Applied Animal Behaviour Science 206 (2018) 18–24

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim

On-farm factors associated with cross-sucking in group-housed organic Simmental dairy calves

Verena Größbacher*,[1], Christoph Winckler, Christine Leeb

Division of Livestock Sciences, Department of Sustainable Agricultural Systems, University of Natural Resources and Life Sciences, Vienna, Austria

ARTICLE INFO

Keywords:
Dairy calves
Group housing
Cross-sucking
On-farm assessment
Hazards

ABSTRACT

In EU organic dairy farming, group housing of calves is required after the first week. Especially in Simmental herds, this is perceived as a risk factor for cross-sucking (CS), i.e. sucking the udder-region or the scrotal area or any other body part of another calf, which may reflect frustrated motivation, lead e.g. to umbilical infections or be continued after weaning. Therefore, this study aimed at identifying factors associated with cross-sucking to provide farmers with effective preventive measures and to investigate potential relations of cross-sucking with treatment incidences. During one-day visits data were collected by the same observer on 31 organic dairy farms with Simmental cattle. The visits included 90 min of direct continuous behaviour observation starting at the morning milk meal, semi-structured interviews and analysis of treatment records (available from n = 25 farms). The average herd size was 31 ± 10 cows (range: 17–59) and 11 ± 7 calves (range: 3–37) with a mean of 4 ± 2 calves per group (range: 2–8). Potential risk factors were screened using univariable analyses or Spearman rank correlation (inclusion threshold $P < 0.2$). General linear models with backward selection of factors were applied for final modelling. Associations between behaviour and health data were identified using Spearman rank correlation. CS was observed on 29 farms (94%) at a median rate of 1.66 (Q1 = 0.70, Q3 = 3.00) events/calf*hour. CS (explained variation 61.3%, Intercept = 2.75) decreased when age was similar within group (estimate = −2.40, p = 0.001) and increased when calves were not restrained during the milk meal (as compared with restraint for > 30 min; 1.46, p = 0.026). It was shown less frequently when use of nose-clips was not reported as a countermeasure (−2.22, p = 0.008). Duration of sucking at teat buckets was negatively correlated with CS (−0.23, p = 0.018) and the age at grouping had no significant effect on its occurrence. There were no significant correlations of cross-sucking and treatment incidences of diarrhoea, respiratory diseases and umbilical infections. This on-farm study comprising Simmental organic dairy herds partly confirms existing knowledge on preventive measures (e.g. homogenous age groups, long duration of sucking) to be applicable on-farm. Furthermore, it provides evidence that grouping after the first week of life is possible without an increased risk for cross-sucking. The perceived risk of cross-sucking leading to infections could not be proven, as most likely other factors are more relevant.

1. Introduction

Artificial rearing of calves is common practice in modern dairy farming. In EU organic agriculture, the minimum milk feeding period is 90 days. Group housing, i.e. any housing other than individual housing, is required by law from the eighth day of life (C.2, Art.11, Commission Regulation (EC) No 889/2008).

Calves are mostly separated from the dams shortly after birth and receive milk from bottles, open buckets, buckets with artificial teats (Klein-Jöbstl et al., 2014, Vasseur et al., 2010) or automatic milk feeding devices (Medrano-Galarza et al., 2017). Especially when fed twice daily only, the rearing and milk feeding conditions may lead to a lack of opportunities to express sucking behaviour in terms of frequency of sucking and total sucking duration and thus cause redirection of the behaviour towards other calves (Jensen, 2003). Calves suckled by their mothers are stimulated to direct their oral activities towards the udder for milk intake (Veissier et al., 2013). Artificially reared calves lacking their mother's support may thus additionally direct the sucking behaviour towards other calves, which is facilitated by group housing of calves.

* Corresponding author at: Division of Livestock Sciences, Department of Sustainable Agricultural Systems, University of Natural Resources and Life Sciences, Vienna, Gregor-Mendel-Straße 33, 1180 Vienna, Austria.
E-mail address: verena.groessbacher@boku.ac.at (V. Größbacher).
[1] Verena Größbacher is currently a recipient of a DOC Fellowship of the Austrian Academy of Sciences.

https://doi.org/10.1016/j.applanim.2018.05.030
Received 16 June 2017; Received in revised form 9 May 2018; Accepted 27 May 2018
Available online 02 June 2018

While definitions vary, cross-sucking is mostly referred to as sucking of any part of another calf's body (Jensen, 2003; Margerison et al., 2003; Jung and Lidfors, 2001), and intersucking as sucking of the udder area (Keil and Langhans, 2001). Cross-sucking results from a strong but thwarted sucking motivation which may reflect frustration in the performing calf (Jensen, 2003; de Passillé, 2001; Costa et al., 2016) and induce digestive disorders and diarrhoea in the sucking calf (Hofman, 1992). Cross-sucking may also lead to hairloss or skin infections in the sucked calf (Lidfors, 1993). A further important concern regards the formation of habits and continuation of the behaviour in the form of intersucking in heifers or cows (Keil et al., 2001; de Passillé et al., 2011), potentially associated with udder deformations, mastitis, and milk loss (Lidfors and Isberg, 2003). A questionnaire study by Lidfors and Isberg (2003) revealed associations of intersucking in calves and heifers with *A. pyogenes* mastitis as well as of intersucking in calves with teat injuries in heifers. However, in an experimental study, heifers which had been sucked on the navel or belly at the age of four to five months did not differ from control animals with regard to mastitis incidence or damaged udders during the first lactation (Vaughan et al., 2016).

In Simmental cattle for which a genetic predisposition for the trait abnormal sucking has been shown (Fuerst-Waltl et al., 2010), cross-sucking and intersucking can present a severe problem. In Austria, where the majority of dairy cattle belong to the Simmental breed (approx. 76%, Kalcher et al., 2017), dairy farmers ranked intersucking together with claw health and metabolic resilience highest in terms of new breeding goals (Steininger et al., 2012). Austrian organic cattle farmers can also make use of an exemption clause to keep calves singly for 'health or behaviour reasons' for up to eight weeks (Circular of BMGFJ 75340/0038-IV/B/7/2007).

To successfully implement group housing at eight days of life, farmers need to be provided with expertise for keeping calves in groups at a young age, feasible for small-scale farming while limiting the risks for cross-sucking. Numerous experimental studies have addressed the motivational basis of the behaviour and factors that affect the incidence of cross-sucking in pre-weaned calves. For example, de Passillé and Rushen (1997) showed that sucking of an artificial teat is triggered by milk intake, but also elicited by external influences such as energy deficit and stimuli from conspecifics. A low energy balance, most likely resulting in hunger (Roth et al., 2009), as well as insufficient concentrate intake around weaning and thus deficient rumen development (Roth et al., 2008) may also trigger cross-sucking.

Apart from the considerable body of evidence resulting from experiments, epidemiological approaches can help provide complementary information in identifying important sources of variation in welfare (Rushen, 2003). In the limited number of previous epidemiological studies, risk factors for cross-sucking were assessed indirectly only. Keil et al. (2000) evaluated hazards for intersucking in dairy heifers with on-site personal interviews, while Lidfors and Isberg (2003) used telephone interviews to identify factors associated with sucking under the belly. The only study assessing cross-sucking in calves directly on-farm conducted no further research on hazards beyond feeding parameters (Keil and Langhans, 2001).

Countermeasures to prevent cross-sucking mainly aim at suppressing symptoms rather than addressing the underlying motivation. In Austria, the most common measures are restraint during the milk meal, individual housing and use of nose clips (Rinnhofer, 2008), which all may impair the wellbeing of calves (e.g. Jensen, 2001).

Therefore, it is important to identify effective preventive measures to reduce the motivation to perform cross-sucking and not solely withdraw the opportunity to perform this behaviour. Due to the multifactorial nature of cross-sucking in calves, on-farm studies of calves housed in groups from a young age may help detect risk factors present under current farming conditions.

In the present study we thus aimed to (1) evaluate the occurrence of cross-sucking in pre-weaned dairy calves along with the farmers' estimation thereof; to (2) assess factors associated with cross-sucking in calves relevant for the conditions of organic dairy farming in Austria; and to (3) determine a possible relationship of cross-sucking with disease incidence.

2. Methods

2.1. Animals and farms

Data were collected on 31 organic dairy farms in Austria. The farms were located in the federal states of Upper Austria and Lower Austria and were visited between April and June 2012. Criteria for selection of farms were group-housing of calves, keeping calves of the breed Fleckvieh ('Simmental') and having a minimum of three pre-weaned Simmental calves. Farms keeping also cows of breeds other than Simmental were considered but in these cases only calves of the Simmental breed were included in the observations, but these calves may have been kept with calves of other breeds. Recruitment of farms was supported by an organic farming association and an advisory body which sent emails and letters to farmers. Due to a low response rate, farmers were additionally phoned and asked for their agreement to participate in the study. Recruitment of farms ended when approx. 40 farms had been identified, but only 31 farms were finally included as not all farm visits were feasible before weaning of calves.

The average number of animals per farm was 11.2 ± 6.7 calves (mean ± SD, range: 3–37) and 30.5 ± 10.0 cows (range: 17–59). In cases in which farms had crossbred calves, these groups were only included if the majority of calves in the pen was of the Simmental breed and only data from Simmental calves were collected. In total data from 39 pens and 295 calves were included in the final data analysis (see 2.6.). The average group size was 3.7 ± 1.6 (range: 2–8) calves with the median age category of observed calves being 5–8 weeks. All calves were housed in pens with a straw-bedded lying area (see also Table 1 for further details).

2.2. Data collection

The data collection protocols were developed based on a literature review followed by a discussion with researchers and an organic farming advisor. Prior to the farm visits, all parts of the assessment were pre-tested on two farms for feasibility and subsequently modified and complemented, if necessary. These two farms were used for pilot-trials only and were not included in the final dataset (n = 31 farms). All farm visits were conducted by the same observer (the first author). Each farm visit started with the behaviour observation, followed by an assessment of the housing conditions, an interview with the farmer and an evaluation of the veterinary treatment records. For the assessment no invasive procedures were used and disturbance of animals was avoided as much as possible. To ensure the health of animals and prevent spreading of disease, standard procedures for hygiene and disinfection were abided.

2.2.1. Behaviour

Using 'behaviour sampling' (Martin and Bateson, 2007), observations took place continuously for 90 min starting with the morning milk meal and, if calves were restrained, periods of restraint were included. In these cases restraint of calves during milk feeding was achieved in lockable feeder stands (29.0 ± 18.5 min, n = 20 farms), which allowed tactile contact to neighbouring calves in the head region. When calves were kept in multiple pens, the observer rotated between groups with a minimum and maximum observation bout length of 10 and 20 min per group, respectively, before switching to the next group. The mean observation period per pen was 51.3 ± 15.7 min. To minimise the influence of the observer, calves were always observed from the same distance (1–1.5 m in front of the feeding rack). Furthermore, the observer did not approach the calves before and during the observation.

Table 1
Characteristics of housing, management and feeding practices for 31 Austrian organic dairy farms enrolled in the study (data presented relate to the conditions the assessed calves were exposed to). Potential risk factors identified in the pre-selection are marked as continuous variable or as categorical variable.

Housing and management characteristics	Unit	Details on characteristics	Type of variable	Used in multivariable regression analysis[a]
Housing type	Warm | Cold | Mixed | Calf hutch[b]	10 (32.3%) | 10 (32.3%) | 6 (19.4%) | 5 (16.1%)[d]	categorical	no
Outdoor run	Yes | No	20 (64.5%) | 11 (35.5%)[d]	categorical	no
Pasture for pre-weaned calves	Yes | No	2 (6.5%) | 29 (93.5%)[d]	categorical	no
Group size	Number of calves per group	3.7 ± 1.6 (range: 2-8)[e]	continuous	no
Size of lying area	m^2 per calf | m^2 in total	3.5 (2.3, 5.5) | 11.8 (9.3, 18.9)[f]	continuous	yes
Animal:feeding place ratio	Number of feeding places per calf	1.3 (1.0, 2.0)[f]	continuous	yes
Age of access to outdoor run	Weeks	2 (1.4, 3.3)[f]	continuous	no
Age of entering group housing	8 days | > 8 days	6 (19.4%) | 25 (80.7%)[d]	categorical	yes
Age difference within groups	Low (one age group) | High (> one age group)[c]	12 (38.7%) | 19 (61.3%)[d]	categorical	yes
Contact with mother	Hours after birth	1.0 (0.5, 6.0)[f]	continuous	no
Milk quantity per day	Litres per day	7.6 ± 2.5 (range: 3.6-15)[e]	continuous	yes
Milk quantity per meal	Litres per meal	3.7 ± 1.2 (range: 1.5-7.5)[e]	continuous	yes
Duration of milk meal	Minutes of drinking milk	1.9 (0.9, 5.1)[f]	continuous	yes
Duration of sucking	Minutes of sucking during and after milk meal	5.4 (3.5, 7.8)[f]	continuous	yes
Restraint during milk meal	No restraint | ≤ 30 min | > 30 min	11 (35.5%) | 12 (38.7%) | 8 (25.8%)[d]	categorical	yes
Preventive measures	Nose clips | Regrouping | Isolation | Hay after milk meal | Concentrates after milk meal	26 (83.9%) | 6 (19.4%) | 5 (16.1%) |19 (61.3%) | 16 (51.6%)[d]	categorical	yes (nose clips)

[a] $P < 0.20$ in univariable testing.
[b] Warm = insulated building, Cold = uninsulated building with openings, Mixed = not clearly assignable to Warm or Cold, Calf hutch = hutch/igloo placed outside.
[c] Age groups were defined as follows: 1 week, 2–4 weeks, 5–8 weeks, 9 weeks to 6 months.
[d] Percentage per category.
[e] Mean ± SD, range.
[f] Median, quartiles.

All incidences of the two following behaviours were recorded: Intersucking (INTER) was defined as a calf sucking the udder-region or scrotal area of another calf as if drinking milk (as indicated by e.g. body posture, head butting, sucking noises), irrespective of the sex of the sucked calf. This was distinguished from sucking any other part of another calf's body with exception of the udder region or scrotal area, e.g. the neck, ear or navel/prepuce of another calf, as if drinking milk was recorded (BODY). For sucking at the muzzle region, both calves were counted as actors. The composite measure cross-sucking (CS) was created by summing up the number of events observed for both BODY and INTER, thus comprising all sucking events directed at any part of another calf's body. Performance of one of these behaviours was counted as one single event when displayed for a minimum of 10 s. When the behaviour was interrupted for more than 5 s and then started again, this was counted as a new event. The number of events was recorded per animal and the incidence per animal and hour was calculated taking the number of animals visible before and after each observation unit into account.

Additionally, the duration of the milk meal and the duration of non-nutritive sucking at the artificial teat after the meal were recorded for the middle calf per group (e.g. third calf fed out of five calves). This information was not considered an outcome variable but used as potential influencing factor in the association analysis.

2.2.2. Management and environment

Data on management and environment of calves were collected for characterisation of farms but primarily served as input for the subsequent analyses. The selection of items covering potential influencing factors was based on previously known relationships and hypotheses.

On all farms calves were fed whole milk from teat buckets. Information about amounts of milk fed and frequency of milk meals was collected by interviewing the farmer. To assess the animals` environment, pen size and structure, the amount of bedding and provision of feed and water were evaluated. After data collection in the barn, semi-structured interviews with the farmer including closed (e.g. 'Which weaning strategy is applied?', possible answers: 'abrupt weaning' or 'gradual weaning') and open questions on herd and farm characteristics, housing, practices of milk, roughage and concentrate feeding and self-evaluation of non-nutritive sucking occurrence (e.g. 'At which age are calves weaned?') were carried out. Housing management and feeding practices are displayed in detail in Table 1 (for full questionnaire see Supplementary material).

Additionally, the farmers were asked whether they are aware of any cross-sucking in the pre-weaned calves at the time of the farm visit.

2.2.3. Health situation

To gain information on the calf health situation per farm, veterinary records of the previous 12 months were analysed. Treatment incidences were expressed as cases per 100 calves per year for the categories diarrhoea, respiratory diseases, umbilical inflammation and diseases in total. Veterinary records were obtained from 25 farms only because not all farmers agreed to provide this information.

2.3. Data management and statistical analysis

Continuous data, e.g. age at entering groups, were recorded in numbers and categorical data e.g. access to outdoor run (yes/no) were recorded as 0 and 1. Behavioural data were expressed as events per calf and hour and subsequently averaged at pen and at farm level.

For data analysis the statistical software package SAS 9.2 (SAS Institute Inc., Cary, NC) was used. As normality assumptions for behavioural data were not fulfilled, incidences of BODY and INTER were expressed as median rates with quartiles.

Due to non-normal distribution and to satisfy underlying assumptions for linear analysis, the composite measure CS was log-transformed. In a preselection step, potential risk factors were univariably screened for associations with CS using a general linear model (categorical factors) or Spearman rank correlation analysis. For this purpose, also independent variables were log-transformed if assumptions underlying parametric statistical methods were not fulfilled. Otherwise they were excluded from further evaluation if normal distribution of residuals was not achieved. Following previous studies using similar

Table 2
Agreement of farmers' and observer's evaluation on the presence of inter-sucking (INTER) and sucking at any other part of another calf's body (BODY) of pre-weaned calves (n = number of farms).

Farmer	INTER				BODY			
	Observer							
	No		Yes		No		Yes	
	n	%	n	%	n	%	n	%
No	16	51.6	7	22.6	3	9.7	20	64.5
Yes	4	12.9	4	12.9	0	0.0	8	25.8

approaches (e.g. Ivemeyer et al., 2009; Svensson et al., 2006), factors were included in the final analysis when found to be associated at $P < 0.2$. Final modelling took place using a general linear model with backward elimination (threshold for removal $p > 0.05$). If the removal of a variable changed the parameter estimate of any of the remaining covariates by > 25%, the eliminated variable was retained as a confounder (Dohoo et al., 2010; Cramer et al., 2009). Residuals were graphically checked for normal distribution. Estimates and Standard Errors presented are based on non-transformed data.

To assess whether the farmers' report on the presence of cross-sucking was in accordance with the behavioural observations, Cohen's Kappa coefficients were calculated. For this purpose, based on the behaviour observations, farms were classified as 1 for INTER or BODY if any occurrence of the respective behaviours and 0 if no occurrence had been recorded by the observer. Similarly, the farmers' responses were categorized as 1 if in their perception cross-sucking was present and 0 if it was not present on the farm.

To identify possible associations between CS and treatment incidences, Spearman rank correlations were used. The alpha level was set at $P < 0.05$.

3. Results

3.1. Incidence of cross-sucking

Intersucking (INTER) was observed at 11 farms (36%), sucking at any other part of another calf's body (BODY) at 28 farms (90%), and CS at 29 farms (94%). Across all farms (n = 31), INTER and BODY were observed at a median rate of 0.00 (Q1 = 0.00, Q3 = 0.39) and 1.25 (Q1 = 0.49, Q3 = 3.00) events per calf and hour, respectively. CS was observed at a median rate of 1.66 (Q1 = 0.70, Q3 = 3.00) per calf and hour. The median percentage of calves per farm performing INTER and BODY was 0% (Q1 = 0%, Q3 = 25%) and 50% (Q1 = 28%, Q3 = 75%), respectively, with a median number of three calves observed. Taking only farms with occurrences of INTER or BODY into consideration, the median incidences were 0.74 (Q1 = 0.27, Q3 = 2.00) and 1.44 (Q1 = 0.56, Q3 = 3.23) events per calf and hour. With the same considerations, the median percentages of calves performing BODY and INTER were 33% (Q1 = 20%, Q3 = 50%) and 50% (Q1 = 33%, Q3 = 75%).

The farmers' assessment of the presence of cross-sucking with the presence of INTER and BODY as assessed by the observer showed low agreement between the farmers' evaluation and the observer ($\kappa = 0.1743$ and $\kappa = 0.0719$, respectively; Table 2).

3.2. Multivariable linear regression model

Out of 10 potential risk factors identified in the pre-selection step (see Table 1), six variables were retained in the final model which explained 61.3% of the variance. Four variables emerged as significant risk factors (see Table 3). Similar age within a group was associated with a decreased occurrence of CS. Likewise, CS was less frequently shown when calves were restrained in the feeder stands during the milk meal for more than 30 min compared to non-restrained calves and on farms where nose clips were reported as a countermeasure. Furthermore, the total duration of sucking the artificial teat during (nutritive) and after the milk meal (non-nutritive) was negatively associated with the occurrence of CS. The amounts of milk per meal and per day had no significant effect on CS but were retained in the final model ($p < 0.2$) to account for confounding. Factors removed from the final model (all $p > 0.5$) were age at entering groups, size of lying area per calf and in total as well as the animal:feeding place ratio.

3.3. Relation between cross-sucking and disease treatment incidences

Median incidences of veterinary treatments were 3.9 (Q1 = 0.0, Q3 = 9.8) for diarrhoea, 0.0 (Q1 = 0.0, Q3 = 11.1) for respiratory diseases, 0.0 (Q1 = 0.0, Q3 = 0.0) for umbilical inflammation and 6.9 (Q1 = 3.9, Q3 = 21.4) for diseases in total per 100 calves and year. There were no significant correlations of cross-sucking and disease treatment incidences, however umbilical inflammation tended to be negatively associated with intersucking with farms with lower incidence of intersucking being more likely to treat umbilical inflammation (Table 4).

4. Discussion

This study (1) reports the occurrence of cross-sucking on small-scale organic farms in Austria. It further (2) identifies factors associated with cross-sucking and (3) aims to determine associations of performing cross-sucking with the health state of calves in terms of treatment incidences. The results indicate that cross-sucking is a frequent behavioural disorder as intersucking, i.e. sucking in the udder/scrotal region, was observed on more than one third of the farms (INTER, 36%) and sucking on any other part of the calf's body on almost all farms (BODY, 90%). At an average group size of 3–4 calves, median percentages of 33% and 50% of calves performed intersucking and sucking of

Table 3
Final multivariable regression model for the incidence of cross-sucking (CS) in 31 Austrian organic dairy farms.

Factor	df	Level/Unit	Estimate	SE	F-value	t-value	p-value
Intercept			2.75	1.10	–		< 0.001
Age difference within group	1	low | high	−2.40	0.63	13.68		0.001
Restraint during milk meal	2		–	–	3.84	–	0.036
		≤ 30 min | > 30 min	0.15	0.73	–	0.26	0.801
		no restraint | > 30 min	1.46	0.72	–	2.38	0.026
Use of nose clips	1	no | yes	−2.22	0.88	8.58		0.008
Duration of sucking	1	min per meal	−0.23	0.08	6.52		0.018
Quantity of milk per meal[a]	1	litres	−0.69	0.77	2.15		0.156
Quantity of milk per day[a]	1	litres	0.55	0.39	2.91		0.102

[a] Confounding variable.

Table 4
Spearman rank correlation coefficients for the association between incidences of intersucking (INTER) and sucking at any other part of another calf's body (BODY) with veterinary treatment incidences for selected diseases (n = 25 farms).

		Diarrhoea	Respiratory Diseases	Umbilical Inflammation	Total Treatments
INTER	Estimate	0.12	−0.03	−0.36	−0,07
	p-value	0.58	0.90	0.08	0.73
BODY	Estimate	0.03	0.13	0.05	0.01
	p-value	0.89	0.53	0.83	0.96

other parts of the body, respectively, on affected farms. These results are similar to those of a Swiss questionnaire study in which mutual sucking of body parts was reported by the farmers on 93% of farms and in 50% of calves per farm (Keil et al., 2000). Survey data may however be biased and therefore we decided to conduct direct observations in the present study. Observations were carried out only once, but given the consistent motivation to cross-suck associated with the milk meal (de Passillè, 2001) no major fluctuations were expected at farm level.

Considering that the majority of cross-sucking events are performed by few calves of a group only and with preferred partners (Keil and Langhans, 2001; Vaughan et al., 2016), actors would have been less likely to find receivers in the comparatively small groups. However, the high percentage of calves performing the behaviour may be due to the less controllable composition of groups in small-scale farming, possibly resulting in higher age differences within groups. This may lead to an increased likelihood of actors finding receivers with higher bodyweights, a risk factor for being cross-sucked (Laukkanen et al., 2010). Another explanation for the high incidence of cross-sucking and the high percentage of calves performing the behaviour is that the investigated breed Simmental is known to hold a genetic predisposition for abnormal sucking (Fuerst-Waltl et al., 2010).

Assessments of the occurrence of cross-sucking by the observer and the evaluation by the farmers were often conflicting as intersucking was observed on 23% of farms and sucking other parts of the body on 65% of farms for which farmers reported no occurrence of these behaviours. This resulted in very low agreement between observer and farmers (kappa coefficients < 0.2; Martin and Bateson, 2007). This discrepancy could be due to farmers leaving the barn soon after milk feeding the calves and simply not observing cross-sucking. In the 12% of cases in which the presence of intersucking was reported by the farmer but no such behaviour was observed during the visits, the farmer may have referred to incidences of cross-sucking independent from the milk meal (Roth et al., 2009), which would not have been recorded due to the design of the study.

To determine risk factors for cross-sucking, BODY and INTER were combined to CS as on 10 of 11 farms where intersucking was observed also sucking of other parts of the body occurred. Moreover, calves restrained for the milk meal might have redirected their motivation to perform intersucking towards sucking the head of another calf. Therefore, both behaviours would be elicited by similar internal and external factors. Although a considerable share of cross-sucking events has been reported to be disconnected from milk ingestion (Roth et al., 2009), we assume that the current study mainly refers to cross-sucking related to the milk meal (Keil and Langhans, 2001), as observations covered only 1.5 h including the morning milk meal and did not last for the entire day.

In the final model, six out of ten factors that had been identified in the univariable screening were retained. Four of these factors were considered significant in explaining the occurrence of cross-sucking while two factors were not removed as they had been recognized as confounding variables. The risk factors ascertained in the current study reflect the importance of management on rearing of calves: Age heterogeneity within group affected cross-sucking as a high age difference increased the performance of CS in this study. Keil et al. (2000) detected a similar risk factor in heifers, arguing that a high age difference within the pen would lead to an inappropriate diet. Thus, a high age difference could cause an inadequate energy supply, resulting in higher risks of cross-sucking (Roth et al., 2009). This, however, only applies to provision with roughage and concentrates as appropriate milk intake was assured. Age heterogeneity may also correlate with a greater variation in rate of ingesting milk with older calves finishing the milk meal sooner and then performing cross-sucking on the calves which are still ingesting milk.

Nevertheless, undisturbed feeding (Keil et al., 2000) and thereby adequate energy intake may also be achieved by restraint during and after the milk meal, which may thus reduce cross-sucking. At the same time restraint during the milk meal at least impedes the performance of cross-sucking. While the ingestion of milk can stimulate cross-sucking (de Passillé et al., 1992; De Passillé et al., 1997), the motivation to perform this behaviour decreases after 10–15 minutes (Lidfors, 1993). Thus, restraint can only inhibit milk-dependent sucking and redirect it towards fixtures or the head of pen-mates.

84% of farmers reported the use of anti-sucking devices fitted into the nostrils, usually with spikes made of sturdy plastic, which cause the target animal to withdraw, but de facto only one calf wore such a device. Thus farmers possibly also referred to weaned calves and heifers when reporting on the use of nose-clips. CS was displayed more frequently on farms reporting to apply nose-clips as a countermeasure but this is likely to solely reflect the use of nose-clips on farms where this behaviour is perceived as a problem.

The only ascertained risk factor directly related to the milk meal was duration of sucking the teat bucket during and after the milk meal with increasing sucking time decreasing sucking directed at other calves. Non-nutritive sucking on an artificial teat has also been found to reduce cross-sucking (de Passillé, 2001) reflecting that the motivation to perform cross-sucking is diminished by performing the sucking behaviour itself (Rushen and De Passillé,1995). While mother-reared calves would perform approximately 60 min of sucking per day (Sambraus, 1985), in the present study the average total duration of sucking the teat of the milk feeding bucket around the morning meal was 5.4 min. The findings indicate that even small increases in the time period calves are allowed to suck the teat (interquartile range: 3.5–7.8 min) result in a reduction of the sucking motivation.

The majority of previous experimental studies addressing cross-sucking in calves investigated its relationship to milk feeding method and ingestion of milk (e.g. Rushen and De Passillé, 1995; De Passillé et al., 1997; Jung and Lidfors, 2001). However, in previous risk factor analyses the only factor related to the milk meal identified was the amount of milk fed. Feeding more than six (Lidfors and Isberg, 2003) or seven (Keil et al., 2000) litres of milk per day increased intersucking, which was explained by a slower development of the rumen when ingesting larger amounts of milk (Keil et al., 2000). On the contrary, in an experimental study Jung and Lidfors (2001) found less milk-dependent cross-sucking in calves fed 5 litres of milk per meal compared to 2.5 and 1 litres. Similarly, Vaughan et al. (2016) reported low cross-sucking incidences in an experimental study supplying 10–12 litres of milk per day. It cannot be excluded that this discrepancy between survey-based and experimental studies results from uncertainty around the information on management procedures as it was obtained through questionnaires in the former. In the current study, this might also apply (amounts of milk fed per meal and day was not measured by the observer but provided by the farmer) which might be a reason that milk amount was not identified as a risk factor. Additionally, the variation in milk quantity was low.

It is important to note that the age of calves entering group housing was not identified as a risk factor. Similarly, in an earlier study group housing of calves during the whole rearing period as compared to individual housing did not affect intersucking in adult heifers (Keil et al., 2000). In the current study calves were grouped at a median age of two weeks instead of eight days after birth, thus farmers have been making use of the exemption clause (Circular of BMGFJ 75340/0038-IV/B/7/2007). This is however solely a symptomatic measure, preventing cross-sucking through social isolation. Age at entering groups was identified as a potential predictor in the pre-selection, thus likely reflecting farms with an existing problem and late grouping of calves, but was not retained in the final model.

Another explanation for prolonged single housing of calves is to prohibit transmission of diseases. The current study as well as previous findings of a questionnaire study on Austrian dairy farms determined diarrhoea as the main health issue (Klein-Jöbstl et al., 2015). Although incidences were lower than in Klein-Jöbstl et al. (2015), the current study likely considered only severe cases of diarrhoea as data was based on veterinary treatment records and not the farmers' evaluation of health problems. As treatment records are required by law they were considered a reasonably reliable source of information on the health situation over a long time period. However, farmers and veterinarians may differ in their thresholds for treatments and veterinary care thus probably increasing noise in the data and results should therefore be interpreted cautiously. There was no association between cross-sucking and treatment incidences. Interestingly, treatment incidences of umbilical inflammation tended to increase with lower occurrence of inter-sucking. This is however believed to be a spurious result, as umbilical inflammations occurred only on 6 out of 25 farms. Postulated health risks of cross-sucking such as bloating of rumen and abomasum, digestive disorders and diarrhoea in the sucking calf (Hofman, 1992) and inflammation, damage or infection of body parts in the sucked calf (Fraser and Broom, 1997) were therefore not confirmed. However, the current study only investigated intersucking and sucking other parts of another calf's body in terms of associations with the treatment incidence in calves, and veterinary treatments of heifers were not taken into consideration.

5. Conclusion

The present study demonstrated that cross-sucking in group-housed organic Simmental calves occurs frequently, thus requiring effective preventive measures. Promising approaches include the use of homogenous age groups and the provision of opportunities for extended sucking duration around milk feeding. This may e.g. be achieved by providing the opportunity to suck at the empty teat bucket. Entering groups at a young age had no detrimental effect on performing cross-sucking. Furthermore, cross-sucking was not associated with the incidence of veterinary treatments in calves. Group housing of Simmental calves at a young age may therefore be promoted.

Conflict of interest

There are no conflicts of interest related to the outcome or publication of this study.

Acknowledgements

The authors wish to thank the UFAW animal welfare student scholarship for providing travel funds to conduct the farm visits. Acquisition of farms was supported by the Agricultural chambers of Upper Austria and Lower Austria and by the organic farming association Bio Austria. Thank you to Stefan Rudlstorfer and Josef Kreuzer for contacting farmers participating in this study. Thank you to Florian Gadermaier (FiBL Research Institute of Organic Agriculture) for supporting this study and for organisation and financial support of accommodation. Many thanks to the organic agricultural school Schlägl for room and board during conduction of farm visits. A very special thanks goes to all the farmers participating in this study.

References

Circular of BMGFJ No 75340/0038-IV/B/7/2007 of 6.12.2007, 'Kälber'; C. 2, Art. 11 of Commission Regulation (EC) No 889/2008.

Commission Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control. Official Journal No L250/1, on 18.09.2008.

Costa, J.H.C., von Keyserlingk, M.A.G., Weary, D.M., 2016. Invited review: Effects of group housing of dairy calves on behavior, cognition, performance, and health. J. Dairy Sci. 99, 2453–2467.

Cramer, G., Lissemore, K.D., Guard, C.L., Leslie, K.E., Kelton, D.F., 2009. Herd-level risk factors for seven different foot lesions in Ontario Holstein cattle housed in tie stalls or free stalls. J. Dairy Sci. 92, 1404–1411.

de Passillé, A.M., 2001. Sucking motivation and related problems in calves. Appl. Anim. Behav. Sci. 72, 175–187.

de Passillé, A.M., Rushen, J., 1997. Motivational and physiological analysis of the causes and consequences of non-nutritive sucking by calves. Appl. Anim. Behav. Sci. 53, 15–31.

de Passillé, A.M.B., Metz, J.H.M., Mekking, P., Wiepkema, P.R., 1992. Does drinking milk stimulate sucking in young calves? Appl. Anim. Behav. Sci. 34, 23–36.

de Passillé, A.M., Rushen, J., Janzen, M., 1997. Some aspects of milk that elicit non-nutritive sucking in the calf. Appl. Anim. Behav. Sci. 53, 167–173.

De Passillé, A.M., Borderas, F., Rushen, J., 2011. Cross-sucking by dairy calves may become a habit or reflect characteristics of individual calves more than milk allowance or weaning. Appl. Anim. Behav. Sci. 133, 137–143.

Dohoo, I., Martin, S.W., Stryhn, H., 2010. Veterinary epidemiologic research, 2nd edition. VER Inc.

Fraser, A.F., Broom, D.M., 1997. Farm animal behaviour and welfare, third ed. CAB International, Wallingford Oxon.

Fuerst-Waltl, B., Rinnhofer, B., Fuerst, C., Winckler, C., 2010. Genetic parameters for abnormal sucking traits in Austrian Fleckvieh heifers. J. Anim. Breed. Genet. 127, 113–118.

Hofman, W., 1992. Rinderkrankheiten Band 1. Innere und chirurgische Erkrankungen. Verlag Eugen Ulmer & Co., Stuttgart.

Ivemeyer, S., Walkenhorst, M., Heil, F., Notz, C., Maeschli, A., Butler, G., Klocke, P., 2009. Management factors affecting udder health and effects of a one year extension program in organic dairy herds. Animal 3, 1596–1604.

Jensen, M.B., 2001. A note on the effect of isolation during testing and length of previous confinement on locomotor behaviour during open-field test in dairy calves. Appl. Anim. Behav. Sci. 70, 309–315.

Jensen, M.B., 2003. The effects of feeding method, milk allowance and social factors on milk feeding behaviour and cross-sucking group housed dairy calves. Appl. Anim. Behav. Sci. 80, 191–206.

Jung, J., Lidfors, L., 2001. Effects of amount of milk, milk flow and access to a rubber teat on cross-sucking and non-nutritive sucking in dairy calves. Appl. Anim. Behav. Sci. 72, 201–213.

Kalcher, L., Fürst, C., Egger-Danner, C., Halbartschlager, G., Mayerhofer, M., Rehling, C., Schwarzenbacher, H., 2017. Jahresbericht 2015. Die österreichische Rinderzucht 2016. ZAR – Zentale Arbeitsgemeinschaft österreichischer Rinderzüchter, Vienna.

Keil, N.M., Langhans, W., 2001. The development of intersucking in dairy calves around weaning. Appl. Anim. Behav. Sci. 72, 295–308.

Keil, N.M., Audigé, L., Langhans, W., 2000. Factors associated with intersucking in Swiss dairy heifers. Prev. Vet. Med. 45, 305–323.

Keil, N.M., Audigé, L., Langhans, W., 2001. Is Intersucking in Dairy Cows the Continuation of a Habit Developed in Early Life? J. Dairy Sci. 84, 140–146.

Klein-Jöbstl, D., Arnholdt, T., Sturmlechner, F., Iwersen, M., Drillich, M., 2015. Results of an online questionnaire to survey calf management practices on dairy cattle breeding farms in Austria and to estimate differences in disease incidences depending on farm structure and management practices. Acta Vet. Scand. 57.

Laukkanen, H., Rushen, J., de Passillé, A.M., 2010. Which dairy calves are cross-sucked? Appl. Anim. Behav. Sci. 125, 91–95.

Lidfors, L.M., 1993. Cross-sucking in group-housed dairy calves before and after weaning off milk. Appl. Anim. Behav. Sci. 38, 15–24.

Lidfors, L., Isberg, L., 2003. Intersucking in dairy cattle - review and questionnaire. Appl. Anim. Behav. Sci. 80, 207–231.

Margerison, J.K., Preston, T.R., Berry, N., Phillips, C.J.C., 2003. Cross-sucking and other oral behaviours in calves, and their relation to cow suckling and food provision. Appl. Anim. Behav. Sci. 80, 277–286.

Martin, P., Bateson, P., 2007. Measuring Behaviour. An Introductory Guide, 3rd ed. Cambridge University Press, Cambridge.

Medrano-Galarza, C., LeBlanc, S.J., DeVries, T.J., Jones-Bitton, A., Rushen, J., de Passillé, A.M., Haley, D.B., 2017. A survey of dairy calf management practices among farms using manual and automated milk feeding systems in Canada. J. Dairy Sci. 100, 6872–6884.

Rinnhofer, B., 2008. Einflüsse der Haltungsumwelt und der Genetik auf das gegenseitige Besaugen beim Rind, Diploma Thesis. Department of Sustainable Agricultural Systems, University of Natural Resources and Life Sciences, Vienna.

Roth, B.A., Hillmann, E., Stauffacher, M., Keil, N.M., 2008. Improved weaning reduces cross-sucking and may improve weight gain in dairy calves. Appl. Anim. Behav. Sci. 111, 251–261.

Roth, B.A., Keil, N.M., Gygax, L., Hillmann, E., 2009. Temporal distribution of sucking behaviour in dairy calves and influence of energy balance. Appl. Anim. Behav. Sci. 119, 137–142.

Rushen, J., 2003. Changing concepts of farm animal welfare: bridging the gap between

applied and basic research. Appl. Anim. Behav. Sci. 81, 199–214.
Rushen, J., De Passillé, A.M., 1995. The motivation of non-nutritive sucking in calves, Bos taurus. Anim. Behav. 49, 1503–1510.
Sambraus, H.H., 1985. Zur Beurteilung von Haltungssystemen für Kälber. Tierärztliche Umschau 40, 758–767.
Steininger, F., Fuerst-Waltl, B., Pfeiffer, C., Fuerst, C., Schwarzenbacher, H., Egger-Danner, C., 2012. Participatory development of breeding goals in Austrian dairy cattle. Acta Agric. Slovenica (Suppl. 3), 143–147.
Svensson, C., Hultgren, J., Oltenacu, P.A., 2006. Morbidity in 3–7-month-old dairy calves in south-western Sweden, and risk factors for diarrhoea and respiratory disease. Prev. Vet. Med. 74, 162–179.
Vasseur, E., Borderas, F., Cue, R.I., Lefebvre, D., Pellerin, D., Rushen, J., Wade, K.M., de Passillé, A.M., 2010. A survey of dairy calf management practices in Canada that affect animal welfare. J. Dairy Sci. 93, 1307–1315.
Vaughan, A., Miguel-Pacheco, G.G., Marie de Passillé, A., Rushen, J., 2016. Reciprocated cross sucking between dairy calves after weaning off milk does not appear to negatively affect udder health or production. J. Dairy Sci. 99, 5596–5603.
Veissier, I., Caré, S., Pomiès, D., 2013. Suckling, weaning, and the development of oral behaviours in dairy calves. Appl. Anim. Behav. Sci. 147, 11–18.