity in the days following disbudding, taking approximately 14 days to return to pretreatment levels.

Keywords: behavior; housing; disbudding

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1. Introduction

The routine husbandry procedure of calf disbudding is carried out by removal of horn buds prior to their attachment to the skull and connection with the frontal sinus [1]. Approximately 72% of EU farmers use thermal cautery methods to disbud [2], with this method destroying the epidermal and dermal skin layers that contain the horn germinal cells [3]. This results in third-degree burns at the horn site, along with second-degree burns in the surrounding tissue [3]. The other main disbudding method used in calves is caustic paste, but this has demonstrated increased wound sensitivity and longer healing times [4]. Disbudding should be conducted under local anesthetic with a bilateral cornual nerve block to desensitize the bud [5] for short-term pain relief [6], combined with a systemic nonsteroidal anti-inflammatory drug (NSAID) to give a longer duration of analgesia [7–9]. Disbudding causes somatic pain, which can be expressed behaviorally by ear flicking and head shaking [7]. Work by [10,11] showed that behavioral changes due to pain are still present at both 11 days and 21 days following cauterization of horn bud tissue, with healing of these wounds by re-epithelialization taking from 6 to 13 weeks, throughout which the wound is still painful to mechanical stimulation [12–14].

Noninvasive monitoring of pain and discomfort in calves can be achieved through assessment of behavioral changes [15]. There can be altered daily lying times due to calves adopting immobile stances in an attempt to minimize pain by reducing stimulation of hyperalgesic tissue, which can also assist healing [16]. There can also be changes to locomotor activity with increased restlessness, which may be a result of animals attempting to escape pain [16], or more time spent inactive, which includes sleeping [10].

There has been much research on the impact of pair and individual housing on productivity parameters. Most studies have shown pair-housed calves may have similar [17–19] or lower [20] disease levels than individually housed calves. Pair housing may also increase solid feed intakes [21–23] and result in similar or improved weight gains [24,25]. As calves age, they naturally spend more time with each other, with the level of socialization increasing rapidly until six weeks of age [26]. Limiting their social contact through individual housing can alter their ability to deal with stress and stressful situations. Socially isolated calves have higher mean serum cortisol levels following short-term stressors [27], thought to be due to altered adrenocorticotrophic hormone responses induced by the chronic stress in isolation [28,29]. Pair housing can lower calf stress [30], with social relationships developing within three weeks of being housed together [31], and the presence of another calf during stressful situations is reported to have a calming effect on behavioral responses. Nogues et al. [32] found no effect of social buffering on the recovery of calves from painful experiences, but calves that have visual contact with a peer only had a moderated fear response in a novel environment [33], and those kept with familiar calves had a reduced heart rate when undergoing stress tests [34]. Bučková et al. [35] assessed of housing type on disbudding behavior and found that the only significant behavior change between the housing treatments was that pair-housed calves had increased forage intakes, which was thought to demonstrate improved recovery following disbudding. However, this study did not provide any NSAID treatment, and the behaviors were recorded by direct observation rather than through use of accelerometer devices.

Given the reported effects of social support, this study investigated whether pair compared to individual housing would alter behavioral changes associated with disbudding, which was assessed using accelerometer continuous monitoring before and after the procedure. We hypothesized that pair-housed calves would be more active and have fewer lying bouts than the individually housed calves.

2. Materials and Methods

This paper utilized data that were collected as part of a larger study [20]. Data were collected on a single commercial dairy farm in the southwest of England between March and December 2020. The herd milked 1800 Holstein dairy cows in an all-year-round calving pattern, averaging 11,936 kg of milk per cow for a standardized 305-day lactation.

Only Holstein heifer calves were recruited for this study. Calves were born between March and July 2020 in individual straw maternity pens. Following birth all calves (regardless of body weight) received two 3 L feeds of maternal colostrum given 8–10 h apart on the day of birth, before being transported in a trailer to the calf rearing unit approximately 2 miles away. On arrival at one day of age, calves were systematically alternately allocated to either individual or pair housing, in which they stayed until weaning. All pair-housed calves were born within one day of each other. The pens were located within A-frame sheds measuring 32m X 11m and were formed from prefabricated plastic dividers (Calf-Tel Pen system, Hampel Corp, Germantown, WI, USA). Internal dimensions were 122 cm × 213 cm for an individual pen and twice this for a pair pen. Calves were fed according to pre-existing farm protocols of 6L of milk replacer per day in two feeds (24% whey protein, 20% fat, made by Nukamel, Holland, and mixed at 15%). This milk was fed manually in the morning and

afternoon through individual teat buckets. Calves also received ad libitum starter pellets (18% crude protein, 4% fats, and 12% crude fiber, made by ForFarmers, Bury St Edmonds, UK) per day and had ad libitum water access. Wheat straw bedding was replenished daily, with additional total mixed ration (TMR) offered to them in a bucket from 4 weeks of age. Calves were step-weaned off milk by reducing milk in week 7 from 6 L to 2 L and moving to once daily feeding of 2 L in week 8. Following weaning, calves moved out of their preweaning housing at approximately 9 weeks of age.

Automatic data logger accelerometers (ABS breeder tag, Genus, Cheshire, UK) were fitted to a forelimb of a convenience subset of calves ($n = 265$) within two weeks of age. These data loggers measured the lying/standing time and activity levels of calves. The calf activity was calculated using an algorithm, which took into consideration the calf's amount and intensity of movement and did not have a unit of measure. Further details on the algorithm were not available from the manufacturer. Data from the tags were synchronized with the farm management software, which was downloaded by the researcher for analysis.

Calves were disbudded at around five weeks of age in batches of approximately 20–30 calves at a time. Disbudding was performed by three different farm staff members across the study period, who had received training from the local veterinary practice as part of their normal farm management skills. Disbudding was conducted via thermal cautery using the following protocol: approximately 20 min prior to disbudding, calves were manually caught and restrained within their pen and received a cornual nerve block using 2 mL of local anesthetic per horn bud (40 mg/mL procaine hydrochloride, Pronestestic, Fatro, Italy) and a systemic subcutaneous nonsteroidal anti-inflammatory drug (20 mg/mL meloxicam given at 0.5 mg/kg, Metacam, Boehringer-Ingelheim, Germany). Once all calves to be disbudded in the batch had been injected, the calves were then recaptured and disbudded using a handheld gas disbudding iron (Alios express gas dehorner) using a mix of butane and propane gas. The calves were manually restrained by one person and disbudded by another person. The buds were cauterized circumferentially (around the base of the bud) and the buds flicked out. A topical oxytetracycline spray was applied following disbudding (Engemycin spray 25 mg/mL). No additional anesthesia was provided to the calves.

Analysis

All data were stored in Excel (Microsoft Office; Microsoft, Redmond, WA, USA). All analyses were performed using SPSS (Version 30.0, IBM SPSS Statistics for Windows, Armonk, NY). Significance was declared at $p \leq 0.05$.

Data were cleaned to remove accelerometer files that had a lying counter of 0 or an activity counter of 0. These null values would not be found in live animals and so were considered to be erroneous data that were likely to have occurred due to problems in wireless accelerometer synchronization with the farm router system, meaning data were not uploaded but awarded a value of 0. The occurrence of null values was distributed across the whole study period and across both calf housing types. Initially, 265 calves were recruited, with 146 calves in pair housing and 119 calves in individual housing. Following cleaning and removal of 60 data files, a total of 205 calves' data were used in the study, with 125 calves from pair calf housing and 80 calves from individual calf housing. Due to the repeated measures of the calves, there were 7482 cases included in each model analysis.

The day of disbudding was set to Day 0, and data from 7 days prior to disbudding up to 30 days following disbudding were collected continuously. The activity, lying bout number, and lying times per day of calves were assessed using generalized estimating equations (GEE) with pen included to take account of clustered measures within a pair of calves. A gamma log link function was used to improve model fit (which was assessed via

quasi likelihood under independence model criterion (QIC) values). An AR1 structure was used to take into account repeated measures from the same calf. The covariates included were the age at disbudding, the day compared to when disbudding occurred, and the housing type (pair or individual). Interaction terms between the calf housing type and the age at disbudding as well as the day compared to when disbudding occurred were also included.

3. Results and Discussion

This study used data from continuous monitoring accelerometers placed on 125 pair-housed and 80 individually housed calves to compare the impact of disbudding on behavior. The mean age that calves were disbudded in this study was 34 days old (range 10 to 61 days). The results of the models are summarized in Table 1.

Table 1. Parameter estimates for the associations between the different calf behaviors as measured by the accelerometers from generalized estimating equation linear models with gamma log link function.

Dependent Variable	Independent Variable	Parameter Estimate (SE)	p-Value
Activity level	Housing type	0.002 (0.13)	0.98
	Age at disbudding	0.002 (0.002)	0.54
	Days compared to disbudding	0.008 (0.002)	<0.001 **
	Interaction between housing type and age at disbudding	−0.002 (0.002)	0.56
	Interaction between housing type and days compared to disbudding	0.002 (0.002)	0.46
Lying bouts	Housing type	−0.083 (0.099)	0.40
	Age at disbudding	−0.003 (0.002)	0.69
	Days compared to disbudding	−0.001 (0.001)	0.96
	Interaction between housing type and age at disbudding	0.005 (0.003)	0.09
	Interaction between housing type and days compared to disbudding	0.002 (0.002)	0.19
Lying times	Housing type	0.008 (0.025)	0.75
	Age at disbudding	−0.001 (0.0005)	0.015 *
	Days compared to disbudding	−0.001 (0.0004)	0.21
	Interaction between housing type and age at disbudding	−0.001 (0.0007)	0.89
	Interaction between housing type and days compared to disbudding	−0.001 (0.0005)	0.24

* Indicates significance $p < 0.05$, ** indicates significance $p < 0.001$.

3.1. Calf Activity

The GEE model to assess the associations with calf activity had a QIC value of 1178.4, with residuals having a normal distribution (see Supplementary Materials Figure S1), indicating a good fit of the model.

The mean overall level of activity of the calves was 47.4 (range 2–192, with means of 43.7 prior to disbudding and 48.1 following disbudding). Comparisons to other publications on calf activity levels are difficult due to differing algorithm usage between technology types. However, these data show a general increase in activity level as the calves aged (Figure 1), which may be linked to increased time spent eating solid feed as calves develop [36] or development of more social behaviors such as play.

The GEE model found no association of activity with the housing treatment of the calves ($p = 0.98$) or the age at disbudding ($p = 0.54$), Table 1. This agrees with [35], who found no difference in exploratory-type behavior between the housing treatments. Although not tested statistically, in the week prior to disbudding occurring, it can be visually

seen that pair-housed calves had greater activity than the individually housed calves (46.6 compared to 39.5). This was also found in a study by the same authors (although using different accelerometers), which compared activity between calves in individual and pair housing [20]. This higher initial activity in pair housed calves resulted in a greater relative decrease in activity following disbudding compared to individually housed calves.

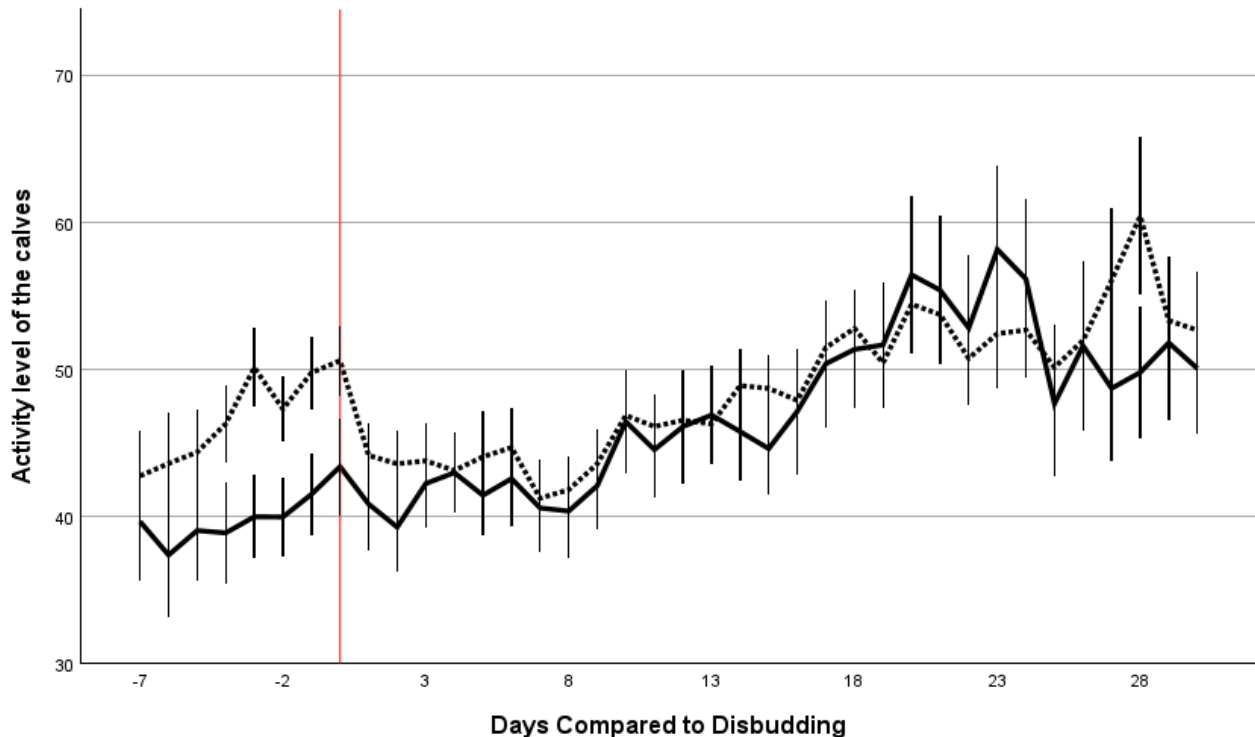


Figure 1. Calf activity levels compared to the day relative to when disbudding occurred, with 95% confidence intervals shown. The red vertical line represents the day at which disbudding occurred. The solid line represents individually housed calves, and the dashed line represents pair-housed calves. $n = 125$ calves from pair calf housing and 80 calves from individual calf housing.

The GEE model demonstrated a significant association with the calf's activity by day of disbudding ($p < 0.001$). Immediately following disbudding, the activity level of the calves decreased, likely due to the severe acute tissue reaction at the disbudding site, consisting of neutrophilic infiltration [37], followed by prolonged oedema around the burn site, which is painful and causes delays to the wound healing process [38]. This may have resulted in the calves having decreased motivation to explore their environment, causing reduced environmental interactions and activity [39]. Cautery disbudding is also known to cause calf stress that lasts 6–24 h even when local anesthetic and NSAIDs are given [8]. When comparing the pre-disbudding to the post-disbudding activity level in Figure 1, it can be seen that it took approximately 14 days for activity to return to pre-disbudding levels. This is less than the three weeks found by [10], who used ear-mounted accelerometers, although that study disbudded calves at a younger age, housed all the calves individually, and used a control group of non-disbudded calves for comparison. Use of NSAIDs such as meloxicam has been shown to help reduce changes in lying activity induced by disbudding for up to 5 days following the procedure [40]. Given activity levels in this study did not return to the pre-disbudding levels for 10–14 days after the procedure, the authors suggest that the use of additional analgesia in the post-disbudding period could be beneficial, with oral NSAIDs offering one method of delivering this [41].

3.2. Calf Lying Bouts

The GEE model had a QIC value of 1099.8, with residuals having a normal distribution (see Supplementary Materials Figure S2), indicating a good fit of the model.

The overall mean number of lying bouts per day of the calves was 28.3 (range 2–115), Figure 2. The GEE model demonstrated no significant change in overall number of lying bouts by day of disbudding ($p = 0.96$), age of calves ($p = 0.69$), or the housing treatment of the calves ($p = 0.40$), Table 1. Lying bouts indicate changes in body position, with increases associated with restlessness, stress, pain, and discomfort [42], which is also seen in adult cattle [43,44]. In contrast to our findings, a study by [41] found that lying bouts decreased, although that study utilized Jersey calves that were given a higher dose of local anesthetic than the calves in this study, which may have contributed to differing behavior patterns. Reduced lying bouts were also found in a study by [45], who demonstrated that calves disbudded without the NSAID flunixin meglumine had reduced lying bout numbers, suggesting that discomfort may have led to reduced lying bout number [7].

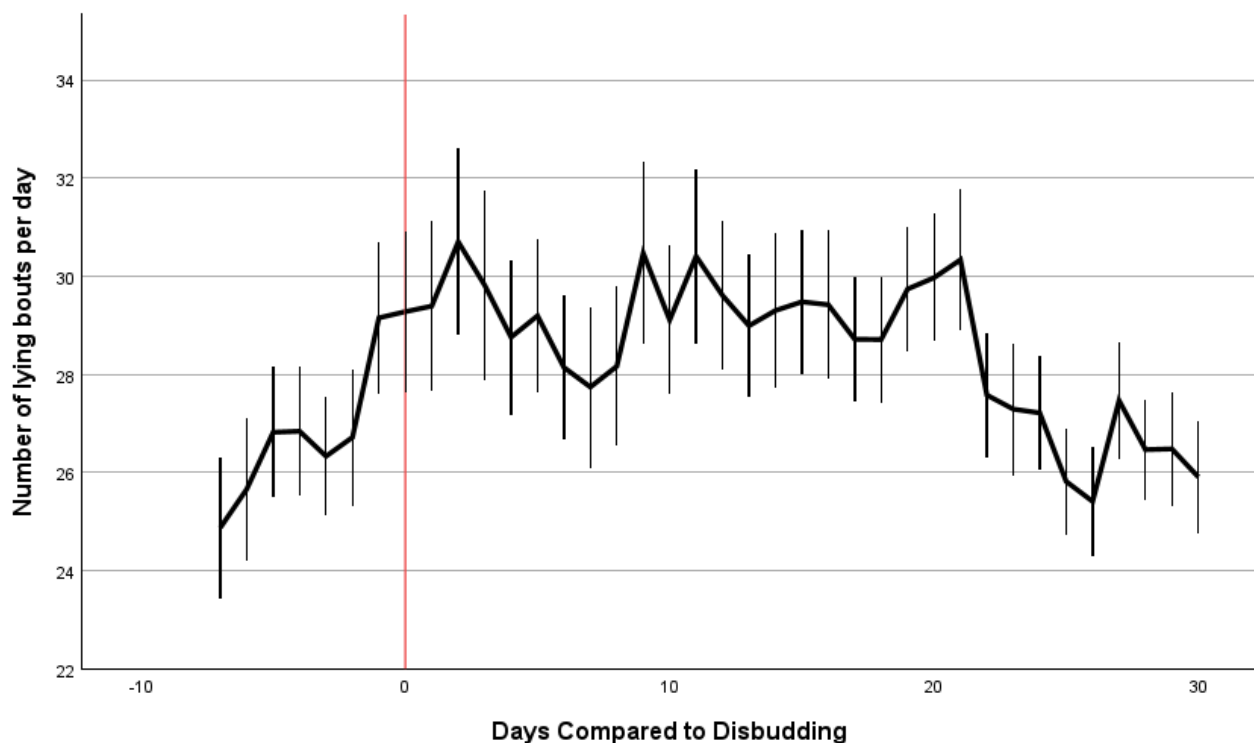


Figure 2. Number of calf lying bouts per day compared to when disbudding occurred, with 95% confidence intervals shown. The red vertical line represents the day at which disbudding occurred, $n = 205$ calves.

3.3. Calf Lying Times

The GEE model had a QIC value of 160.7, with residuals having a normal distribution (see Supplementary Materials Figure S3), indicating a good fit of the model.

The mean overall lying time per day of the calves was 17 h 45 min (SD 1 h 59 min), which is up to an hour longer than other reports [17,46,47]. This may be linked to their relatively restricted pen size (1.3 m² per calf), with increased space allowance decreasing lying times due to increased activity [48]. Other calf behavior studies have reported space allowances of 2.9 m² [10] and 4.7 m² per calf [49], although some studies do not report pen sizes used [3,50].

The GEE model demonstrated there was no significant association with the housing type ($p = 0.75$), or the days compared to disbudding ($p = 0.21$) on the lying times, Figure 3.

This agrees with [35], who found no difference in resting behavior between the housing treatments. In contrast to our findings, others have identified increased lying times in the four days following disbudding [41], while [10] observed that disbudded calves spent 54 min more per day sleeping following disbudding, which may be linked to burn healing being metabolically demanding (but not due to the use of sedation in this study) [51]. However, a study by [49] found that calves spent 40 min less time lying down following disbudding, with calves also increasing their use of a shelter for seclusion, which was thought to be caused by calves wanting to avoid potentially painful physical contact with pen mates, despite having a relatively large space allowance per calf (4.7 m²).

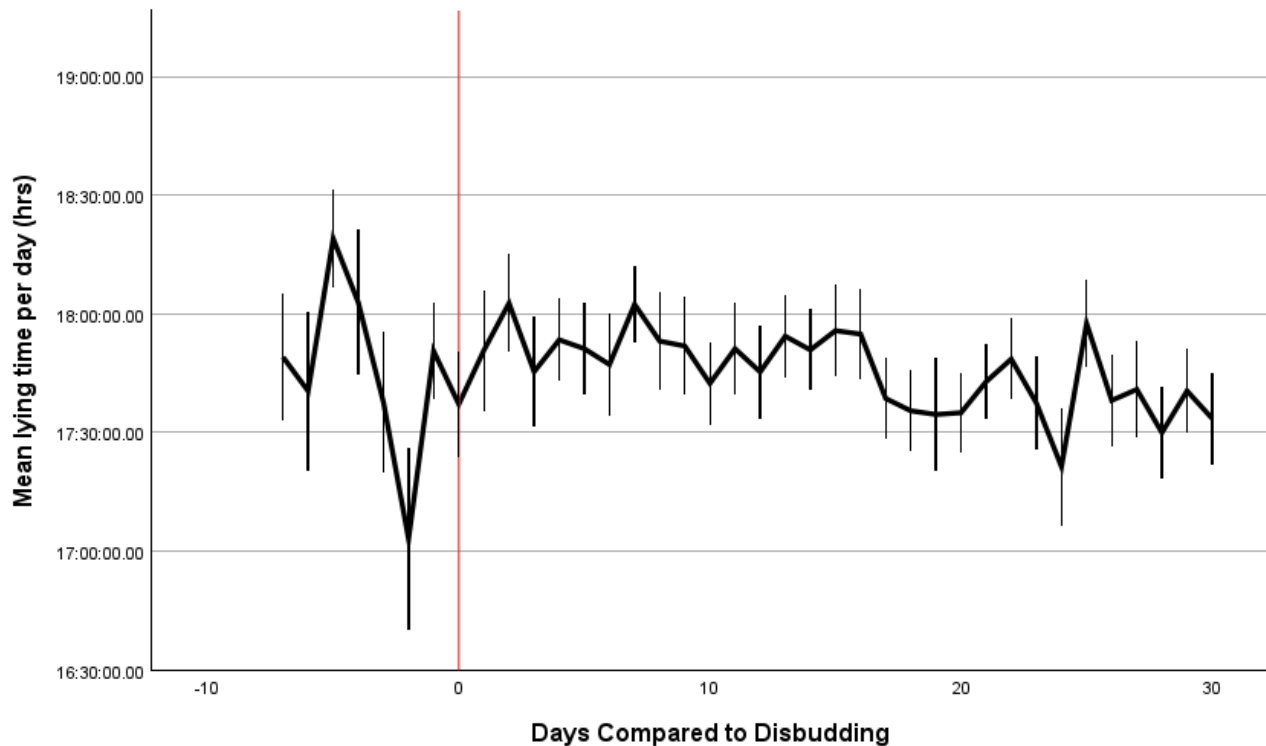


Figure 3. Hours per day that calves spent lying down compared to when disbudding occurred, with 95% confidence intervals shown. The red vertical line represents the day at which disbudding occurred. N = 205 calves.

In contrast to the other two parameters measured, the lying time per day was affected by the age at disbudding ($p = 0.015$), with calves disbudded at older ages having lower overall lying times. The calves in this study had a mean age at disbudding of 34 days (sd 9.9 days), which is similar to those used by [39,49], but older than those used by [10,39]. Lying times do appear to reduce as calves get older [34,45], which may explain this apparent trend in the data.

4. Conclusions

The data from this study suggest that individual compared to pair housing had no significant effects on calf behavior following disbudding. Regardless of this, it is clear that disbudding is a painful event that alters calf behaviors, irrespective of the housing that they live in, with changes to activity levels and lying patterns of the calves when local anesthetic and a single dose of NSAIDs are provided. Some of these behavior changes appeared to persist for up to two weeks following disbudding, providing further support for continued analgesia provision for these calves.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/dairy6020016/s1>, Figure S1: Histogram of the residual values from the generalized estimating equations model for calf activity, demonstrating a normal distribution. Figure S2: Histogram of the residual values from the generalized estimating equations model for calf lying bouts, demonstrating a normal distribution. Figure S3: Histogram of the residual values from the generalized estimating equations model for calf lying times, demonstrating a normal distribution.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author due to privacy policies at the Institute that the study was undertaken.

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