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Pasture access and social housing influence the behaviour of dairy calves

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Abstract

This Research Communication set out to (1) evaluate the behaviour and performance of dairy calves raised on pasture individually or in groups, and (2) evaluate the influence of physical enrichment on the behaviour and performance of dairy calves raised in groups on pasture. Although there was no difference in grazing behaviour when housed in groups, calves spent longer eating concentrate, ruminating and drinking water. Additionaly, calves housed individually spend part of their time trying to get close to a neighbouring calf. When available, the brush was the physical enrichment item most used by calves followed by straw-man and ball. Pasture access may allow calves to exhibit their highly motivated natural behaviours such as grazing and rumination. Furthermore, social housing provides dairy calves an opportunity for social bonding. Thus, social housing with free access to pasture areas could be an alternative in tropical regions to the typical individual rearing system used in intensive dairy farming.

In dairy farms, rearing calves individually is a common practice that goes against the natural behaviour of cattle (von Keyserlingk and Weary, 2007) and public opinion (Sirovica *et al.*, 2022). Due to the increase in criticism against the dairy sector, environmental enrichment has been the focus of researchers in recent years, as it can improve the welfare of calves. Previous studies have reported that the inclusion of physical enrichment can improve the adaptability of calves to challenges (Zhang *et al.*, 2022), while group housing can reduce fear responses (Costa *et al.*, 2016). Regarding enriched environment, access to pasture is seen as important by society (Schuppli *et al.*, 2014) and can provide a complex environment for animals, giving them free choice to perform grazing, an important behaviour for herbivores. To our knowledge, no attempt has been made to study the effects of the inclusion of physical enrichment items on dairy calves housed in groups in a pasture area. Therefore, this study aimed to evaluate the influence of group housing and the inclusion of physical enrichment for calves raised on pasture. First, we evaluated the behaviour and performance of dairy calves raised on pasture individually or in groups (Experiment 1). Second, we evaluated the behaviour and performance of group housing dairy calves with and without access to different physical enrichment items (Experiment 2). We expected that pasture access, social companionship, and physical enrichment would affect the behaviour of dairy calves. Therefore, we were interested in the interactive effects of these factors on expressing natural behaviours that calves are highly motivated to perform.

Material and methods

The study was divided into two experiments, and both were approved by the Ethics Committee on Animal Use of *Embrapa Pecuária Sudeste* (experiment 1 – protocol number 02/2020 and experiment 2 – protocol number 03/2022). All management procedures followed animal welfare guidelines and were conducted by São Paulo State Law No. 11.977. The study was conducted at the *Embrapa Pecuária Sudeste* in São Carlos, São Paulo State, Brazil (21°56′59″ S, 47°50′57″ W). The climate of the region is tropical, described by Köppen's classifcation as Cwa. Experiment 1 was carried out between January and July 2021, and experiment 2 was carried out between November 2022 and May 2023.

Experimental area and management

At *Embrapa Pecuária Sudeste*, calves are raised on pasture from when they are born. The pasture area was divided into fourteen paddocks (64 m^2 each) under a rotational grazing system (Online Supplementary Fig. S1). When calves were born, 6 l of colostrum (>23% BRIX) was offered in a feeding bottle within 24 h of birth. Birth weight, ID and date of birth of the newborn calves were recorded. From the second day of life onwards, calves received whole milk (~15% of body weight) twice a day in teat buckets (Milkbar®). All calves had free access to water, a pasture area (*Cynodon ssp.*) and artificial shade provided by a polypropylene screen (north–south direction). Furthermore, calves had free access to a commercial calf starter (18% crude protein; 70% ground corn, 25% soybean meal, and 5% mineral salt). The solid diet was always provided once a day after morning milk feeding.

Experiment 1

Animals, experimental area, and treatments

Within 48 h following birth, 18 dairy calves (Holstein and Jersolando) were enrolled in a replicated study. Calves were pseudo-randomly assigned (balanced for breed and birth order; Nogues *et al.*, 2023) into three blocks (6 calves/ block). Within blocks, calves were allocated to either individual housing (IH, three calves per block, $n = 9$; birthweight 31.4 ± 3.1 kg) or group housing (GH, three calves per block, $n = 9$; birthweight 31.5 ± 4.3). In the group housing ($n = 3$ Holstein, and $n = 6$ Jersolando), the calves were allocated in collective paddocks (64 m^2; Online Supplementary Fig. S2A). In the individual housing (Online Supplementary Fig. S2B), each calf ($n = 3$ Holstein and $n = 6$ Jersolando) had a collar and was restrained by a chain (1.2 m) attached to wires (8 m) at the ground, allocated in the east–west direction. The distances between the wires were 4 m, sufficient to ensure that no physical contact occurred between the calves.

Experiment 2

Animals, experimental area, and treatments

Within 48 h following birth, 36 dairy calves (Holstein and Jersolando) were enrolled in a replicated study. Calves were pseudo-randomly assigned (balanced for breed and birth order; Nogues *et al.*, 2023) into six blocks (6 calves/block). Within blocks, calves were allocated to either group housing with physical enrichment (PE, three calves per block, $n = 18$; birthweight 32.4 ± 4.7 kg; breed: $n = 9$ Holstein and $n = 9$ Jersolando) or group housing without physical enrichment (WPE, three calves per block, $n = 18$; birthweight 31.2 ± 4.8 kg; breed: $n = 9$ Holstein, and $n = 9$ Jersolando). In both PE and WPE, the calves were allocated in collective paddocks (64 m^2) with physical enrichment (Online Supplementary Fig. S3A) or without physical enrichment (Online Supplementary Fig. S3B). Three physical enrichment items were provided simultaneously to group housing with physical enrichment. The physical enrichment items included were: (1) a straw-man (1.5 m in height × 1.4 m in width × 1.1 m in circumference) with outstretched arms and wearing farmer's similar clothes hanging from a wooden post; (2) a plastic ball (0.6 m of circumference), positioned at a height of 0.9 m from the ground; and (3) a stationary wooden brush (0.40 m long × 0.08 m width) with flexible bristles (0.11 m long) hanging from a wooden post at a height of 0.6 m from the ground.

Experiments 1 and 2: behaviour and performance

In both experiments, the calves were observed once a week from birth to weaning (60 d). All calves were identified, and behaviours were directly recorded between 7:00 and 16:55 h by scan sampling at 5-min intervals. Definitions of the behaviours are shown in Online Supplementary Table S1. For both experiments, the behaviours of exploring, grazing, idle, ruminating, non-nutritive oral behaviour, drinking, eating concentrate and social interaction were registered. In calves housed individualy, we register as a social interaction, a clear attempt of a calf getting close to a neighbouring calf. We included the observation of social interaction in individually housed calves because farmers constantly report this behaviour, and this approach ensures a fair comparison between treatments. For group housing calves in experiment 2, we also registered the interaction with physical enrichment items (strawman, ball and brush). Additionally, once a week the calves were weighed to calculate the average daily gain.

Experiments 1 and 2: experimental design and statistical analysis

The experimental design consisted of three replications for experiment 1 and six replications for experiment 2. Treatments (experiment 1: IH and GH; and experiment 2: PE and WPE) were considered as independent variables, and as dependent variables we considered each behaviour evaluated over time. The database was built with each observation (behaviour) synchronized by date and time of day and the performance parameter evaluated over time and synchronized by treatment. To determine the influence of treatments (housing system and environmental enrichment) on the behaviour of calves (Poisson distribution) and performance (Gamma distribution) mixed generalized linear models with 95% confidence interval were built. For all models, the treatments were defined as fixed effects and the days, hours, calf and paddock were defined as random effects. For interpretation purposes, the model estimate was used. The 'day and hours' were included as a random effect to correct for day-specific conditions that may influence time budgets and the 'calves' were included as a random effect to correct for multiple observations per animal. Paddocks with 3 calves or a group of 3 individual calves were the experimental unit and were used as a random effect. The paddock was specified as a random effect and nested within it was the calf, given that calves were grouped in threes. Mixed models were specified to estimate the influence of treatment (experiment 1: IH and GH; and experiment 2: PE and WPE) on calf behaviour. Model fit was evaluated by comparing the Akaike information criterion (AIC), where the model with a lower AIC information criterion was deemed to have a better fit. All analyses were performed in R (detailed in the Online Supplementary File).

Results

Experiment 1

The details from the mixed regression models built to determine the influence of the housing system on the behaviour of calves raised on pasture are shown in Table 1. Calves housed in groups spent more time ($P < 0.05$) at the feeder (GH: 3.6%; IH: 3.2%), drinking water (GH: 2.3%; IH: 1.7%), and ruminating (GH: 17.3%; IH: 11.3%) than calves housed individually. No significant difference in non-nutritive oral behaviour was found. There was a difference ($P < 0.001$) in social interation behaviour between housing systems. Calves in group housing spent 0.3% of their time interacting with other calves, while calves in individual housing spent 4.6% trying to get close to other calves.

There was no influence of the housing system on average daily gain or body weight at the end of the experimental period. Overall, calves in the group housing presented an average daily gain of 0.65 ± 0.15 kg/d, and calves in the individual housing

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Table 1. Posterior estimates of mixed regression models of the influence of housing system on behaviour of calves raised on pasture

Parameter	Estimate	SE	CI Lower	CI Upper	*z* value	*P*-value
Exploring	0.06	0.15	0.79	1.44	0.44	0.65
Grazing	−0.05	0.42	0.42	2.16	−0.11	0.91
Idle	0.03	0.10	0.85	1.26	0.39	0.69
Rumination	0.54	0.05	1.55	1.88	2.91	0.004
Non-nutritive oral behaviour	0.74	0.88	0.37	1.98	0.84	0.39
Drinking	0.44	0.44	1.21	2.01	3.46	<0.001
Eating concentrate	1.05	0.32	1.52	5.41	3.25	0.001
Scratching	0.54	0.21	1.14	2.57	2.62	0.01

Model estimate represents the odds of a given events occurring in relation to the reference category (individual housing). Mixed regression models with standard error (SE), degree of freedom (df = 5), and 95% confidence intervals (CI).

presented a gain of 0.66 ± 0.19 kg/d. Body weight at the end of the experimental period was 70.7 ± 9.3 kg for calves in the group housing and 70.9 ± 11.9 kg for calves in the individual housing.

Experiment 2

The details from the mixed regression models built to determine the influence of physical enrichment on the behaviour of calves are shown in Table 2. Calves with physical enrichment spent less time ($P < 0.05$) on social interaction (PE: 1.7%; WPE: 2.1%), exploring (PE: 9.5%; WPE: 11.4%) and grazing (PE: 10.2%; WPE: 13.1%) than those calves without physical enrichment. In contrast, calves with physical enrichment spent more time ($P < 0.001$) at the feeder (PE: 3.5%; WPE: 2.1%) and spent numerically (non-significantly) more time ruminating (PE: 8.8%; WPE: 7.7%) than those calves without physical enrichment. No significant difference in non-nutritive oral behaviour (PE: 0.4%; WPE: 0.6%) was found.

The frequency of use of physical enrichment varied in relation to the hours of observation (Fig. 1). The most used physical enrichment item was the brush (47%) followed by the straw-man (29%) and ball (24%). Overall, 17% of calves did not use the straw-man and ball, while 11% of calves did not use the brush.

Calves in the PE (0.509 ± 0.3 kg/d) has slightly (non-significantly) higher average daily gain than calves in the WPE (0.444 ± 0.2 kg/d). However, there was no significant difference in body weight between PE (51.29 ± 14.41 kg) and WPE (52.95 ± 14.96 kg) at the end of the experimental period.

Discussion

We considered the first experiment as a baseline to evaluate the effects of group housing. In the second experiment we increased the complexity of the environment where calves were raised by adding physical enrichment items. Our findings showed that calves housed individually spent longer trying to get close to a neighbour calf, whereas calves raised in group and with physical enrichment spent less time on social interaction. In natural conditions with other conspecifics, calves are raised by dams and experience a complex social and dynamic environment (Cantor *et al*., 2019). Social companionship is essential for raising gregarious animals, as living in groups has accompanied the evolution and domestication of cattle. For that reason, we did not consider the group housing as a form of social enrichment. Despite the well-documented benefits of raising dairy calves in groups, there is a notable lack of scientific literature evaluating the effects of raising calves on pasture. It is known that calves raised in complex environments, like in groups and with access to physical enrichment, are more optimistic and express more exploratory behaviour (Bučková *et al*., 2019; Zhang *et al*., 2022). Grazing behaviour also makes part of the natural behavioural repertoire of cattle, and allowing cattle to access pasture areas also promotes positive emotional states. This underscores the need for a deeper understanding of the effects of pasture access and the opportunity to graze in all cattle ages. When animals are unable to satisfy their needs, it generates a negative emotional state of frustration, as the mechanisms of satiety are not triggered and the seeking system continues its activity (see review: Coria-Avila *et al*., 2022).

Calves in the complex environments (group housing and group housing with physical enrichment items) spent longer eating concentrate, ruminating and drinking water. The presence of other calves probably increased the likehood of calves exbiting these behaviours. Aside from social learning, living in group reduces the fear response to novelty (Costa *et al*., 2016) and increases solid feed intake in early life (Miller-Cushon and DeVries, 2016). We did not find a difference in grazing frequency among evaluated housing systems, which indicates that accessing pasture since early life is beneficial to development. In natural conditions with pasture access, calves begin nibbling grass within the first few weeks of life (Tedeschi and Fox, 2009) as consumption of forage is a motivated behaviour. The diet diversity from pasture contributes to the faunation of the microbiota in the calf's rumen (Bryant and Small, 1960; Cantor *et al*., 2019) and promotes the development of the gut and rumen, as well as rumination behaviour. Drinking water is another important behaviour that calves show in low frequency in the first weeks of life, but it significantly impacts their development, thermoregulation and dry matter intake (see review: Jensen and Vestergaard, 2021). Calves decrease weight gain and feed intake when deprived of water (Kertz *et al*., 1984). During growth, calves undergo shifts in ruminal microbiota development, as the rumen becomes functional (Rey *et al*., 2012). Thus, in tropical regions (as in this study) animals are exposed to high solar radiation (Deniz *et al*., 2021), so water has an important role in thermoregulatory mechanisms aside from its influence on feed intake.

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Table 2. Posterior estimates of mixed regression models of the influence of physical enrichment on behaviour of calves raised in groups

Parameter	Estimate	SE	CI		*z* value	*P*-value
			Lower	Upper		
Exploring	−0.17	0.07	0.73	0.97	−2.29	0.02
Grazing	−0.22	0.08	0.68	0.94	−2.66	0.008
Idle	0.04	0.02	0.99	1.09	1.61	0.11
Ruminating	0.14	0.08	0.97	1.37	1.68	0.09
Non-nutritive oral behaviour	−0.30	0.29	0.41	1.31	−1.04	0.29
Drinking	0.18	0.19	0.81	1.77	0.91	0.36
Eating concentrate	0.51	0.12	1.32	2.09	4.35	<0.001
Social interation	−0.24	0.11	0.62	0.98	−2.07	0.04

Model estimate represents the odds of a given events occurring in relation to the reference category (without physical enrichement). Mixed regression models with standard error (SE), degree of freedom (df = 5), and 95% confidence intervals (CI).

Concerns about non-nutritive oral behaviours are often cited as a motivator for keeping calves in individual housing. In our study, the frequency of non-nutritive oral behaviour in both experiments was low, and housing systems had no influence. The complex environment, including pasture access, may have contributed to this; in both experiments, calves had the opportunity to spend time exploring (∼10%) and grazing (∼11%). Providing a highly stimulating environment decreases the frequency of undesirable behaviours. However, environmental enrichment alone is not sufficient; calves in individual housing with environmental enrichment still show high frequencies of non-nutritive oral behaviour (Horvath *et al.*, 2020). Non-nutritive oral behaviour is an undesirable behaviour in calves, as it can result in hair loss, inflammation, and disease in receivers (Jensen, 2003). On the other side, exploring is an important behaviour that can help calves develop, since it is a process of information gathering for animals (Rojas-Ferrer *et al.*, 2020), which may help them to better control or predict new environments (Wood-Gush and Vestergaard, 1989).

Not surprisingly, the brush was the physical enrichment item most used by calves. Scratching is part of the cattle behavioural repertoire because this helps animals remove dirt, parasites and other contaminants from the skin and coat (Moncada *et al.*, 2020). Newberry (1995) argued that to achieve the maximum of benefits of an enrichment, it must have a high functional significance to the animals. Usually, brush use by calves is stable over time when compared to the use of other environmental enrichments (Strappini *et al.*, 2021). Scratching and social interaction are basic requirements for growing dairy calves. Noteworthy, the straw-man was the second most used physical enrichment item, and the highest use occurred on the hour close to the milk offer. We believe that calves associated the straw-man with the farmer's presence since the straw-man had similar clothes. We are not aware of other studies that have evaluated the straw-man as an item of physical enrichment, and we suggest that future research could be addressed to understand the human–animal relationship using the straw-man.

In conclusion, pasture access provides opportunities for a greater range of natural behaviours, including grazing, rumination and exploring, which has benefits for calves' behavioural development. Overall, our findings highlight the importance of environmental complexity in early rearing environments. Providing pasture access and social housing supports calves in expressing highly motivated natural behaviours, such as grazing and rumination. Socially housing dairy calves provides an opportunity for social bonding and could be an alternative to a typical habitation

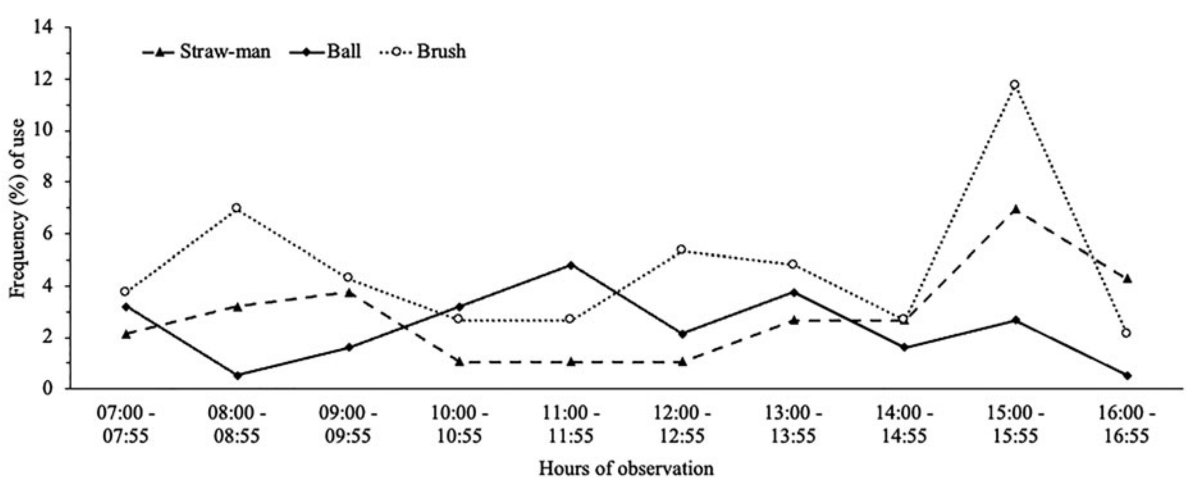

Figure 1. Frequency of use the different (strawman, ball, and brush) physical enrichment in relation to the hours of observation (7 h to 16:55).

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used in intensive dairy farming. However, even housed in a group, calves interact with physical enrichment items, especially those that have biological functions, such as brushes.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0022029924000633

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