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Analysis of the behaviour of dairy-type Simmental-Fleckvieh calves in outdoor pen-and-shelter systems

Analýza životních projevů telat českého strakatého skotu ve venkovním individuálním boxu

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ABSTRACT

Calf behaviour in rearing systems is an important indicator of calf welfare and influences efficient dairy production. In this study, the behavioural patterns of dairy calves in outdoor individual pen-and-shelter units were investigated. The study was done over 12 months with 683 Simmental-Fleckvieh calves, kept for two months (pre-weaning) in outdoor individual pen-and-shelter units, and observed at monthly intervals. During the study the calves' lying and moving behaviour in the shelters were separately observed and evaluated. The ambient temperature outdoors was also recorded. Statistically significant relationships between the calf's season of birth, as well as the age of the calf and the evaluated forms of behaviour, were found. Outdoor ambient temperature was found to have a statistically significant effect on calf preference for standing or lying down. More standing calves than lying calves were recorded outdoors at higher outdoor ambient temperatures. Calves showed a clear preference for lying down, especially in the sheltered parts of the units (64.86%). Only 4.98% of the calves lay outside; 19.18% were standing outside, while 10.98% preferred standing inside the shelter. The calves lying down outside were significantly younger while older calves were lying inside the shelter.

Keywords: dairy, Fleckvieh, standing, lying, temperature

ABSTRAKT

Chování telat při odchovu je důležitým indikátorem welfare telat a ovlivňuje následnou mléčnou užitkovost zvířat v dospělosti. V této studii bylo hodnoceno chování telat dojeného skotu ve venkovním individuálním boxu. Pozorování bylo provedeno během 12 měsíců u 683 telat českého strakatého skotu, která byla odchovávána po dobu dvou měsíců ve venkovních individuálních boxech. Sledování probíhalo v měsíčních intervalech. Během této studie bylo sledováno ležení a stání telat a také, zda se vyskytují vně, a nebo uvnitř boxů. Rovněž byla zaznamenávána venkovní teplota. Byl nalezen statisticky průkazný vliv sezóny narození telat a věku telat na tyto životní projevy. V případě venkovní teploty byl nalezen statisticky průkazný vliv pouze na ulehávání a vstávání telat. Při vyšší venkovní teplotě více telat stálo, než leželo před boxem. U telat byla prokázána preference ležení, zejména uvnitř boxu (64.86%). Pouze 4.98% telat leželo venku; 19.18% stálo venku, zatímco 10.98% preferovalo stání v boxu. Telata ležící venku před boxem byly průkazně mladší, zatímco starší telata ležela uvnitř boxů.

Klíčová slova: dojený skot, Fleckvieh, stání, ležení, teplota

INTRODUCTION

Food animal production systems are economically of great significance, making farm animal welfare an important aspect to ensure sustainability. Animal welfare is also considered an important ethical social concern and needs to be integrated into the practice of sustainable agriculture. In this context, it is not conducive to 'compete' with environmental goals (Hötzel 2014) cited by Von Keyserlingk et al. (2015). For the purposes of this publication, we have adopted the definition of animal welfare that acknowledges that there are three pillars of sustainability: economic, environmental and social (Von Keyserlingk et al., 2015). Historically farmers and most scientists have placed great emphasis on the environmental and economic pillars (Boogaard et al. 2011b) cited by Von Keyserlingk et al. (2015).

Rearing newly born dairy calves in outdoor pen-and-shelter systems is the preferred and common practice in Czech dairy farms and also worldwide (Buchli et al., 2017). Although this separation of calves from dams within 24 hours of birth is common in dairy production, there is no consensus on the prevailing positive or negative effects on calf behaviour, social well-being, and overall welfare. Among the more important advantages of raising a calf separate from the dam are larger quantities of saleable milk, easier handling of the cow and calf and easier control of the calf milk intake (Buchli, et.al., 2017). In addition, Edwards, and Broom (2020) and Flower, and Weary (2001) site a possible prevention of disease transmission from cow to a calf as a further benefit.

Although research suggests that there are many dairy farmers who satisfactorily adapted the conventional system of calf isolation with a more "dam/foster rearing" approach, there is still no conclusive evidence that calf welfare is objectively improved compared to the traditional artificial rearing under on-farm conditions (Buchli et al., 2017).

Regarding the effects of cow contact on stress reactivity (as opposed to isolated rearing), there are several results that are somewhat contradictory. Calves reared with cow-contact (on the one hand), were found to be more active and tended to show a reduced cortisol response to an isolation test. With regard to cardiac response, however, no difference was found compared with calves reared without cow contact (Wagner et al., 2013). Regarding social reactions and adaptability, no conclusive and uniform results could be formulated to suggest that calves reared in isolation systems were significantly disadvantaged (Von Keyserlingk et al., 2017) although findings reported by Waiblinger et al. (2013) suggest that there are situations in which calves raised in isolation systems showed strong attentive responses to some social situations when encountering other cows.

It is clear, therefore, that animal behaviour can be a particularly useful disciplinary approach to addressing animal welfare issues from a research point of view. Another advantage of behavioural studies is that they also address more fundamental questions (e.g., the nature of social relationships) and practical issues (e.g. heat detection, stress behaviour) unrelated to animal welfare (Von Keyserlingk et al., 2017). The integration of biological functioning, natural behaviour, and affective states in the study of welfare can also be undertaken, supporting the argument that welfare problems can emerge in any of these 3 areas and that the best practices will address all 3 areas of concern.

Standing and lying, as well as shelter-seeking behaviour, are considered normal and typical activities of dairy animals. This approach was introduced in completing this study with dairy calves. Distinct differences in energy utilization occur during direct exposure to sunlight as opposed to sheltering (Hill et al., 2013). This is an indication of either susceptibility or resistance to excessive sunlight exposure. Von Keyserlingk and Weary (2017), goes further to argue that allowing cows to seek shade on a hot day, prevents them from experiencing uncomfortable heat (affective state) while reducing the health and production risks associated with heat stress (biological functioning). This behaviour is analyzed in this study, using variables that describe the differential reactions of Simmenthal-Fleckvieh calves in isolation-type rearing conditions (in this case the outdoor pen-and-shelter system) to outdoor heat conditions.

The differences in the behaviour and growth of dairy-type calves reared in individual as opposed to combined housing were studied, and discussed by Tapki (2007). In this study, calves were kept separate in individual pen-and-shelter units throughout the weaning period (or for the first 30 days) and then placed in groups. A significant increase in feed intake and growth rate of calves was reported.

The behaviour of dairy-type calves has also been studied by authors like Pempek et al. (2017), Ugwu et al. (2021) and Swartz et al. (2020). Conneely et al. (2014) analyzed the effect of the amount of milk feed and the frequency of feeding on the behaviour, health, and body weight of the calves. Although no significant relationship between probiotic intake and calf weight gain in early life could be statistically verified (Zábranský et al., 2021; Zábranský et al., 2022), it is still important for ensuring healthy conditions during this very sensitive growth period of the calf. Similarly, Borderas et al. (2009) addressed the standing and lying down behaviour, as well as the setting preferences of calves and dairy cows. The feeding behaviour of calves, in particular the amount of milk compound and the frequency of feed intake, was carefully analysed. Edwards et al. (1982) investigated the choice of setting before birth in heifers and cows. Lying laterality in dairy cows has been addressed by Gibbons et al. (2012) and Forsberg et al. (2008). The relationship between movement activity and the lying frequency of grazing cows was also discussed by Hendriks et al. (2020).

The lying or standing behaviour of calves can suggest many problems, especially health problems. The relationship between lying behaviour and diarrheal disease in calves was reported by Swartz et al. (2020), who describe a statistically significant lesser period spent lying down in calves with diarrheal disease. The behaviour of calves housed in individual pen-and-shelter systems, the development of an etogram for these purposes and the influence of various effects of this housing method, are addressed in the work of Ugwu et al. (2021). They report extensively on the relationship between calf sex and some behavioural manifestations, such as tongue movement inside the mouth, tail wagging, and duration of walking around. The frequency of lying down, in relation to the feeding of calves during rearing practices, was also analyzed by Todd et al. (2018). The latter analyzed the effect of the *ad libitum* feeding of acidified milk feed on the behaviour of calves.

It is becoming increasingly clear that the study of farm animal welfare is focusing on improving the lives of farm animals, but the meaning of this has changed over time. The traditional concept of "a good life" used to be associated with good health and appropriate levels of production. In more recent times, with a greater focus on sustainable agriculture and more environmentally friendly production practices, scientists begin to recognize the importance and role of animal health or on-farm production research as being the equivalent of studying animal welfare issues (Von Keyserlingk et al., 2017).

The outdoor pen-and-shelter system consists of several individual pen-and-shelter units and is also the most common way of rearing dairy calves in the intensive dairy production systems in Europe. Usually, calves are placed in these individual pen-and-shelter units immediately after birth and remain individually housed until weaning (in 40-60 days) (Hoshiba, 1986). The outdoor pen-and-shelter system as a calf rearing practice became popular in the 1970s, when dairy farmers in the United States began using the system to rear replacement heifers and obtained very good results, especially in reducing calf mortality rates (Hoshiba, 1986). Figure 1 is an illustration of the measurements and layout of an individual pen-and-shelter unit used for rearing dairy-type calves. The construction of one individual pen-and-shelter unit consists of two equally sized enclosed sections. One section is an open enclosure of approximately 1.44 m^2 allowing the calf access to open outside conditions. The other section is an enclosed, shelter-type construction of similar size (1.44 m^2) simultaneously giving the calf access to shelter.

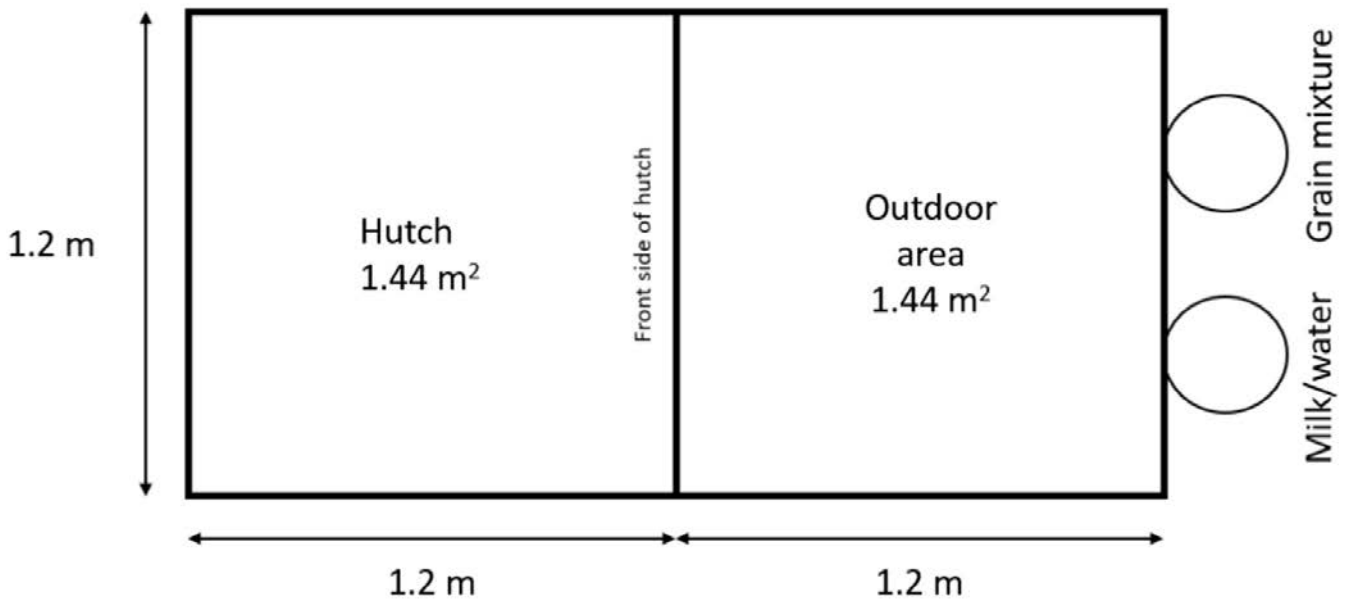

Figure 1. Illustration of individual pen-and-shelter unit measurements used for calves in the study

The use of this type of outdoor individual pen-and-shelter unit proved to be similarly effective in colder climates. This observation is supported by Hepola et al. (2006), who studied the influence of temperature and type of housing on the behaviour of dairy-type calves. In a study conducted in Finland, Hepola et al. (2006) studies the effect of different calf-rearing housing types using classic outdoor housing or heated housing over a period of seven weeks. A general observation confirmed that calves spent less time at lower temperatures ingesting feed. This could have a negative impact on the development of rumen during this important period. This implies that, during a very cold period, it is more efficient, especially in pen-and-shelter units arranged in groups, to place the feed in the sheltered section (Hepola et al., 2006).

An important challenge when using outdoor individual pen-and-shelter units is the stringent limitation on direct social contact between calves, as opposed to free social contact, such as in the case of group calf housing. Pempek et al. (2017) reported individual housing of calves limits their freedom to fully express their natural behaviour. This limitation is, however, still in compliance with the European guidelines for housing dairy calves. Costa et al. (2016) studied the effect of group housing on the behaviour, health and performance of dairy calves. The issue of individual and group housing regarding behaviour and ethological and physiological responses in dairy-type calves was also studied and described by Hanninen et. al. (2005). Their study on 36 calves in India identifies differences in behaviour between different types of housing. For example, in group-housed calves, more time was spent on feed intake compared to individually housed calves, but individually-housed calves spent more time lying down and resting activities. The possibility of using an individual pen-and-shelter system to house a pair of calves was also studied by Wormsbecher et al. (2017). In this study the authors report that the use of these pen-and-shelter units for the paired housing of calves is a suitable alternative to individual pen-and-shelter units, allowing better social contact than individual housing. No differences in daily gain between calves housed in individual or paired pen-and-shelter units were, however, observed. The issue of individual and paired housing of calves was also addressed by Chua et al. (2002) and Liu et al. (2020), reporting similar findings.

MATERIALS AND METHODS

A total of 683 Simmental-Fleckvieh calves were housed in conventional pen-and-shelter units commonly used for rearing young dairy calves on dairy farms in the

Czech Republic. The study took place on a specifically selected farm in the Czech Republic, that met all the requirements for this study. The study was conducted over a 12-month period, with calves continuously included in the study and removed at the end of the two-month observation period. This means that, at any given time, there were calves of different ages between birth and two months old and born in any of the seasons of the year, in the study. The Simmental-Fleckvieh is a typical dual-purpose breed kept for its very good milk and beef production performance. On the farm where the study was conducted, 840 Simmental-Fleckvieh cows are kept. They produce an average milk yield of 8,000 kg of milk per 305-day lactation.

As previously mentioned, the farm where this study was conducted, is a functionally efficient commercial dairy farm and the study was conducted as part of the normal activities of the dairy farm. Since management factors like housing conditions, feeding management, and human–animal relationships strongly affect the behaviour of farm animals, including on-farm studies into research on calf rearing is necessary. The study was conducted on a functioning, operationally active, and efficient commercial dairy farm, so that calves were reared under real conditions. The selected pens and animals were managed specifically according to the requirements of the study determined by scientific experimental procedures.

Calves were born in the conventional single calving pen and fed on colostrum immediately after birth. Approximately 4-8 hours after birth, calves were separated from cows and moved to individual pens where they remained until weaning (maximum 56 days). The calves were then fed regular colostrum three times a day for 5 days each. Then the calves were fed a milk feed mixture (2 x 3 litres), with the addition of a starter grain mixture. The milk feed mixture consists of 73% whey protein, 6% coconut fat, 11% palm oil, 4% wheat protein concentrate and 6% soy protein concentrate. The powder mixture is diluted in the ratio of 1 part powder: 8 parts water.

The starter mixture consists of a mix of barley flakes, whole barley grain, sunflower meal, whole grain wheat, pea flakes, rapeseed meal, corn flakes, dried alfalfa hay, molasses, whole oats, black oats, mineral supplements, corn distiller's dried grains, wheat bran, soybean meal, vegetable oil.

The calves had *ad libitum* access to water. Calves were observed for one year (1st November 2015 to 31st October 2016), once a month (the fifteenth day of the month provided it does not rain, in which case observations were made on the first following clear day) at 12:00 (midday).

Straw was used as bedding and was added every day to each individual pen-and-shelter unit. After weaning the calves were moved to the group housing complex and the individual pen-and-shelter units were cleaned and disinfected. Feeding of the calves took place twice a day. During the experimental period, the outdoor air temperature close to the outdoor individual pen-and-shelter units was also measured. In addition to temperature, the effect of calf age, season of birth, calf sex and calf sire on calf behaviour was also statistically analyzed.

Two types of behaviour were observed:

1. the lying or standing behaviour of the calf (trait: standing/lying),
2. the positioning of the calf in relation to the shelter outside (inside or outside the shelter; trait: inside/outside).

Calves were not directly handled before, during, or after the experiment and no invasive methods were used.

Statistical analysis

Statistical analyses of the effects of housing in individual pen-and-shelter units on the standing/lying and inside/outside behaviour of dairy-type calves were performed using the GENMOD procedure and the FREQ procedure in the SAS statistical program. The main statistical test employed was the Chi-square test. The graphs were processed using the statistical programme Statistica 12. The statistical relationships between the selected variables were analysed separately, first for the standing/lying trait and then for the inside/outside trait using the following linear model (binomial distribution):

$$y_{ijkl} = temp_i + seas_j + sex_k + sire_l + b^*age + e_{ijkl},$$

where *y* is a dependent variable (standing/lying or inside/outside), *temp* is the fixed effect of ambient temperature for level *i* (i = 1 – 5: up to 4.9 °C; 5 °C to 9.9 °C; 10 °C to 14.9 °C, 15 °C to 19.9 °C and above 20 °C). The effect of the calving season (*seas*) is divided into 4 levels: winter, spring, summer, and autumn (j = 1 – 4: December to February; March to May, June to August and September to November). The effect of sex (*sex*), where *k* has two levels: heifer and bull. Symbol *b* expresses a regression coefficient expressing the relationship of the dependent variable *y* to the age of the calf in days (*age*). Symbol *e* is the residual error.

RESULTS AND DISCUSSION

Table 1 shows the frequency of behaviour for each combination of the two observed traits: standing/lying and inside/outside. In this table and in Figures 1 and 2, the two observed behaviours are evaluated in their mutual interactions. The subsequent analysis of the influence of chosen effects on this behaviour is performed separately for both behavioural traits.

Table 1. Frequency of calf behaviour recorded during observation periods

Behaviour	№ (x)	%
Standing inside shelter	75	10.98
Lying inside shelter	443	64.86
Standing outside shelter	131	19.18
Lying outside shelter	34	4.98
Total	683	100

The values in Table 1 show that the calves were most often inside the shelter at the time of observation (64.86% of observations). Almost one-fifth of the calves (19.18%) were standing outside the shelter and 10.98% of the calves were standing in the shelter during this period. The least number of calves observed (4.98%) were lying down in front of the shelter. Thus, in general, it could be stated that calves preferred to lie down in a shelter, this being the most common observed behavioural expression. When calves were encountered outdoors, they were standing 80% of the time. Comparing the two observed behaviours separately, most calves were lying down and resting at the time of observation. Calves mostly spent their time inside the shelter. These results were expected, given the timing of observation, i.e., the period of relative rest between feedings, and the time when animals should be resting.

Hoshiba (1986) monitored and studied the behavioural activity of 3 calves for 81 days in winter (average temperature -4.6 °C). These calves spent 85.6 – 89.8% of the observation period inside the shelter, compared to the 75.84% observed in this study. It is important to note that Hoshiba (1986) collected observations only during the winter while this study was conducted over a 12-month period. It is therefore possible that better weather conditions during the non-winter seasonal periods could explain why calves spent less time inside the shelter.

Figure 2 shows histograms of observed behaviours as a function of calf age. The graphs show that younger calves are more likely to lie down in the individual stalls, while the histogram for standing outdoors is skewed in favour of older calves. It can also be noted that lying outside the shelter does not occur at all in older calves, and standing in the shelter is also observed minimally in older calves. This is consistent with the results previously reported by Hill et al. (2013). Despite the considerable variability and deviation of the observed values of the whole group in favour of lying in the shelter, it is observed that older calves show more activity, especially outdoors. However, during rest period, they often remain inside the shelter. Few of the younger calves were observed to lay outside.

Figure 3 shows the frequency distributions of the observed behaviours as a function of ambient outdoor temperature near each pen-and-shelter unit. In the case of the histogram showing standing outside the shelter, the preference for standing outside the shelter is evident in warmer weather. On the other hand, at very high temperatures (above 20 °C) a significant increase

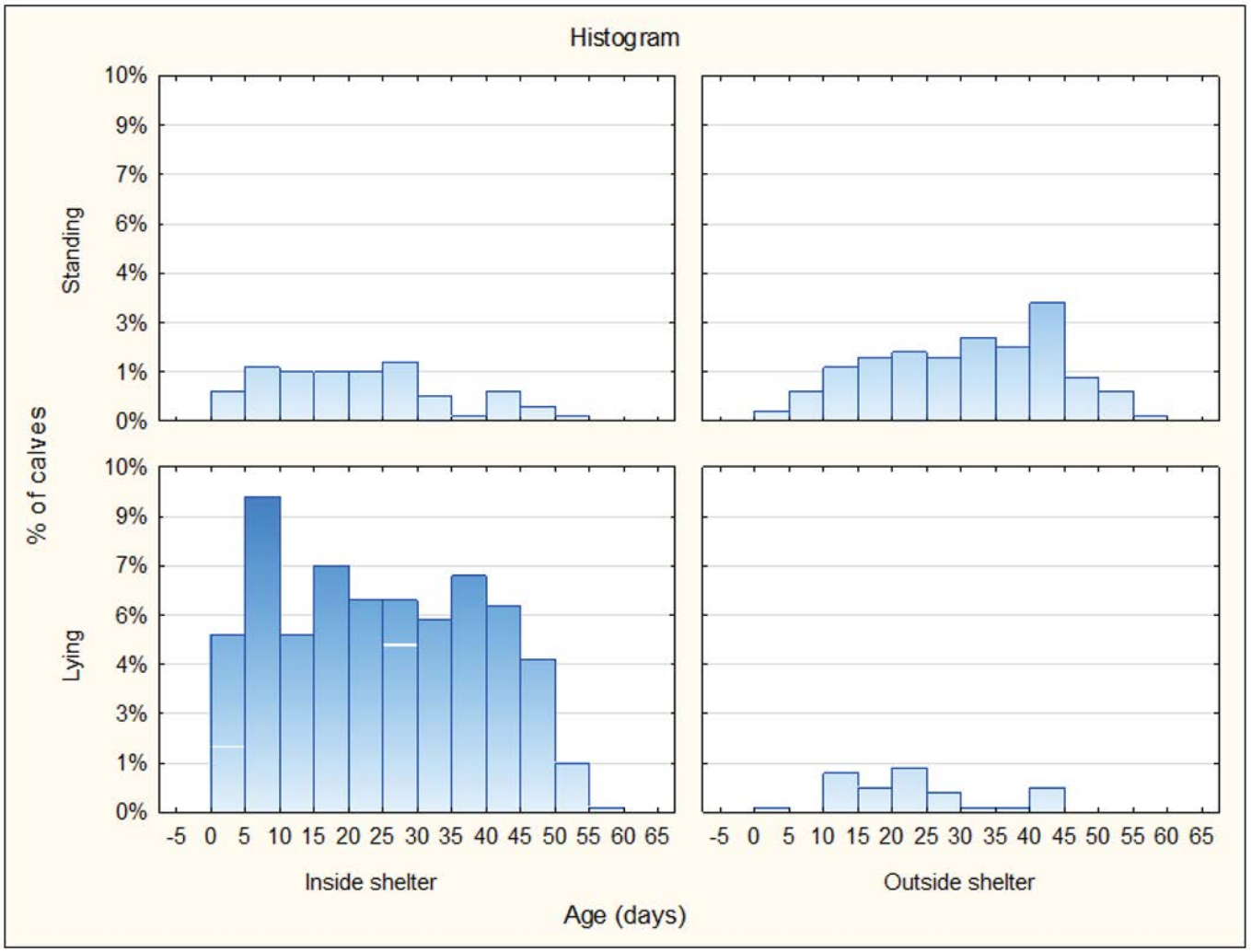

Figure 2. Frequency distributions of observed behaviour relative to the age of the calves

in the proportion of calves lying in shelters is observed. This can be explained as the calves' effort to protect themselves from the intense sunlight during the summer months (normal behaviour). No significant change in behaviour was observed at lower temperatures. This is due to the fact that, despite the measurements during winter, no extremely low temperatures were measured and temperatures as low as -5 °C can be considered acceptable, and not extreme for Simmental-Fleckvieh dairy cows. The above confirms that in temperate climates, the protection of dairy cows, not only calves, is essential, especially from higher temperatures, i.e., during the summer months.

Table 2 shows the statistically significant differences in the effects recorded between the tested behavioural traits based on a linear model with binomial distribution. Standing/lying behaviour and the inside/outside behaviour were analysed separately using a chi-squared analysis of the different groups of traits.

The influence of the calves' sire and, at the same time, the influence of sex, i.e., whether the calf was a bull or a heifer, proved to be statistically insignificant in both cases. On the contrary, the season of birth of a calf shows a statistically significant relationship with both observed behavioural traits. In the case of standing/lying, the statistical relationship is highly significant (at the $P < 0.01$ level). The effect of ambient temperature on calf behaviour was observed only in the case of standing/lying traits and showed a highly statistically significant relationship (at the $P < 0.01$ level).

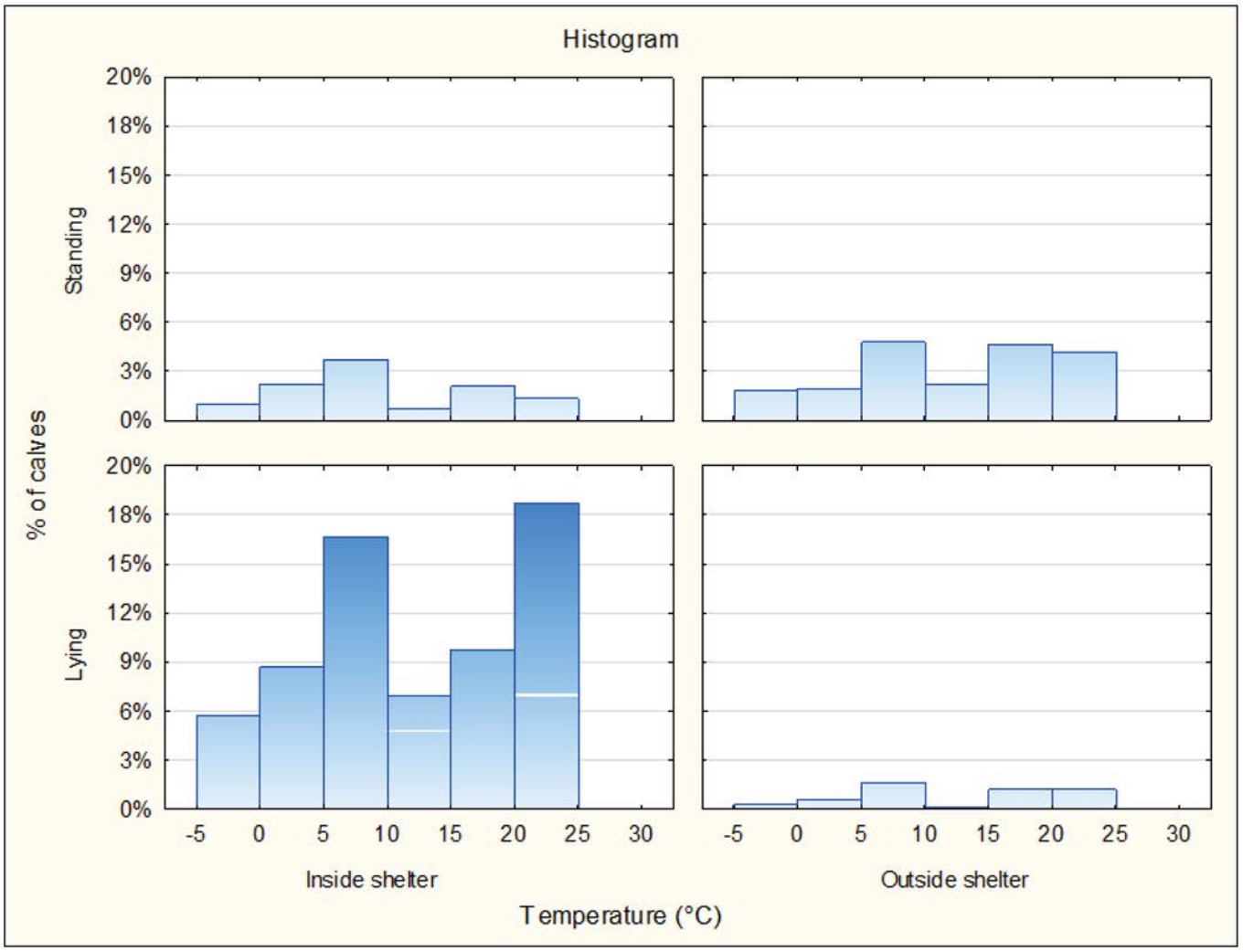

Figure 3. Frequency distribution of observed behaviour relative to the ambient temperature

A statistically non-significant effect of ambient temperature on the inside/outside selective behaviour was found. Hoshiba (1986), studying the relationship between ambient temperature and calf abundance of being inside shelters, reported a weak correlation (r = -0.071 to 0.192) between ambient temperature and calf abundance of being inside shelters.

Calf age as a continuous explanatory variable was evaluated and found to be statistically significantly related to calf behavioural characteristics in both cases. In the case of inside/outside, this relationship is highly statistically significant ($P < 0.01$). Average calf ages for the different behaviour types are shown in Table 3. Standing calves had an average age of 27.77 days compared to lying calves, which had an average age of 25.15 days.

Table 2. Influence of the selected effects on the behavioural traits of calves

Effect	Inside/outside	Standing/lying
	ChiSq	ChiSq
Temperature	N.S.	***0.01***
Season of birth	***0.05***	***0.01***
Sex	N.S.	N.S.
Sire	N.S.	N.S.
Age	***0.01***	***0.05***

N.S., not significant (*P* values > ChiSq); 0.05, 0.01, α values (level of significance)

Table 3. The average age of calves at different behavioural traits

Standing/lying	Mean age (days)	№	Inside/outside	Mean age (days)	№
Standing	27.77*	206	Inside	29.66*	165
Lying	25.15	477	Outside	24.76*	518

*statistically different means at $P < 0.05$ in the columns

Hanninen et al. (2005), in their study of calf behaviour on different flooring surfaces, confirm the results that age has a statistically significant effect on the interaction between lying and standing behaviour in pre-weaning dairy caves. Their findings suggest that standing behaviour becomes more prevalent as calves grow older. When observing standing inside or outside the shelter component, the average age of calves that stood in the shelter component was 29.66 days, while calves outside had an average age of 24.76 days. Liu, et al. (2020) evaluated the frequency of standing and lying in calves in both individual and pair housing. A group of 30 Holstein calves was used to determine the average duration of calf lying and standing during the day for different age groups of calves. Until the age of nine weeks, the proportion of lying down decreased and the proportion of standing increased. However, after nine weeks of age, the frequency of standing decreased and the frequency of lying increased for these calves.

The increasing frequency of standing up to nine weeks of age corresponds with the higher age value found with standing calves in this study. However, in the case of this study, all calves were housed in individual pen-and-shelter units no later than 8 weeks of age. Overvest et al. (2018) in their study of 20 Holstein calves also described the frequency of calves lying down with respect to their ages, reporting a continuous decrease of lying on the timeline between the 40th and 56th day of age of the calves.

Tables 4 and 5 provide a detailed Chi-square analysis of calf behaviour relative to levels of each trait for both observed behavioural traits. Both tables show the absolute and relative (%) frequencies of calves, divided on the one hand on the basis of each behaviour trait and on the other hand according to the levels of individual relationships that entered the model. Using superscripts for each level of each effect, a statistically significant difference between the individual levels of each relationship is indicated (the difference between the frequencies of each behavioural trait for each level of relationship, the values of these relative frequencies are highlighted in the tables by bold and italics).

Results in Table 4 reflect the analyses of the standing/lying behaviour of the calves. For the sex variable, there is no statistically significant difference in the frequency of lying/standing behaviour between the sexes, which is also evident from Table 2, where the effect of sex on this behaviour was not statistically significant in the observed group of calves. Heifer calves were observed to be standing in 33.13% of cases compared to 27.55% in the case of bull calves. As for the influence of the calves' time of birth, there were significant differences between seasons 1 (winter) and 2 (spring) and between 1 (winter) and 4 (autumn). In winter, 36.14% of calves preferred standing, while in spring it was 26.40% and in autumn 24.44% of calves.

The relationship between the ambient temperature and the frequency of lying and standing was especially evident at the highest temperatures, where significant differences between group 5 (temperatures above 20 °C) and the others, with the exception of the 3rd group (statistically non-significant difference compared to group 5) were found. In the group with temperatures above 20 °C, 21.76% of the animals were standing, while in the other temperature groups, which were significantly different, in that more than 30% of the calves were standing.

Table 4. Chi-square Analysis – Standings/lying

Standing/lying													
		Temperature					Season of birth				Sex		
Units	Level	1[a]	2[a]	3[a,b]	4[a]	5[b]	1[a]	2[b]	3[a,b]	4[b]	male[a]	female[a]	Total
Frequency	Standing	47	57	20	45	37	60	52	61	33	100	106	206
Percent		***31.54***	***31.84***	***29.85***	***38.14***	***21.76***	***36.14***	***26.40***	***32.97***	***24.44***	***27.55***	***33.13***	*30.16*
Frequency	Lying	102	122	47	73	133	106	145	124	102	263	214	477
Percent		***68.46***	***68.16***	***70.15***	***61.86***	***78.24***	***63.86***	***73.60***	***67.03***	***75.56***	***72.45***	***66.88***	*69.84*
Frequency	Total	149	179	67	118	170	166	197	185	135	363	320	683
Percent		*21.82*	*26.21*	*9.81*	*17.28*	*24.89*	*24.3*	*28.84*	*27.09*	*19.77*	*53.15*	*46.85*	*100*

In italics – frequencies in %; other – absolute frequencies. Different superscripts denoted statistically different behaviour on each level of effect (frequencies in bold italics)

Table 5. Chi-square Analysis – Inside/outside

Inside/outside													
		Temperature					Season of birth				Sex		
Units	Level	1[a]	2[a]	3[a,b]	4[a]	5[b]	1[a]	2[b]	3[a,b]	4[b]	male[a]	female[a]	Total
Frequency	Inside	118	136	51	79	134	120	152	133	113	275	243	518
Percent		***79.19***	***75.98***	***76.12***	***66.95***	***78.82***	***72.29***	***77.16***	***71.89***	***83.70***	***75.76***	***75.94***	75.84
Frequency	Outside	31	43	16	39	36	46	45	52	22	88	77	165
Percent		***20.81***	***24.02***	***23.88***	***33.05***	***21.18***	***27.71***	***22.84***	***28.11***	***16.30***	***24.24***	***24.06***	24.16
Frequency	Total	149	179	67	118	170	166	197	185	135	363	320	683
Percent		*21.82*	*26.21*	*9.81*	*17.28*	*24.89*	*24.3*	*28.84*	*27.09*	*19.77*	*53.15*	*46.85*	*100*

In italics: frequencies in %; other: absolute frequencies. Different superscripts denoted statistically different behaviour on each level of effect (frequencies in bold italics)

Overall, regardless of the above conditions, 30.16% of calves were standing at the time of observation and 69.84% of calves were lying down. The time spent by calves lying during the day is described in the study of Swartz et al. (2020), reporting that healthy calves spent on average 1093 minutes during the day lying down. This equates to 76% of the length of the day. Ugwu et al. (2021) evaluated the lying time of calves at different times of the day between 10:00 and 17:00. The calves were most active in the morning at 10.00 and then at 13:00 but exhibited resting behaviour around 12.00.

These results correspond with the findings of this study. Similar results were also reported by Todd et al. (2018), suggesting that calves lay down 70-83% of the day. Similarly, Chua et al. (2002) reported a lying down frequency of 72%.

In contrast, Tapki (2007) reported lying behaviour with calves up to 33 days of age in 26.61% of cases and in older calves in 39.53%. Sutherland et al. (2014) state that calves spend 69.7-73.1% of the time lying down and 30.3-26.9% standing, which is in line with the findings of this study. The mentioned authors used different types of bedding (stones, sawdust) in their work, while in this study all calves were housed in individual pen-and-shelter units with a standard straw bedding cover in all the shelters. Færevik et al. (2008) report from a study completed with 30 calves in Norway, that lying-down behaviour was observed in 64.65% of the calves. These calves were group-housed, with 5 calves per pen. Despite the different types of housing evaluated, this study reports a very similar trend in the frequency of calves laying down.

Table 5 reflects the results of the analysis of the inside/outside behaviour. The frequencies are different though non-significant relationships were reported between the sexes, similar to the findings reported in Table 3. With heifer calves, the abundance of presence inside the shelter was 75.94%, while in the case of bull calves almost identically at 75.76%. Regarding calf birth season, season 2 (spring) did not show a statistically significant difference from any other calf birth season. Of this group, 77.16% of calves preferred shelter. Seasons 1 (winter) and 3 (summer) did not differ significantly in their observations regarding shelter presence. During the winter months, the abundance of the presence of calves in the shelters was 72.29% and in the summer 71.89%. Compared to the winter and summer groups, the autumn group differed statistically significantly. The highest abundance of the presence of calves in shelters (83.70%) was recorded in autumn. The statistical relationship between the ambient temperature and preference for the shelter, is not as conclusive as in the case of the lying/standing trait, because the group experiencing the highest temperatures above 20 °C reaches almost the same occupancy frequencies (78.82%) as the group experiencing lower ambient temperatures. Temperature groups 1 (79.19%), 2 (75.98%) and 3 (76.12%) are therefore not statistically significantly different from group 5. As reflected in Table 5, only temperature group 4 shows a statistically significant difference (66.95% calves in the shelters) compared to groups 1 and 5.

In summary, 75.84% of calves were inside the shelter at the time of observation and only 24.16% of animals were outside. The findings of Chua et al. (2002) and Ugwu et al. (2021) correspond with the findings of this study.

According to Wormsbecher et al. (2017), 75.7% of animals were recorded as being outside the shelter in the summer months. Of these, 36.2% were standing and 47.4% were lying down. The ratio of animals recorded inside and outside the shelters was almost similar in the winter months (48.7% outside and 51.3% inside the shelter). These results, especially in the summer, are in conflict with the results found in this study. Wormsbecher et al. (2017) also report a higher ratio of animals standing in the summer months. This differs from the findings reported in this study.

In line with the reasoning forwarded by (Von Keyserlingk et al., 2017), the authors share the perspective and orientation that it would be improper to address one type of welfare concern (e.g., high rates of disease in dairy calves - a biological functioning concern) by imposing a solution that introduces new welfare concerns around natural living and affective state (e.g., the use of individual

housing that prevents natural interactions and play). Further research is necessary to assess the possibilities of interchangeably using different calf-rearing systems to avoid animal welfare challenges. The findings of Zábranský et al. (2021) and Zábranský et al. (2022) clearly highlight the importance of healthy feed in this sensitive period of growth of the calf and the authors found this very important practice during the assessment of the wellness of calves during the experimental period. The authors also view this completed study as a contribution to this process, thus also confirming the truth that welfare relies on scientific evidence, to support the building of consensus between the various stakeholders. This work can, however, not continue in isolation, void from context.

CONCLUSION

The findings of this study are in accordance with and support earlier findings that rearing pre-weaned dairy-type calves in outdoor individual pen-and-shelter systems is an acceptable practice and in alignment with the compliance measures set for animal welfare criteria in dairy production. Calves in such systems were not disadvantaged during the process. Results of this study suggest that the behaviour of calves in individual pen-and-shelter units shows considerable variability. Identifying and describing specific patterns of behaviour of calves in outdoor individual pen-and-shelter systems will require far more extensive research. The findings of this study contribute strongly to suggesting the acceptability of this practice.

A clear general preference for sheltering is evident, especially during the summer months. This is most probably related to the calves' natural biological need and effort to protect themselves from higher temperatures and intense sunlight outside the shelter. The age of calves has a significant effect on the sheltering preference and lying/standing behaviour of calves. Calves recorded lying outside the shelter were significantly younger than the calves remaining inside the shelter. At the same time, older calves preferred to stand. This corresponds to a higher degree of development of the individual and better physical condition of the calf. Similarly, no statistically significant heritability influence of the calf's father was observed in this study. Based on the findings of this study, an increased share of additive genetic variability in the behaviour of offspring at the beginning of life is not expected. The sex of the calf is also found to not play a significant role in the preference of shelter or standing/lying behaviour.

The significant influence of ambient temperature and the age of the calves (and thus the quality of weaning, which is significantly influenced by the breeder) and at the same time the non-significant influence of the father and sex of the calf suggest that the behaviour of calves is mainly influenced by environmental, especially animal production practices, and climatic influences. This suggests a considerable influence of the farmer management and decision-making system on the quality of calf rearing, not only by feeding but also by the suitable use and placement of outdoor individual pen-and-shelter systems.

The selected behavioural traits used in this study are considered important in analysing calve behaviour during their post-weaning rearing phase. The behaviour of calves is significantly affected by ambient temperature and the age of the calves. It can also be stated that no significant difference in lying/standing or inside/outside behaviour based on the sex of calves or the influence of the sire was observed. In conclusion, the authors recommend continued studies on the influence of environmental and livestock management practices on the rearing of pre-weaned dairy-type calves in outdoor individual pen-and-shelter systems.

REFERENCES

Borderas, T.F., de Passillé, A.M.B., Rushen, J. (2009) Feeding behaviour of calves fed small or large amounts of milk. Journal of Dairy Science, 92 (6), 2843-2852. DOI: https://doi.org/10.3168/jds.2008-1886

Buchli, C., Raselli, A., Bruckmaier, R., Hillmann, E. (2017) Contact with cows during the young age increases social competence and lowers the cardiac stress reaction in dairy calves. Applied Animal Behaviour Science, 187, 1-7. DOI: http://dx.doi.org/10.1016/j.applanim.2016.12.002

Conneely, M., Berry, D.P., Murphy, J.P., Lorenz, I., Doherty, M.L., Kennedy, E. (2014) Effects of milk feeding volume and frequency on body weight and health of dairy heifer calves. Livestock Science, 161, 90-94. DOI: https://doi.org/10.1016/j.livsci.2013.12.022

Costa, J.H.C., von Keyserlingk, M.A.G., Weary, D.M. (2016) Invited review: Effects of group housing of dairy calves on behaviour, cognition, performance, and health. Journal of Dairy Science, 99 (4), 2453-2467. DOI: https://doi.org/10.3168/jds.2015-10144

Edwards, E.M., Krawczel, P.D., Dann, H.M., Schneider, L.G., Whitlock, B., Proudfoot, K.L. (2020) Calving location preference and changes in lying and exploratory behaviour of preparturient dairy cattle with access to pasture. Journal of Dairy Science, 103 (6), 5455-5465. DOI: https://doi.org/10.3168/jds.2019-17218

Edwards, S.A., Broom, D.M. (1982) Behavioural interactions of dairy cows with theirnewborn calves and the effects of parity. Animal Behaviour, 30, 525-535.

Færevik, G., Tjentland, K., Løvik, S., Andersen, I.L., Bøe, K.E. (2008) Resting pattern and social behaviour of dairy calves housed in pens with different sized lying areas. Applied Animal Behaviour Science, 114, 54-64. DOI: https://doi.org/10.1016/j.applanim.2008.01.002

Flower, F., Weary, D. (2001) Effects of early separation on the dairy cow and calf: 2: Separation at 1 day and 2 weeks after birth. Applied Animal Behaviour Science, 70, 275-284. DOI: https://doi.org/10.1016/S0168-1591(00)00164-7

Forsberg, A.M., Pettersson, G., Ljungberg, T., Svennersten-Sjaunja, K. (2008) A brief note about cow lying behaviour - Do cows choose left and right lying side equally? Applied Animal Behaviour Science, 114, 32-36. DOI: https://doi.org/10.1016/j.applanim.2008.02.008

Gibbons, J., Medrano-Galarza, C., de Passillé, A.M., Rushen, J. (2012) Lying laterality and the effect of IceTag data loggers on lying behaviour of dairy cows. Applied Animal Behaviour Science, 136, 104-107. DOI: https://doi.org/10.1016/j.applanim.2011.12.005

Hanninen, L., de Passille, A.M., Rushen, J. (2005) The effect of flooring type and social grouping on the rest and growth of dairy calves. Applied Animal Behaviour Science, 91 (3–4), 193-204. DOI: https://doi.org/10.1016/j.applanim.2004.10.003

Hendriks, S.J., Huzzey, J.M., Kuhn-Sherlock, B., Turner, S.A., Mueller, K.R., Phyn, C.V.C., Donaghy, D.J., Roche, J.R. (2020) Associations between lying behaviour and activity and hypocalcemia in grazing dairy cows during the transition period. Journal of Dairy Science, 103 (11), 10530-10546. DOI: https://doi.org/10.3168/jds.2019-18111

Hepola, H., Hänninen, L., Pursiainen, P., Tuure, V.M., Syrjälä-Qvist, L., Pyykkönen, M., Saloniemi, H. (2006) Feed intake and oral behaviour of dairy calves housed individually or in groups in warm or cold buildings. Livestock Science, 105, 94-104. DOI: https://doi.org/10.1016/j.livsci.2006.04.033

Hill, T.M., Bateman II, T.G., Aldrich, J.M., Quigley, J.D., Schlotterbeck, R.L. (2013) Intensive measurements of standing time of dairy calves housed in individual pens within a naturally ventilated, unheated nursery over different periods of the year. Journal of Dairy Science, 96, 1811-1814. DOI: http://dx.doi.org/ 10.3168/jds.2012-6206

Hoshiba, S. (1986) Environmental characteristics of calf hutches. Journal of the Faculty of Agriculture, Hokkaido University, 63 (1), 64-103.

Chua, B., Coenen, E., van Delen, J., Weary, D.M. (2002) Effects of Pair Versus Individual Housing on the Behaviour and Performance of Dairy Calves. Journal of Dairy Science, 85 (2), 360-364. DOI: https://doi.org/10.3168/jds.S0022-0302(02)74082-4

Liu, S., Ma, J., Li, J., Alugongo, G.M., Wu, Z., Wang, Y., Li, S., Cao, Z. (2020) Effects of Pair Versus Individual Housing on Performance, Health, and Behaviour of Dairy Calves. Animals, 10 (1), 50. DOI: https://doi.org/10.3390/ani10010050

Overvest, M.A., Crossley, R.E., Miller-Cushon, E.K., DeVries, TJ. (2018) Social housing influences the behaviour and feed intake of dairy calves during weaning. Journal of Dairy Science, 101 (9), 8123-8134. DOI: https://doi.org/10.3168/jds.2018-14465

Pempek, J.A., Eastridge, M.L., Proudfoot, K.L. (2017) The effect of a furnished individual hutch pre-weaning on calf behaviour, response to novelty, and growth. Journal of Dairy Science, 100 (6), 4807-4817. DOI: https://doi.org/10.3168/jds.2016-12180

Sutherland, M.A., Worth, G.M., Stewart, M. (2014) The effect of rearing substrate and space allowance on the behaviour and physiology of dairy calves. Journal of Dairy Science, 97 (7), 4455-4463. DOI: https://doi.org/10.3168/jds.2013-7822

Swartz, T.H., Schramm, H.H., Petersson-Wolfe, Ch.S. (2020) Short Communication: Association between neonatal calf diarrhea and lying behaviours. Veterinary and Animal Science, 9. DOI: https://doi.org/10.1016/j.vas.2020.100111

Tapki, I. (2007) Effects of individual or combined housing systems on behavioural and growth responses of dairy calves. Acta Agriculturae Scandinavica, 57, 55-60. DOI: https://doi.org/10.1080/09064700701464405

Todd, C.G., Millman, S.T., Leslie, K.E., Anderson, N.G., Sargeant, J.M., DeVries, TJ. (2018) Effects of milk replacer acidification and free-access feeding on early life feeding, oral, and lying behaviour of dairy calves. Journal of Dairy Science, 101 (9), 8236-8247. DOI: https://doi.org/10.3168/jds.2018-14487

Ugwu, N., Love, E., Murrell, J., Whay, H.R., Knowles, T., Hockenhull, J. (2021) Development of an ethogram for hutch-housed dairy calves and determination of factors influencing their behaviour. Applied Animal Behaviour Science, 234. DOI: https://doi.org/10.1016/j.applanim.2020.105165

Von Keyserlingk, M.A.G., Hötzel, M.J. (2015) The Ticking Clock: Addressing Farm Animal Welfare in Emerging Countries. Journal of Agricultural and Environmental Ethics, 28, 179-195. DOI: https://doi.org/10.1007/s10806-014-9518-7

Von Keyserlingk, M.A.G., Weary, D.M. (2017) A 100-Year Review: Animal welfare in the - The first 100 years. Journal of Dairy Science, 100, 10432-10444. DOI: https://doi.org/10.3168/jds.2017-13298

Wagner, K., Barth, K., Hillmann, E., Palme, R., Futschik, A., Waiblinger, S. (2013) Mother rearing of dairy calves: reactions to isolation and to confrontation withan unfamiliar conspecific in a new environment. Applied Animal Behaviour Science, 147,43-54. DOI: https://doi.org/10.1016/j.applanim.2013.04.010

Waiblinger, S., Wagner, K., Hillmann, E., Barth, K. (2013) Play and social behaviour of calves with or without access to their dam and other cow. Journal of Dairy Research, 87 (S1), 144-147. DOI: https://doi.org/10.1017/S0022029920000540

Wormsbecher, L., Bergeron, R., Haley, D., de Passillé, A.M., Rushen, J., Vasseur, E. (2017) A method of outdoor housing dairy calves in pairs using individual calf hutches. Journal of Dairy Science, 100 (9), 7493-7506. DOI: https://doi.org/10.3168/jds.2017-12559

Zábranský, L., Poborská, A., Gálik, B., Šoch, M., Brož, P., Kantor, M., Kernerová, N., Řezáč, I., Rolinec, M., Hanušovský, O., et al. (2022) Influence of Probiotic Strains Bifidobacterium, Lactobacillus, and Enterococcus on the Health Status and Weight Gain of Calves, and the Utilization of Nitrogenous Compounds. Antibiotics, 11 (9), 1273. DOI: https://doi.org/10.3390/antibiotics11091273

Zábranský, L., Poborská, A., Malá, G., Gálik, B., Petrášková, E., Kernerová, N., Hanušovský, O., Kučera, J. (2021) Probiotic and prebiotic feed additives in calf nutrition. Journal of Central European Agriculture, 22 (1), 14-18. DOI: https://doi.org/10.5513/JCEA01/22.1.3057