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Non-nutritive sucking, health situation and identification of risk factors in group-housed dairy calves in Austria

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Inhalt

1. Introduction

Group-housing of calves at a young age can support social behaviour and display of normal behaviour patterns such as play behaviour. In particular in artificially reared calves, the opportunities to perform natural behaviour may at the same time be associated with an increased risk to develop abnormal behaviours, i.e. non-nutritive sucking, as well as health problems.

Non-nutritive sucking presents a major welfare risk in dairy cattle in terms of subsequent health issues and the use of countermeasures. Close contact as provided in group-housing allows calves to display non-nutritive sucking on the bodies of other calves. Preferred areas for sucking are ears, navel, udder, prepuce and scrotum. This may lead to ingestion of hair of the sucking calf and inflammation of the skin in the sucked calf. However, a more particular concern is the continuation of this behaviour after weaning. There is a high likelihood, that calves carrying out intersucking before weaning will display this behaviour as heifers and cows and thereby induce udder damage and mastitis. Furthermore it may require exclusion of animals from breeding. In addition, use of countermeasures such as nose-clips and isolation further compromise welfare. Especially Fleckvieh seems to have a predisposition for inter/cross-sucking with this behaviour being displayed more frequently compared to other breeds.

Herd management and prevention of diseases represent other challenges of group-housing of very young calves. At a young age, calves are highly prone to illnesses. Therefore housing calves in groups requires more accurate observation of individuals. An outbreak of disease is more likely to remain undetected for a longer time and thus calves are falling ill with respiratory diseases and diarrhoea. Furthermore group-housing may pose a higher risk of transmission of diseases.

Group housing is essential to ensure good welfare of calves, although it presents farmers with a number of challenges. Therefore it is important to offer sound advice to avoid problems or to improve the situation, if non-nutritive sucking and diseases occur.

2. Problem definition and objectives

Group housing of calves from the eighth day of life is required by law on organic farms within the EU (C. 2, Art. 11, Commission Regulation (EC) No 889/2008). This provides calves with the opportunity to perform natural behaviour but it presents farmers with the challenge to avoid known areas of concern, non-nutritive sucking and health issues.

Although many studies have been conducted on behaviour and health of group-housed calves, most of them were carried out in an experimental setting. On-farm assessment is essential to describe the current situation and evaluate actual management practices. To further promote group-housing it is necessary to find risk and success factors concerning care and management in Austrian production systems enhancing the situation on farms.

The aim of this study is to describe the situation and assess risk factors for non-nutritive sucking and health issues in order to reduce the incidence of both. Furthermore we investigated potential associations between non-nutritive sucking and health parameters. The focus of this study was on calves of the breed Fleckvieh with emphasis on calves younger than eight weeks of age, although calves up to an age of six months were included in the study. This represents the opportunity to provide farmers with further knowledge about critical points in calf rearing, concerning housing, management and feeding. Medical treatments and countermeasures regarding non-nutritive sucking may thus be avoided, thereby also contributing to increased animal welfare.

3. Literature review

3.1. Group housing of calves

Cattle are herd animals. They seek social contact and have a common rhythm of activity. Separating an animal from its herd makes it feel unsettled. They vocalize and try to get back to their herd. This also applies for calves (Sambraus, 1985). Group housing allows calves to perform natural behaviour and helps them living in groups in their adult life. When comparing calves reared in groups or individually, group-reared calves associated more with one another. Furthermore they performed more competitive interactions, such as butting, pushing and displacing. Calves reared in individual housing retreated more often in such competitive situations and seemed to lack skill in responding to it (Broom and Leaver, 1978). Furthermore calves housed in group-housing showed more walking, playing and grooming and less licking objects, idle standing, lying and restlessness than individually housed calves (Tapki, 2007). Boissy et al. (2007) review on how to assess positive emotions to improve animal welfare. They argue good welfare is not just when abnormal behaviour is absent and animals have no negative experiences but when they enjoy positive experiences for example pleasure. They characterize play behaviour as rewarding and reason it occurs when primary needs are satisfied. Thus, performance of play behaviour may indicate good welfare. When calves are reared in groups, they have greater space allowance since more shared space is available to them. A greater space allowance increased performance of locomotor play and synchrony of locomotor play (Jensen and Kyhn, 2000). In consequence various studies demonstrated the positive effects of group-housing of calves. On the other hand, group housing provides calves with the opportunity to show abnormal behaviour and represents challenges to herd management and prevention of diseases. Previous findings and existing knowledge about these matters will be reviewed in this chapter.

3.2. Non-nutritive sucking

When investigating non-nutritive sucking in dairy cattle, the majority of studies are focusing on abnormal sucking behaviour aimed at the body of another individual. Non-nutritive sucking directed at the pen is often neglected. It is for this reason that in this literature review non-nutritive sucking on another individual is primarily discussed.

3.2.1. Definition of non-nutritive sucking

Abnormal behaviour is defined as behaviours deviating from the norm in terms of frequency of movements, intensity of actions or behavioural context. Non-nutritive sucking of calves can be categorized as redirected behaviour, aimed toward the calf's inanimate environment or towards another calf in an inappropriate manner. Therefore non-nutritive sucking can be classified into behaviour directed at the inanimate surrounding or towards other members

of their own species (Fraser and Broom, 1997). When sucking is aimed towards the environment, calves try to take hold and suck parts of the pen and buckets with their mouth. Sucking aimed towards another calf can be further distinguished by the body area. Cross-sucking describes when a calf is trying to take hold and suck body parts of another calf except the udder area (Keil and Langhans, 2001). Preferred body areas for cross-sucking are ears, navel, prepuce and scrotum. Their body position and posture resembles a naturally sucking calf, including pushing movements (Fraser and Broom, 1997). Lidfors and Isberg (2003) found that cross-sucking in calves was primarily aimed either under the belly (60%) or at the mouth (43%) of another calf. Findings by Margerison et al. (2003) are fairly similar reporting cross-sucking to be observed most often at the inguinal region (78%), ears (8%), mouth (6%), throat (3%) and navel (2%). Intersucking refers to a calf trying to take hold of the udder area of another calf and suck a teat from behind or the side. This behaviour is commonly followed by warding off and moving away of the sucked animal (Keil and Langhans, 2001).

3.2.2. Incidence of non-nutritive sucking

Previous studies investigating the occurrence of non-nutritive sucking primarily focused on intersucking in cows and heifers. Lidfors and Isberg (2003) summarized reports on the occurrence of intersucking (Table 1).

Table 1. Reports of intersucking cows in different studies (Lidfors and Isberg, 2003)

Number of farms	Percentage of farms with intersucking	Percentage of intersucking cows	Country studied	Reference
6935	1.1-1.4	2.5	England and Wales	(Wood et al., 1967)
10, 3	80, 100[a]	7.5, 6.4	East Germany	(Schlüter et al., 1976)
16	100	14.1	Czechia	(Kursa and Kroupová, 1976)
1900	13.5[b]	0.7	Germany	(Kelz, 1977)
236	49.6[b]	2.0	Holland	(Peterse et al., 1978)
8	-	4.3	Czechia	(Mácha et al., 1981)
2	-	2.4	Hungary	(Illés et al., 1981)
1	-	13	East Germany	(Schlüter et al., 1981a)
12	100[b]	4.5-15.8	East Germany	(Schlüter et al., 1981b)
1	-	9.13-15.04	Czechia	(Vavak, 1990)
1[c]	-	0.5	Germany	(Berger, 1989)
275	46.4	3.4	Norway	(Bøe, 1990)
1	-	1.7	Egypt	(Abou-El-Ella, 1999)
6	100	5.1	Slovakia	(Debrecéni and Juhás, 1999)
114	26.3	1.6	Switzerland	(Keil et al., 2001)

[a] Cows in first lactation vs. higher lactation
[b] Both cows and heifers
[c] Observed during 9 years

In addition Lidfors and Isberg (2003) did a questionnaire survey in Sweden finding one third of farmers (29%) reporting intersucking in cows and two thirds of farmers (60%) reporting intersucking in heifers. A questionnaire survey in Austria reported cross-sucking and

intersucking on two thirds of organic farms (64%) in calves before and after weaning (Gugatschka, 2008). Numbers by Keil et al. (2000) are even higher with 93% of farms reporting cross-sucking in calves. Furthermore they report that 50% of calves per farm perform this behaviour.

A study by Rinnhofer (2008) investigated the effect of breeds on cross-sucking and intersucking. He detected one third of farms having minor problems in both Fleckvieh and Braunvieh and only 14% of farms having minor problems in Holstein. Furthermore one third of farms having Fleckvieh reported severe problems with intersucking, suggesting higher risks of cross-sucking and intersucking in Fleckvieh cattle. Indeed, heritabilities of 0.040 in a linear model and 0.116 in a sire threshold model for sucking Fleckvieh cattle were found (Fürst-Waltl et al., 2010).

3.2.3. Motivation of non-nutritive sucking

In a natural situation cows suckle their newborn calves five to ten times a day with each meal lasting up to ten minutes. These numbers are decreasing with age to three to six suckling bouts per day when six months old (Fraser and Broom, 1997). When comparing calves reared artificially or suckled by their mothers, the performance of cross-sucking in non-suckled calves was five times greater than in suckled calves (1.8 events/day vs. 0.33 events/day) (Margerison et al., 2003). Moreover, the incidence of cross-sucking significantly decreased within 10-15 minutes after the milk meal (de Passillé et al., 1992, De Passillé et al., 1997, Lidfors, 1993). These results suggest a close connection of cross-sucking and the ingestion of milk. Furthermore Lidfors (1993) speculated whether the ingestion of milk is inducing a positive feedback on the sucking behaviour. Indeed, this hypothesis can be confirmed by various studies (De Passillé et al., 1997, Rushen and De Passillé, 1995). The taste of milk stimulates non-nutritive sucking. In addition, performing non-nutritive sucking is reducing this motivation rather than ingestion of milk (Rushen and De Passillé, 1995). To further substantiate these findings, de Passilé and Rushen (1997) developed a model based on 'Lorenzian' motivational processes (Figure 1). This motivational model implies that cross-sucking is induced by a combination of hunger, ingestion of milk and stimuli from the mother, in particular its udder, or other calves. The model suggests that while milk intake has a potential positive feedback, the underlying motivation to perform sucking is mainly decreased by performing this behaviour rather than drinking milk. Furthermore the ingested amount of milk is independent of sucking motivation to a great extent. Hence Jensen (2003) emphasizes the importance of milk feeding via teat to stimulate the motivation to suck by providing an outlet for it.

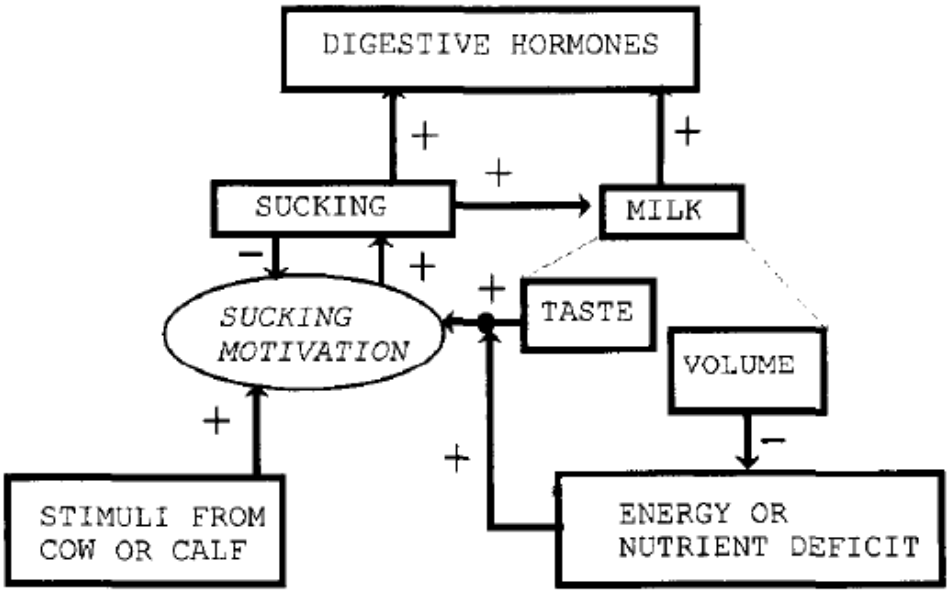

Figure 1. Feedback model of the motivation of sucking by the calf (De Passillé and Rushen, 1997)

Veissier et al. (2002) reason one of the motives to perform nutritive and non-nutritive sucking is because it stimulates rest in calves. Indeed they demonstrated that teat-fed calves lie down more quickly and bucket-fed calves with access to a dry teat spend more time lying down. Therefore they argue that nutritive sucking can be compensated by non-nutritive sucking in some part.

3.2.4. Physiological and cardiological effects of sucking

Letting a calf suck its mother affects the excretion of hormones as compared to calves which are bucket-fed. Calves sucking their mothers had higher levels of oxytocin, prolactin and CCK (Cholecystokinin). Furthermore the level in plasma-cortisol was decreased 30 minutes after sucking (Lupoli et al., 2001). De Passille and Rushen (1997) review the physiological consequences of cross-sucking and state a higher increase of CCK and insulin in calves sucking an artificial teat. Both hormones correlate with the amount of sucking. They are associated with satiety. Also production of saliva and absorbing pregastric enterases when sucking a teat might have an effect. The authors argue that when calves are deprived of sucking, their metabolic processes are affected and hence affect physiological responses to food. In addition Veissier et al. (2002) detected a difference in heart rate of calves that were milk-fed via teat rather than with a bucket. Their heart rate increased at a lower level during the meal and their heart rate variability had a higher increase after the meal.

3.2.5. Calves receiving non-nutritive sucking

Which dairy calves are cross-sucked? Laukkanen et al. (2010) pursued this issue and found that calves performing cross-sucking show higher odds of being cross-sucked. Furthermore

they argue that calves receiving cross-sucking have a higher weight and spend more time in the milk feeder. This is in line with finding of Lidfors (1993) in bucket-fed calves, finding calves being cross-sucked are slightly heavier. Additionally Laukkanen et al. (2010) reports that cross-sucking was not aimed to displace a calf from the milk feeder. In 80% of cases calves being cross-sucked did not move but cross-sucking was ended by the performing calf. Therefore they reason that a calf's predisposition for receiving cross-sucking and social dominance is not related. Fürst-Waltl et al. (2010) report that 4.1% of calves allow sucking. For the trait of allowing sucking they determined heritabilities of 0.007 in a linear model and 0.026 in a sire-threshold model for Fleckvieh cattle.

3.2.6. Milk-associated non-nutritive sucking

It is well known that there is coherence between non-nutritive sucking and the milk meal. When calves were fed small quantities of various solutions, milk induced more sucking than water, casein solution or whey protein (De Passillé et al., 1997). De Passillé and Rushen (2006) investigated the effects of different components of milk on non-nutritive sucking. They compared the influence of whey protein, casein, lactose and fat and discovered that only lactose had a significant effect. A high concentration of lactose increased the time spent sucking. Also feeding method affects the performance of this behaviour. When comparing calves fed via bucket or teat, teat-fed calves spent more time drinking milk and less time cross-sucking and licking parts of the pen. Furthermore a lower number of teat-fed calves performed intersucking (Jensen and Budde, 2006). While Nielsen et al. (2008) found no effect of the amount of milk on the frequency of cross-sucking, Jung and Lidfors (2001) reported a high milk allowance of five litres of milk per meal lowered non-nutritive sucking in contrast to a low milk allowance of 2.5 or 1 litres of milk per meal. Non-nutritive sucking was also affected by the duration of the milk meal. On the contrary, Keil et al. (2000) reported lower risks of intersucking in heifers, when calves where fed less than a maximum of seven litres of milk per day. When the milk-meal of bucket-fed calves lasted for two minutes compared to twelve minutes, calves showed an increased frequency of non-nutritive sucking (Loberg and Lidfors, 2001). In teat-fed calves a smaller orifice-size increased the milk flow resistance and prolonged the duration of the milk meal, thus resulting in a shorter amount of time spent non-nutritive sucking (Haley et al., 1998). Furthermore non-nutritive sucking could be reduced when calves were fed simultaneously (Keil et al., 2001).

3.2.7. Milk-independent non-nutritive sucking

While various studies point out the correlation of non-nutritive sucking with the milk meal, Roth et al. (2009) investigated the temporal distribution of sucking behaviour in calves fed via automatic milk feeder. 21.1% of cross-sucking bouts were performed within 15 minutes before visiting the milk feeder, 28.4% were performed within 15 minutes after the milk meal and 15.2% were performed within 15 minutes after the calf left the milk feeder without milk

intake. In the intermediate time more than 15 minutes before or after the milk meal, calves performed 35.3% of cross-sucking bouts. They argue that solely cross-sucking behaviour within 15 minutes after the ingestion of milk is related to milk intake, leaving two thirds of cross-sucking bouts milk-independent cross-sucking. Roth et al. (2008) supposed that milk-independent cross-sucking is primarily induced by other motivational mechanisms such as hunger rather than milk intake. They proofed that an adequate concentrate intake and a higher amount of time spent feeding hay decreased the occurrence of milk-independent cross-sucking in weaned calves.

3.2.8. Non-nutritive sucking and weaning

Weaning is the transition from being dependent on the mother to being independent in social and nutritional aspects. In nature the milk intake is gradually lowered combined with higher intake of solid feed and growing social independence. In dairy cattle systems weaning takes place in two stages. First, calves are separated from their mothers shortly after birth and second, calves are usually weaned off milk when only several weeks old. The stage of weaning is sometimes accompanied by social and environmental changes. Calves might be housed in new pens or barns with unfamiliar penmates, representing additional stressors (Weary et al., 2008). While nutritive sucking ceases at weaning, non-nutritive sucking may continue after weaning off milk. Even though there is a significant decrease in the frequency of cross-sucking (Lidfors, 1993), several studies report on the association between intersucking in calves and intersucking in heifers and cows (Lidfors, 1993, Lidfors and Isberg, 2003, Keil et al., 2001, Keil and Langhans, 2001). De Passillé et al. (2011) argue that pursuing this behaviour after weaning might be the result of habit formation. Before weaning, intersucking was observed in more than 90% of calves, although with varying frequency between animals and farms. When calves were observed performing no intersucking or only at a low level before weaning, they were not likely to perform this behaviour after weaning. On the contrary, calves with a high performance of intersucking before weaning either ceased or continued to perform this behaviour after weaning. They argue that the continuation and even increase of cross-sucking after weaning potentially indicate habit formation. Furthermore calves performed intersucking after weaning at a similar diurnal distribution close to their meals as before weaning, thus indicating it might be induced by the same factors (Keil and Langhans, 2001). Keil et al. (2001) argued that to find reasons for intersucking in cows, one must consider factors related to earlier stages of the cows life. Therefore factors causing intersucking in calves may also affect intersucking in heifers and cows (Figure 2).

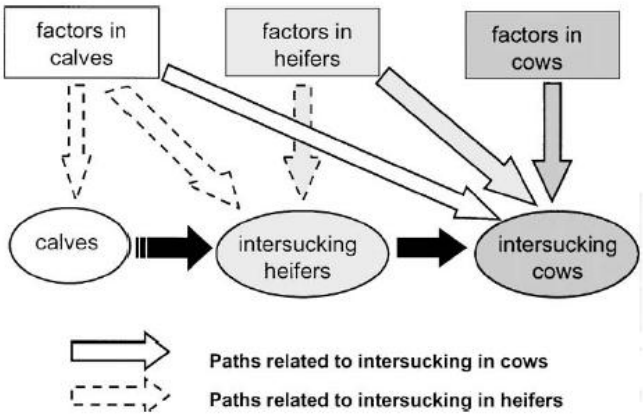

Figure 2. Hypothesis model of risk factors for the occurrence of intersucking in dairy cows and heifers (Keil et al., 2001)

Weaning is certainly a critical point in the development of non-nutritive sucking. Keil and Langhans (2001) found that one week after weaning a low energy density of the feed leads to a high number of intersucking bouts. Indeed, when weaning was done individually according to the concentrate intake per calf, the number of calves performing cross-sucking was reduced. Furthermore when calves spent more time eating hay, the occurrence of cross-sucking decreased (Roth et al., 2008). These findings confirm the conclusion of Keil and Langhans (2001), that the development of intersucking directly after weaning is influenced by the duration of feeding as well as the energy density and availability of food. Furthermore they concluded that the calves' transition to fully developed rumination is a critical point for the establishment of intersucking.

3.2.9. Risk factors of non-nutritive sucking

The multifactorial nature of non-nutritive sucking results in a high number of possible risk factors. As mentioned above, many factors are related to the milk meal. Still there are various other factors triggering non-nutritive sucking. Only few studies investigated the on-farm-situations to determine risk factors of non-nutritive sucking (Lidfors and Isberg, 2003, Keil et al., 2000, Keil et al., 2001, Keil and Langhans, 2001).

3.2.9.1. Non-nutritive sucking and feed intake

When investigating the influence of feed on non-nutritive sucking, the milk meal is just one of the critical points to consider. Roth et al. (2009) argued that the energy balance is essential. A lower energy balance and therefore inadequate energy supply increased the risks of cross-sucking. Nevertheless not only energy content of the feed had an impact. Restricted feeding increased the performance of intersucking in weaned calves. Even adequate energy density could not offset the limited availability of feed (Keil and Langhans, 2001). This observation was complemented by Keil et al. (2000) reporting higher risks of intersucking when heifers were fed a high amount of maize silage after weaning, due to a

low amount of roughage in the ration. In addition they stated that feeding weaned heifers large amounts of concentrates had a decreasing effect on intersucking. Keil and Langhans (2001) argued that also amount of roughage in the ration might affect intersucking. Indeed this corresponds to results by Roth et al. (2008) finding a lower performance of cross-sucking when calves spent more time feeding hay. Keil et al. (2000) reasoned that nutritional and behavioural needs need to be met when feeding. This includes stimulation, occupation and oral activity. With feeding maize silage energy needs are met but amount of roughage is low. They concluded that feeding concentrates satisfies the energy needs and provides the opportunity to feed a high amount of roughage to extend time spent ruminating.

3.2.9.2. Non-nutritive sucking and environment

The environment can have a strong impact on behaviour of calves. Keil et al. (2000) reported lower risks of intersucking in heifers with calves having access to an outdoor run or pasture. Housing in an enclosed building and low space allowance increased that risk. This was confirmed by Hepola et al. (2006), finding less non-nutritive sucking in calves housed in cold-housing. Furthermore they stated less oral behaviour when temperature was low. They reasoned the environment in cold-housing is more variable than in warm-housing, thus the motivation to explore their surrounding is stimulated more easily. Furthermore Lidfors and Isberg (2003) argued that calves having access to an outdoor area focus less on their pen-mates. In addition it might be easier to move away. Ude et al. (2011) investigated the impact of environmental enrichment on cross-sucking. They set up an environmentally enriched post-feeding area with three sealed rubber teats, a net filled with a hay bale, a concentrate feeder, a hayrack and an exercise yard. Calves in the optimized group showed a significantly lower frequency of cross-sucking and sucking and nibbling the feeding stall than calves in the control group. 54-100% of calves were sucking the sealed artificial teats and 58-72% of calves used the hay net, depending on the age. Hence the authors recommended provision of a post-feeding area to calves for prevention of cross-sucking.

3.2.10. Consequences of non-nutritive sucking

Non-nutritive sucking seems to have an impact on the remaining behaviour of cattle. While the duration of common behaviour, such as lying, standing and feeding, and social activities were not different between normal and milk-sucking cows, behaviours were performed at different times of the day and with different peaks. Milk-sucking cows showed differences in ruminating, attacks, body contacts and udder contacts. Thus the presence of milk-sucking cows might have increased disturbance and decreased the number of resting periods in the herd (Debrecéni and Juhás, 1999). Although no comparable studies were conducted in younger animals, this might also apply for calves.

Non-nutritive sucking may increase health risks. The calf performing non-nutritive sucking is at risk of swallowing air, bloating of rumen and abomasum, digestive disorders, diarrhoea,

emaciation and bacterial contamination of the digestive tract with pathogenic germs (Hofman, 1992). Calves performing cross-sucking or intersucking may ingest large quantities of hair, forming into hair balls or bezoars in the rumen, clogging the rumen and causing digestive disorders. Sucking the penis might lead to drinking urine and thus induce reduced nutrient intake and liver disorders. Also the sucked calves experience higher health risks. Sucking might lead to inflammation, damage or infection of the sucked body part (Fraser and Broom, 1997). Farms with intersucking calves had a higher occurrence of C. *pyogenes* mastitis, teat injuries and tended to a higher incidence of mastitis in heifers (Lidfors and Isberg, 2003). A questionnaire on health issues induced by non-nutritive sucking reported udder damage, umbilical inflammation, loss of appetite and growth disorders, although no distinction between the sucking and sucked calf was made (Gugatschka, 2008).

3.2.11. Measures to prevent non-nutritive sucking

When asked how to prevent non-nutritive sucking in calves, most common measures in Austria were restraining during the milk meal, individual housing and nose clips (Rinnhofer, 2008). Further measures mentioned to be in use on farms were regrouping, applying smelly and bad tasting cream on udder, giving concentrates after the milk meal and leaving the bucket for the calf to suck after it finished the meal. Animals were culled only after failure of all other methods (Lidfors and Isberg, 2003).

3.3. Diseases of calves

The welfare of animals is critically at risk when the animal suffers from health disorders. Furthermore poor welfare caused by disease results in reduced disease resistance and possibly more diseases and worse welfare. Soon after birth, major welfare risks in young calves can arise such as enteric and respiratory diseases (Fraser and Broom, 1997). Therefore, herd management and prevention of diseases represent challenges in calf rearing in both, individual and group housing.

3.3.1. Occurrence of diseases

When asked about the health situation of their calves, Austrian dairy farmers reported issues with diarrhoea (71% of farms), respiratory diseases (19% of farms) and umbilical inflammation (25% of farms) (Gugatschka, 2008). In a Swedish study the incidence of diarrhoea was 7.8%, of increased respiratory and respiratory diseases was 14.3% and 3.0%. Increased respiratory sounds were diagnosed by lung auscultation or by indication of symptoms such as coughing and nasal discharge. Further mentioned diseases were arthritis and umbilical inflammation (Lundborg et al., 2005).

3.3.2. Diseases and group housing

Svensson et al. (2003) investigated the effect of calves housed individually, in small groups (3-8 calves) with manual milk feeding or in large groups (6-30 calves) with automatic milk feeding on the incidence of diseases. They found cases of diarrhoea to be more severe in calves housed in large groups than calves housed individually. Also the diagnosis of diarrhoea was performed at a younger age in calves housed in small groups (16 days) than individually (30 days). Furthermore risks of respiratory disease and increased respiratory sounds were higher in calves housed in large groups compared to small groups and individual housing. Age of diagnosis and severity of cases did not differ between housing systems.

3.3.3. Diarrhoea

Diarrhoea is one of the major health problems in calf rearing. A distinction must be drawn between diarrhoea induced by the environment or by pathogens. Environmental or unspecific diarrhoea is caused by housing and feeding conditions including transport, stress, change of diet, poor hygiene and poor quality of feed. Secondary microbial infections may follow unspecific diarrhoea. Pathogenic or specific diarrhoea can be induced by virus infections such as Rota-virus, Corona-virus or BVD/MD-Virus, by bacterial infections such as E.-coli or Salmonella and by parasite infections such as cryptosporidium, coccidia and nematodes. Symptoms of a diarrhoeic calf include watery and smelly faeces. After a while general health and appetite are impaired and calves become apathetic. Heart rate and respiratory rate may be increased. If not treated, diarrhoea in calves may cause death within days (Hofman, 1992).

There are several risk factors affecting the occurrence of diarrhoea. In calves younger than 90 days risks of diarrhoea were increased when source of colostrum was a first lactation cow rather than a cow in a higher lactation. Furthermore incidence of diarrhoea was higher when calves were suckled by their mothers rather than fed colostrum by the farmer. This might be due to delayed ingestion of first colostrum when suckled by their mothers. An additional factor of occurrence of diarrhoea was season (Svensson et al., 2003). Further factors increasing risks of diarrhoea in calves younger than 90 days of age were a pen place against the outer wall and when the farmer did not check the milk temperature before feeding (Lundborg et al., 2005). Also non-weaned calves in cold-housing tended to have higher incidences of diarrhoea (Hänninen et al., 2003). Slatted concrete floors, purchase of calves and birth during the winter had an increasing effect on occurrence of diarrhoea (Gulliksen et al., 2009a). In three to seven months old dairy calves Svensson et al. (2006) reported higher risks of diarrhoea with a small pen area, winter season (December-April) and if calves had a previous respiratory disease and their pens were placed against the outer wall.

3.3.4. Respiratory disease

Apart from diarrhoea, respiratory disorders are among the most important diseases in calves with high losses. Causes are either multifactorial or pathogen specific, often preconditioned by reduced immunity. Inducing factors include bad stable environment, transport and contact with diseased animals. Pathogens causing respiratory diseases can be bacteria, viruses, parasites or fungi. Diseased calves show symptoms of fever, nasal discharge, coughing, high respiratory rate, shallow breathing, loss of appetite and general weakness. When calves are infected severely, it might lead to abdominal breathing, diarrhoea, dehydration and death (Hofman, 1992).

In calves younger than 90 days of age, risks of increased respiratory sounds at lung auscultation were higher when a bovine viral diarrhoea virus infection was present in the herd and when calves were housed in large groups (6-30 calves) or exposed to draught air. Weaning by adding water to the milk also had an increasing effect on respiratory sounds. Respiratory disorders were increased with housing in a large-group pen and season (Lundborg et al., 2005). Risks were further increased with calves and cows sharing housing during their first week of life, larger herds (>50 cows) and a high age difference of calves within the pen (>8 weeks). Also calves being with their mothers for more than 24 hours after birth and feeding colostrum later than 30 minutes after birth amplified the odds of respiratory diseases (Gulliksen et al., 2009b). Svensson et al. (2003) found higher risks of respiratory diseases in calves housed in large-group pens. Furthermore in large groups a high age difference within the group is more likely and the common teat of the automatic milk feeding system provides an additional potential of infection. Also a cow giving birth in a cubicle or group maternity pen increased the odds of respiratory diseases. Calves previously suffering from diarrhoea or respiratory disease had higher risks of falling ill (again) with respiratory diseases (Svensson et al., 2006).

3.3.5. Umbilical inflammation

The navel of a calf can get infected through contamination with bacteria such as *Actinomyces pyogenes*, Streptococcus or Staphylococcus. Affected areas of the navel can be the umbilical cord, subcutis, umbilical vein, umbilical artery or the urinary tract. In a healthy calf the navel would be dried up after a few days. A calf suffering from umbilical inflammation shows a swollen, hardened and wet navel that is sensitive to pain. If not medically treated, umbilical inflammation can devolve into blood vessels and induce infection of lungs, kidneys, joints and other organs. Thus it may lead to emaciation and death. Risk factors affecting the occurrence of umbilical inflammation are poor hygiene of bedding and of birth, as well as sucking and licking of the navel (Hofman, 1992). No studies concerning risk factors of umbilical inflammation were found.

4. Animals, material and methods

This chapter outlines the general characteristics of the farms and animals on which this study is based upon. Furthermore it provides details about the collection of data concerning behaviour, health and management of calves and on the statistical evaluation of the data.

4.1. Animals and Farms

Data was collected during an on-farm study in 37 organic dairy farms in Austria. The farms were located in the federal districts of Rohrbach, Urfahr, Freistadt, Amstetten, Scheibbs, Melk and Waidhofen an der Ybbs in the federal states of Upper Austria and Lower Austria. They were visited over a period of ten weeks in the months of April, May and June 2012. Acquisition of farms was performed by organic farming bodies by an e-mail and letter sent to farms included in the preselection. Due to a low response rate, farms meeting the criteria were phoned and asked for participation by organic farming bodies. Criteria for acquisition of farms were group housing of calves, the location of the farm in one of the selected districts, the organic status of farms, keeping calves of the breed Fleckvieh and having a minimum of 20 cows or three calves. The average number of animals per farm was 18.4 heifers (min=0 - max=41, SD=9.2) and 30.5 cows (17-59, SD=9.6) per farm. In case farms had some crossbred calves, they were only included in the survey if the majority of calves in the pen was of Fleckvieh breed. Only calves with an age of up to six months were considered in the study. Data of certain groups of calves of three farms were excluded from the analysis because the calves were of a different breed or they were handled by the farmer during the observation period. Also single-housed calves were excluded and calves fed with automatic milk feeding systems (2 farms).

4.2. Data collection

Selection of assessment criteria was based on a literature research of peer-reviewed articles published in scientific journals followed by a discussion with the supervisor and an organic farming advisor. Each farm visit started with a behaviour observation of the calves and was followed by an assessment of the housing, a clinical examination of the calves and an interview with the farmer, including assessment of veterinary treatment records. All information was gathered on standard recording sheets. Prior to the visits of the selected farms, all parts of the assessment were tested on two farms for feasibility and subsequently modified and complemented, if necessary. To carry out the clinical examination, the observer was trained by a veterinarian (Dr. Christine Leeb). 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.

4.2.1. Behaviour

Behaviour observations consisted of 90 minutes of direct continuous observation starting with the morning milk meal using 'behaviour sampling' (Martin and Bateson, 2007). To monitor multiple pens, the observer rotated between groups with a minimum observation bout length of 10 minutes per group before switching. The main focus was on calves younger than eight weeks of age. Non-weaned calves were observed for a minimum period of 1 hour in total. The behaviour of weaned calves was observed for a minimum of 30 minutes in total. The incidence of the following behaviours was recorded: Cross-sucking (CROSS) was defined as a calf sucking at a body part e.g. the neck or ear of another calf as if drinking milk (body posture, head butting, sucking noises). For cross-sucking at the mouth region both calves were counted as actors. Intersucking (INTER) is characterized as a calf sucking in the udder-region of another calf as if drinking milk, irrespective of the sex of the sucked calf. PEN describes sucking and licking at parts of the pen environment. Performance of one of these behaviours was counted as one single event when displayed for a minimum of ten seconds. When the behaviour was interrupted for more than 5 seconds it was counted as a new event. The number of events per animal was individually recorded. To minimize the influence of the observer, calves were always observed from the same distance (1-1.5 m in front of feeding rack). Furthermore the observer didn't approach the calves before the observation. The number of animals visible was recorded before and after each observation unit in order to calculate an incidence per animal and hour.

4.2.2. Health

To determine the health situation of the calves, an individual examination was carried out in the home pen according to the ANIPLAN calf welfare protocol (Lund and Mejdell, 2009). Symptoms of diseases were diagnosed according to guidelines by Jackson and Cockcroft (2002) and Jaksch and Glawischnig (1990). During the health assessment the number of hairless patches and lesions were recorded. Further features of the health assessment included joint inflammation, coughing and sneezing, respiratory rate, ocular or nasal discharge, umbilical infection, inflammation of the udder and diarrhoea. These health issues were classified in three categories with 1 calves showing no indication of health impairment and 2 calves showing one symptom of disease and measures necessary in the long-term. Calves were classified as category 3 when they showed more than one symptom of disease and immediate measures were inevitable. In addition the level of dirt on the calves coat was assessed in three categories. During the assessment calves were approached from only one side, alternating between left and right. The guidelines for the health assessment can be found in Appendix 1.

To gain further information on the calf health situation of the farms, veterinary records of the 12 months prior to the visit were analysed. Information from veterinary records was obtained from 28 farms only because not all farmers agreed to provide them. The data of farmers who didn't present their veterinary records was excluded from health related

statistical models. In addition, farmers were asked to estimate the incidence of diseases of non-weaned calves for 12 months prior to the visit.

4.2.3. Management and Environment

To gain information on milk feeding practices, the duration of the milk meal and duration of non-nutritive sucking at the teat bucket after the meal were recorded by measuring the total time of the median calf (e.g. third out of five calves). Further information about quantity and frequency of milk meal was collected by interviewing the farmer.

To assess the animals` environment, pen size and structure, bedding and provision of feed and water were evaluated. Pen size was determined by a laser measuring device. After data collection in the barn, semi-structured interviews with the farmer on herd/farm characteristics (herd size, experience with group housing), housing (outdoor run, pasture), milk feeding (colostrum management, milk feeding practices), feeding of roughage and concentrates, weaning practices and criteria for weaning, health situation (incidence of disease, preventive measures) and behaviour situation (incidence of non-nutritive sucking, preventive measures) were carried out. The farmer was also asked to evaluate the situation of group-housed calves regarding non-nutritive sucking and health in general.

4.4. Statistical analysis

Data entry was made in Microsoft Office Excel 2007. Continuous data e.g. age at entering groups were recorded in numbers and categorical data e.g. access to outdoor run (yes/no) were categorized and recorded as 0 and 1. For the statistical analysis groups of calves (pens) were allocated to categories of under 8 weeks of age (<8W), over eight weeks of age until weaning (>8W) and calves weaned off milk until 6 months of age (WEANED). Furthermore the parameter INTERCROSS was created by merging the behaviour categories CROSS and INTER. Calves kept in single pens were included in the survey but excluded from the analysis. Behavioural data were expressed as events per animal and hour at pen level. Further analysis was carried out at farm level, using a weighted mean of all the groups of one farm within the various age- and behaviour categories. Results from clinical examination were calculated as prevalence at farm level. Treatment incidences obtained from farm records were expressed as cases per 100 animals per year for the categories diarrhoea, respiratory diseases, umbilical inflammation, other diseases and diseases in total.

In total 316 calves were observed, out of which 68 calves for <8W, 90 and 91 for >8W and WEANED, respectively, were statistically evaluated. The sample size of farms evaluated was n=19 farms for <8W, 18 farms for >8W and 20 farms for WEANED, due to varying number and age of calves at the farms. A total of 39 pens of calves younger than eight weeks of age, 27 pens of calves older than eight weeks of age and 25 pens of weaned calves were observed. The average number of evaluated pens per farm was 1.4 pens (1-4, SD=1.4) of calves for <8W, 1.2 pens (1-2, SD=0.4) of calves for >8W and 1.2 pens (1-2, 0.4) of calves for

WEANED. For non-weaned calves the mean observation period was 49.4 min (SD=16.7), for weaned calves it was 38.8 min (SD=16.3).

For data analysis the statistical software package SAS 9.2 was used. All continuous variables used as potential risk factors were tested for normal distribution. Categorical variables were controlled on the allocation of data in the categories. The final models were tested for normal distribution of residuals. Data and variables not complying with these criteria were excluded from further evaluation (CROSS and REC UMB in weaned calves). In a preliminary selection step, potential risk factors were kept for further analysis when $P<0.2$ in univariate analysis and Pearson and Spearman rank correlation. Final modelling took place using a general linear model with elimination of factors from the model when $P<0.2$ for behavioural data and for health data. Possible associations between behaviour and health data were identified using Spearman rank correlation. The alpha level was set at $P<0.05$ ($P<0.1$ was regarded a tendency).

5. Results

5.1. Housing and Management

The average number of calves (<6 months of age) was 10.7 (3–37, SD=6.6). Group-housing for calves under eight weeks of age had been implemented on average 14.3 years ago (0.8-30, SD=10.1). The mean age of calves entering the groups was 2.7 weeks (0-8, SD=1.9). 23 farms (68%) provided an outdoor run for their calves for an average time of 18.8 hours per day (2-24, SD=7.5) and at an average age of 3.8 weeks (0-13.5, SD=3.6). Eight farms (24%) provided pasture for calves at an average age of 14.9 weeks (1.5-26.4, SD=10.9). Calves were held at pasture for an average time of 17.9 hours per day (7.5-24, SD=7.1) and 6.3 months per year (3-8, SD=1.6). Housing type, access to an outdoor run and provision of bedding to calves are displayed in Table 2.

Table 2. Distribution of housing systems for calves of different age categories on farms

	<8W		>8W		WEANED	
	Number of farms	Percentage	Number of farms	Percentage	Number of farms	Percentage
Cold housing	6	32	6	33	6	30
Calf hutches	3	16	2	11	0	0
Warm housing	3	16	9	50	13	65
Modified housing	7	37	1	6	1	5
Outdoor run	13	68	12	67	11	55
Pasture	1	6	1	6	5	25
Fully deep bedding	12	63	16	89	13	65
Partly deep bedding	7	37	1	6	5	25
Cubicle housing	0	0	1	6	2	10
Solid floor	17	89	17	94	13	65
Perforated floor	2	11	1	6	7	35
Straw bedding	19	100	18	100	17	85

Regarding the colostrum management, calves were fed colostrum within the first two hours after birth at 27 farms (79%) and within two to six hours after birth at 7 farms (21%). For their first meal calves were fed a minimum of 2.4 litres of colostrum (0.3-4.0, SD=1.0). On all farms the first meal of colostrum was obtained from the calf's own mother only. After birth, calves spent an average of 11.2 hours (0-120, SD=25.2) with their mothers. At 6 farms (18%) calves were separated from their mothers right after birth, while at 15 farms (44%) and 13 farms (38%) calves spent up to one hour and more than one hour with their mothers. They were fed milk from their own mothers for an average of 7.2 days (5-13, SD=1.6). At 9 farms (26%) the farmers controlled the temperature of the colostrum by thermometer, farmers at 13 farms (38%) controlled the temperature by hand and farmers at 12 farms (35%) didn't control the temperature at all. 31 farms (91%) were freezing colostrum in case of need and 9 farms (26%) sold colostrum. On 32 farms (89%) calves were fed milk with a teat bucket, on 2 farms (6%) calves were fed with an automatic feeder and on 2 farms (6%) they were fed with both, teat buckets and normal buckets with and without floating teat, depending on the age

of the calves. Calves fed with an automatic milk feeder are only mentioned here and are excluded from all other statistical evaluation.

Calves were offered forage at a mean age of 5.9 days (0-21, SD=6.1), concentrates at 17.6 days (0-56, SD=13.7) and water at 12.7 days of age (0-42, SD=8.3). The average amount of concentrates before weaning was 0.9 kg (0-2.5, SD=0.9), water and forage were offered ad libitum either in buckets or bowls. Calves were weaned at an average age of 14.6 weeks (10-28.6, SD=4.7). When asked about criteria for weaning, 16 farmers (49%) answered feed intake, while 9 farmers (27%) referred to age and 8 farmers (24%) mentioned live weight. At one farm calves were sold before weaning. After weaning they received an average of 0.8 kg (0-2, SD=0.5) of concentrates. Details about milk feeding routines and pens for all age groups are shown in Table 3.

Table 3. Features of milk meals, feeding practices and pens for calves of different age categories on farms

	<8W		>8W		WEANED	
	Mean	SD	Mean	SD	Mean	SD
Quantity of milk per meal (l)	3.7	1.0	3.6	1.4		
Quantity of milk per day (l)	7.8	2.0	7.3	2.9		
Number of milk meals per day	2.2	0.4	2.0	0.0		
Duration of milk meal (min)	2.9	1.5	3.0	2.6		
Rate of drinking milk meal (l/min)	1.5	0.7	1.5	0.8		
Non-nutritive sucking at teat bucket (min)	4.4	5.2	4.2	5.1		
Group size (animals/pen)	3.0	0.9	4.4	2.1	4.3	1.5
Number of age groups per pen	1.7	0.7	1.7	0.8	1.4	0.5
Lying area per pen (m^2)	13.0	8.9	17.2	13.4	22.3	16.3
Lying area per calf (m^2)	4.3	2.6	4.4	3.2	5.4	3.6
Number of feeding places per animal	1.5	0.6	1.5	0.2	1.7	1.1
Number of waterbowls per animal	0.4	0.3	0.4	0.6	0.3	0.1
Restraining during meal (min)	26.5	17.1	31.6	17.7	27.7	22.1

A total of 26 calves (29%) at ten farms (37%) categorized as <8W and 2 calves (2%) at one farm (5%) categorized as >8W were held in single housing and older than 8 days of age. No calves at farms categorizes as WEANED were held in single housing. When asked about their opinion, 18 farmers (53%) regarded group housing of calves under 8 weeks of age as positive, 7 farmers (21%) were indifferent and 9 farmers (26%) regarded it as negative.

5.2. Behavioural measures

5.2.1. Incidences of non-nutritive sucking

22 farmers (65%) reported a problem with cross-sucking and intersucking, with 10 farmers (29%) perceiving it a problem in non-weaned calves and 13 farmers (38%) in weaned calves. 17 farmers (50%) reported intersucking in heifers and 7 farmers (21%) in cows. The average estimated percentages of animals on farms with problems were 30% of non-weaned calves (5-100, SD=28), 27% of weaned calves (3-65, SD=20), 20% of heifers (3-50, SD=13) and 6% of cows (3-13, SD=4) displaying this behaviour. Two farmers (7%) stated that they do not know which calves were sucking, 17 farmers (63%) stated they knew which calves were sucking and 9 farmers (26%) could name the sucking calves.

During the farm visits CROSS was observed at 16 farms (84%) for calves younger than 8 weeks of age, at 14 farms (78%) for calves older than 8 weeks of age and at 3 farms (15%) for weaned calves. INTER was observed at 5 farms (26%) classified as under 8 weeks of age, at 5 farms (28%) for calves older than 8 weeks of age and at 7 farms (35%) for weaned calves. No performance of INTER/CROSS was observed at 2 farms (11%) for calves younger than 8 weeks of age, at 4 farms (22%) for calves older than 8 weeks of age and at 11 farms (58%) for weaned calves. There were no significant correlations ($p<0.05$) between percentages of observed number of calves and percentages of number of calves estimated by farmers that perform non-nutritive sucking, for both non-weaned and weaned calves.

Table 4. Incidence of non-nutritive sucking in calves of different age categories on farms

	CROSS				INTER			
	Events/calf/hour		Percentages of calves affected		Events/calf/hour		Percentages of calves affected	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<8W	1.8	1.8	50	35	0.3	0.6	7	13
>8W	1.2	1.4	39	32	0.2	0.5	10	18
WEANED	0.2	0.7	5	17	0.3	0.7	11	21
	INTERCROSS				PEN			
	Events/calf/hour		Percentages of calves affected		Events/calf/hour		Percentages of calves affected	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<8W	2.1	1.9	57	37	1.8	1.8	62	34
>8W	1.4	1.6	49	43	1.7	1.9	48	37
WEANED	0.5	0.9	17	24	1.0	1.5	31	31

Table 4 shows the observed incidence of non-nutritive sucking during one hour after the milk meal and the percentage of calves performing this behaviour. For CROSS and INTERCROSS the number of events and calves on average numerically decreased with age, contrary to INTER where the number of events was numerically constant and the percentage of calves increased numerically. PEN events were nearly the same for non-weaned calves and numerically decreased when calves were weaned. The percentage of calves displaying this behaviour was numerically highest for calves younger than eight weeks of age and decreased with age.

Farmers reported the use of the following measures to prevent non-nutritive sucking in calves: nose clip (82%), restraint during milk meal (71%), regrouping (18%), isolating cross-/intersucking animals (18%) and providing hay (59%) and concentrates (53%) after the milk meal. Only 1 farmer (3%) made no use of any preventive measures.

5.2.2. Risk factors of non-nutritive sucking

Table 5. Potential risk factors for non-nutritive sucking considered in the pre-selection step for calves younger than eight weeks of age including significant factors

Risk factor	Unit	CROSS	INTER	INTER CROSS	PEN
Housing system					
Type of housing	Warm/cold/modified/calf hutch housing		x		x
Type of deep bedding	Fully/partly				x
Experience with group-housing	Number of years	x		x	
Age of entering groups	Weeks	x		x	x
Age of access to outdoor run	Weeks		x		
Hours of access to outdoor run	Hours per day	x			x
Waterbowls per calf	Number per calf		x	x	x
Management					
Age groups per pen	1/>1		x	x	
Time after birth spent with mother	0/<1/>1 hours				x
Time of receiving colostrum	Number of days	x	x	x	
Duration of milk meal	Minutes	x			x
Rate of drinking milk meal	Litres per minute				x
Amount of forage	kg				x
Age of offering forage	Days		x		x
Age of offering water	Days	x			
Measures					
Fixating at milk meal	Minutes				x
Fixating at milk meal	Yes/no	x		x	
Hay after milk meal	Yes/no		x		
Regrouping	Yes/no				x
Administering of selenium	Yes/no		x		

Table 5 shows the factors for non-nutritive sucking in calves under 8 weeks of life, which were obtained from the initial selection step ($p<0.2$ in univariate analysis). Potential risk factors for CROSS were mainly associated with housing and management factors. For INTER and INTERCROSS housing factors were mainly considered for inclusion in the model but also management factors and measures. Potential risk factors for PEN appeared to be associated with all three categories of housing system, management and measures directed at reducing cross-/intersucking.

Table 6. Risk factors for non-nutritive sucking in the final model for calves younger than eight weeks of age

Risk factor	Estimate	SD	p-value
CROSS (n=19)			
Intercept	2.81	0.81	0.0031
No fixating vs fixating at milk meal	1.88	0.80	0.0324
INTER (n=19)			
Intercept	0.34	0.11	0.0219
Warm housing vs modified housing	1.53	0.36	0.0057
Cold housing vs modified housing	0.10	0.12	0.4527
Calf hutch vs modified housing	-1.04	0.22	0.0035
Age of access to outdoor run	-0.15	0.03	0.0021
1 vs >1 age groups per pen	-1.00	0.18	0.0013
No administering vs administering selenium	0.93	0.18	0.0021
INTERCROSS (n=19)			
no significant factors			
PEN (n=19)			
Intercept	-3.22	0.98	0.0093
Warm housing vs modified housing	1.97	0.68	0.0173
Cold housing vs modified housing	1.20	0.71	0.1242
Calf hutch vs modified housing	2.55	0.74	0.0071
0h vs 24h access to outoor run	0.60	0.43	0.1960
2-18h vs 24h access to outdoor run	1.83	0.58	0.0114
Rate of drinking milk meal	1.82	0.45	0.0027
Number of waterbowls offered per calf	2.03	0.77	0.0280

Significant risk factors in the final model are displayed in Table 6. One risk factor was significant ($P<0.2$) in the final model for CROSS. Fixating during the milk meal led to lower performance of CROSS. Four risk factors were significant for INTER. Holding calves in warm housing increased the occurrence of INTER whereas holding calves in calf hutches decreased it. Cold housing and modified housing were not significantly different. Display of INTER was lower when calves were of a similar age within the pen and when calves had access to an outdoor run at an older age. Administering of selenium also decreased the performance of INTER. No significant factors could be determined for INTERCROSS. For PEN four risk factors were significant. Calves held in warm housing, cold housing and calf hutches had a higher occurrence of PEN compared to modified housing. Display of PEN was lowest for calves having access to an outdoor run for 24 hours compared to 0 hours and 2-18 hours. Furthermore a high rate of drinking the milk meal increased the performance of PEN as well as a high number of waterbowls per calf.

Table 7. Potential risk factors for non-nutritive sucking considered in the pre-selection step for calves older than eight weeks of age including significant risk factors

Risk factor	Unit	CROSS	INTER	INTER CROSS	PEN
Housing system					
Type of housing	Warm/cold housing	x		x	
Experience with group-housing	Number of years	x	x	x	x
Access to outdoor run	Yes/no				x
Age of access to outdoor run	Weeks		x		
Hours of access to outdoor run	Hours per day	x		x	
Feeding places per calf	1/>1				x
Management					
Time after birth spent with mother	0/<1/>1 hours				x
Temperature control of colostrum	Yes/no				x
Amount of milk per meal	Litres	x		x	x
Amount of milk per day	Litres	x		x	x
Age of offering forage	<1/>1 weeks	x		x	
Age of offering concentrates	Days				x
Age of offering concentrates	<10/>10 days		x		
Age of offering water	Days	x			
Measures					
Fixating at milk meal	Minutes				x
Isolating	Yes/no			x	
Regrouping	Yes/no			x	
Hay after milk meal	Yes/no	x		x	
Homoeopathic treatment	Yes/no	x			x

Table 7 displays risk factors for non-nutritive sucking of calves older than eight weeks of age included in the pre-selection step ($p<0.2$ in univariate analysis). The behaviours of CROSS, and INTERCROSS were very similar, including some identical factors of all three categories of housing system, management and measures in the pre-selection. For INTER only three factors were potentially significant, associated with housing system and management. Risk factors of all three categories were included in the final model for PEN.

Table 8. Risk factors for non-nutritive sucking in the final model for calves older than eight weeks of age

Risk factor	Estimate	SD	p-value
CROSS (n=18)			
Intercept	5.10	0.83	<0.001
Amount of milk per meal	42.96	14.53	0.012
Amount of milk per day	-21.78	7.28	0.011
Age of offering water	-0.15	0.03	0.001
No hay vs hay after milk meal	1.25	0.40	0.009
INTER (n=12)			
Intercept	-0.14	0.19	0.484
Age of access to outdoor run	0.11	0.03	0.005
Offering concentrates before vs after 10 days of age	0.65	0.21	0.015
INTERCROSS (n=18)			
Intercept	2.10	0.82	0.024
Warm housing vs cold housing	-1.26	0.45	0.017
Amount of milk per meal	34.66	15.87	0.050
Amount of milk per day	-17.56	7.94	0.047
No isolating vs isolating	1.40	0.59	0.035
No hay vs hay after milk meal	1.47	0.46	0.007
PEN (n=16)			
Intercept	-3.61	2.44	0.173
1 vs >1 feeding places per calf	2.07	0.91	0.049
Age of offering concentrates	0.07	0.03	0.035

Table 8 shows significant risk factors in the final model (P<0.2). CROSS increased with feeding a high amount of milk per meal and a low amount of milk per day. The performance of CROSS was lower when calves were offered water at an older age and when they were offered hay after the milk meal. INTER decreased when calves had access to an outdoor run at a young age and when they were offered concentrates after 10 days of age. Displaying of INTERCROSS increased with having calves in cold housing. Similar to CROSS, the occurrence of INTERCROSS was intensified with a high amount of milk per meal and a low amount of milk per day. Providing hay after the milk meal and isolating calves declined the incidence of INTERCROSS. PEN increased when more than one feeding place per calf was offered. The occurrence of PEN also declined with offering concentrates at an early age.

Table 9. Potential risk factors for non-nutritive sucking considered in the pre-selection step for weaned calves including significant risk factors

Risk factor	Unit	CROSS	INTER	INTER CROSS	PEN
Housing system					
Type of housing	Warm/cold housing			x	
Amount of straw bedding	Floor fully/partly covered		x		x
Type of floor	Solid/perforated	x	x	x	
Hours of access to outdoor run	0/12/24 hours		x	x	
Age of entering groups	Weeks		x		
Management					
Time after birth spent with mother	0/<1/>1 hours			x	
Minimum amount of colostrum	Litres	x			
Amount of milk per meal	Litres				x
Number of milk meals per day	2/3 meals		x		
Amount of concentrates	kg	x			
Age of offering water	Days				x
Criteria for weaning	Weight/feed intake/age	x			
Age of weaning	Days	x		x	
Manner of weaning	Abrupt/subtle				x
Measures					
Fixating at milk meal	Min	x			
Fixating at milk meal	Yes/no				x
Regrouping	Yes/no	x		x	
Isolating	Yes/no				x
Homoeopathic treatment	Yes/no	x			
Administering of selenium	Yes/no				x
Hay after milk meal	Yes/no				x
Concentrates after milk meal	Yes/no				x
Offering artificial teat	Yes/no	x		x	

The potential risk factors for abnormal oral behaviour in weaned calves are displayed in Table 9. For the behaviours of CROSS, INTERCROSS and PEN, factors associated with housing system, management and measures were considered as potentially significant in the final model. For INTER mainly factors of the categories housing system and one factor of management were selected for inclusion in the model.

Table 10. Risk factors for non-nutritive sucking in the final model for weaned calves

Risk factor	Estimate	SD	p-value
INTER (n=20)			
no significant factors			
INTERCROSS (n=20)			
Intercept	0.62	0.70	0.3890
Solid vs perorated floor	-0.83	0.30	0.0153
Age of weaning	0.07	0.03	0.0452
PEN (n=20)			
Intercept	4.13	1.46	0.0163
No time vs time after birth spent with mother	1.83	0.75	0.0322
Floor fully vs partly covered with straw bedding	-2.21	0.64	0.0054

Table 10 outlines significant risk factors (P<0.2) included in the final model for non-nutritive sucking of calves weaned off milk. No significant risk factors were obtained for INTER. Display of INTERCROSS increased with calves in housing with a perforated floor compared to housing on solid floor. In addition a high age of weaning calves off milk increased the performance of INTERCROSS. The incidence of PEN decreased when calves spent time after birth with their mothers and with a high amount of bedding, covering all floor.

5.3. Health measures

5.3.1. Incidences of diseases

The mean number of veterinary treatments (REC TOTAL) (n=28) per 100 calves within one year was 23.9 (0-178.9, SD=36.3), with 8.5 (0-61.5, SD=14.9) treatments for diarrhoea (REC DIARR), 6.6 (0-63.2, SD=13.1) treatments for respiratory diseases (REC RESP), 1.2 (0-12.5, SD=2.9) treatments for umbilical inflammation (REC UMB) and 7.6 (0-63.2, SD=15.8) treatments for other diseases.

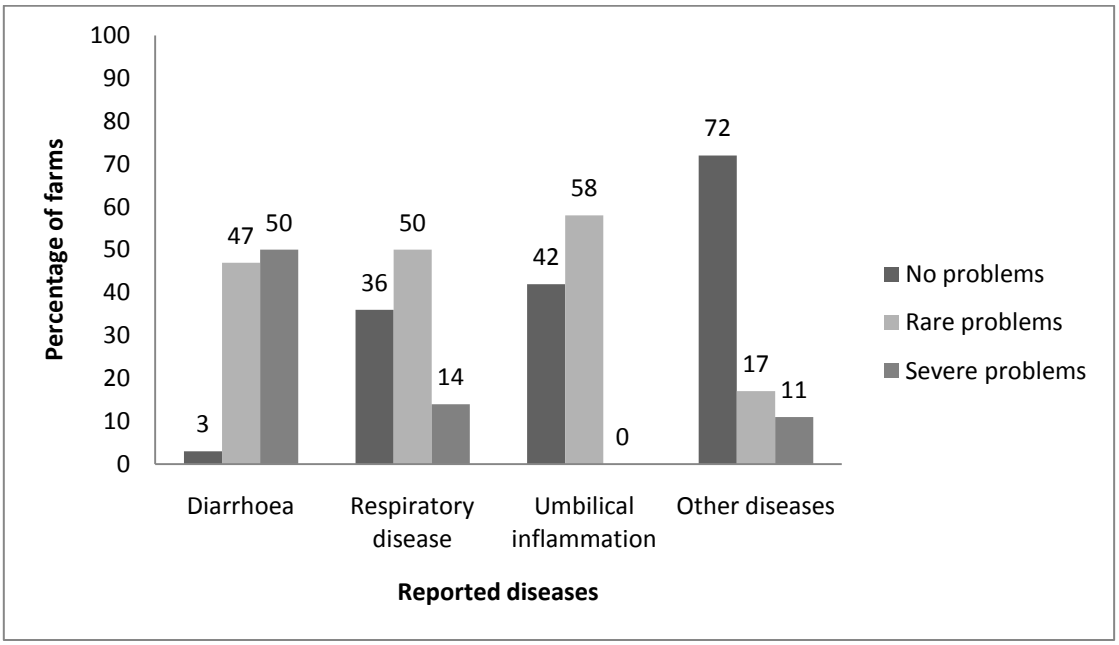

Figure 3. Farmers' perception of different categories of diseases

Results regarding the farmers' perception of diseases (n=36) are displayed in Figure 3. Only 3% of the farmers reported no problems with diarrhoea, 44% reported rare and 53% reported severe problems. In case of respiratory diseases, 32% of the farmers reported no problems, 53% reported rare problems and 15% severe problems. No farmer reported severe problems with umbilical infections, 56% reported rare problems and 44% reported no problems. Other diseases were not regarded a problem at 74% of the farms, rare and severe problems at 18% and 9% of the farms, respectively.

Table 11. Assessment of symptoms of diseases

Symptoms of diseases	<8W Percentage of calves affected	SD	>8W Percentage of calves affected	SD	WEANED Percentage of calves affected	SD
Diarrhoea	15.4	26.2	20.6	24.1	19.6	27.1
Coughing	26.9	24.8	25.6	30.8	5.7	15.1
Nasal discharge	21.4	23.5	12.2	19.6	12.1	24.5
Ocular discharge	1.1	4.6	0.0	0.0	2.5	7.7
Umbilical inflammation	8.1	14.8	1.9	5.6	0.0	0.0
Dirty coat	2.6	11.5	5.0	10.4	28.5	36.7

Findings of the health assessment of calves during the farm visits are displayed in Table 11. The average number of hairless patches was 1.2 (0-8, SD=2.3) for calves younger than eight weeks of age, 1.4 (0-10, SD=2.5) for calves older than eight weeks of age and 3.7 (0-20, SD=5.2) for weaned calves. The average number of lesions was 0.0 (0-0.3, SD=0.1) for calves younger than eight weeks of age and 0.2 (0-3.3, SD=0.7) for weaned calves. No lesions were found in calves older than eight weeks of age. No symptoms were found for joint inflammation, increased respiratory rate and inflammation of the udder in any of the calves.

5.3.2. Risk factors of diseases

Table 12. Potential risk factors for diseases considered in the pre-selection step for calves younger than eight weeks of age including significant factors

Risk factor	Unit	REC DIARR	REC RESP	REC UMB	REC TOTAL
Housing system					
Type of deep bedding	Fully/partly			x	
Amount of straw bedding	Floor fully/partly covered	x	x	x	x
Group size	2/>2 calves per pen				x
Size of lying area in total	m^2 in total		x		x
Size of lying area per calf	m^2 per calf		x		x
Feeding places per calf	Number per calf	x	x		x
Waterbowls per calf	Number per calf	x	x	x	x
Management					
Age groups per pen	1/>1			x	
Minimum amount of colostrum	Litres at first meal		x		
Amount of milk per meal	Litres		x		
Amount of milk per day	Litres		x		
Number of milk meals per day	2/3 meals	x	x		x
Duration of sucking artificial teat	Minutes	x			
Age of receoving forage	Days	x			
Measures					
Homoeopathic treatment	No/individual/all animals	x	x	x	x
Administering of selenium	Yes/no	x	x	x	x
Offering artificial teat	Yes/no	x	x		x

In Table 12 potential risk factors for diseases in calves younger than eight weeks of age are displayed, which were obtained from the pre-selection step ($p<0.2$ in univariate analysis). For REC DIARR and REC RESP risk factors included in the final model are associated with all three categories of housing system, management and measures. Risk factors in the final model of REC UMB and REC TOTAL are mainly associated the categories of housing system and measures.

Table 13. Risk factors for diseases in the final model for calves younger than eight weeks of age

Risk factor	Estimate	SD	p-value
REC DIARR (n=14)			
Intercept	-7.48	7.92	0.373
Waterbowls per calf	46.59	10.97	0.003
2 vs 3 milk meals per day	-14.90	5.99	0.038
No administering vs administering selenium	-20.17	8.03	0.036
REC RESP (n=14)			
Intercept	7.70	16.79	0.663
Waterbowls per calf	53.93	14.19	0.009
Amount of milk per meal	-14.77	4.71	0.020
No vs all animals receiving homoeopathic treatment	20.64	12.26	0.143
Individual vs all animals receiving homoeopathic treatment	34.65	12.06	0.028
REC UMB (n=14)			
Intercept	9.25	1.59	<0.001
Fully vs partly deep bedding	-3.06	1.30	0.037
Floor fully vs partly covered with straw bedding	-6.65	1.51	0.001
REC TOTAL (n=14)			
Intercept	-3.58	27.48	0.900
Waterbowls per calf	162.94	33.70	0.002
2 vs 3 milk meals per day	-59.92	17.70	0.012
No vs all animals receiving homoeopathic treatment	66.02	33.17	0.087
Individual vs all animals receiving homoeopathic treatment	93.75	32.63	0.024

Significant risk factors (P<0.2) in the final model are displayed in Table 13. The incidence of REC DIARR was positively associated with a high number of waterbowls per calf, receiving three instead of two milk meals per day and when selenium was administered. Similar to REC DIARR, a high number of waterbowls per calf increased the occurrence of REC RESP. The incidence of REC RESP decreased with a high amount of milk per meal and with treating all calves homoeopathically. REC UMB was lower with having calves in fully deep bedding instead of partly deep bedding and with fully covering the floor with straw. As with REC DIARR, REC TOTAL increased with a high number of waterbowls and with three instead of two milk meals per day. It decreased when all calves received homoeopathic treatment.

Table 14. Potential risk factors for diseases considered in the pre-selection step for calves older than eight weeks of age including significant factors

Risk factor	Unit	REC DIARR	REC RESP	REC UMB	REC TOTAL
Housing system					
Type of housing	Warm/cold housing			x	
Experience with group-housing	Number of years		x	x	x
Age of entering groups	<3/>3 weeks	x			x
Hours of access to outdoor run	Hours/day	x		x	
Size of lying area in total	m^2 in total			x	x
Size of lying area per calf	m^2 per calf	x			
Feeding places per calf	Number per calf		x		
Management					
Time after birth spent with mother	Hours				x
Minimum amount of colostrum	Litres at first meal		x	x	
Amount of milk per meal	Litres		x		x
Amount of milk per day	Litres		x		x
Temperature control of milk meal	Yes/no	x	x	x	
Amount of forage	Kg		x		
Age of receiving forage	Days			x	
Age of receiving water	Days	x			
Measures					
Fixating at milk meal	Yes/no	x	x		
Hay after milk meal	Yes/no		x		
Administering of selenium	Yes/no			x	

Table 14 displays risk factors for diseases of calves older than 8 weeks of age included in the pre-selection step ($p<0.2$ in univariate analysis). For the diseases of REC DIARR, REC RESP and REC UMB risk factors of all three categories were considered in the final model. For REC TOTAL only risk factors associated with the categories of housing system and management were included in the model.

Table 15. Risk factors for diseases in the final model for calves older than eight weeks of age

Risk factor	Estimate	SD	p-value
REC DIARR (n=15)			
Intercept	30.99	10.41	0.014
Size of lying area in total	-2.82	0.92	0.012
REC RESP (n=15)			
Intercept	-0.47	5.13	0.929
No hay vs hay after milk meal	8.05	2.66	0.013
Minimum amount of colostrum	3.55	1.29	0.020
REC UMB (n=15)			
Intercept	0.11	0.78	0.890
Warm housing vs cold housing	1.29	0.51	0.033
No control vs control of temperature of milk meal	1.69	0.41	0.003
Age of receiving forage	0.15	0.04	0.003
REC TOTAL (n=15)			
No significant factors			

Table 15 outlines significant risk factors (P<0.2) included in the final model for diseases of calves older than eight weeks of age. The incidence of REC DIARR increased with less lying area in total available. There was a higher incidence of REC RESP when no hay was fed after the milk meal and when a high minimum amount of colostrum was fed at the first milk meal. REC UMB decreased with controlling the temperature of the milk meal before feeding and with holding calves in cold housing. A higher age when forage was offered increased the incidence of REC UMB. No significant risk factors were found for REC TOTAL.

Table 16. Potential risk factors for diseases considered in the pre-selection step for weaned calves including significant factors

Risk factor	Unit	REC DIARR	REC RESP	REC UMB	REC TOTAL
Housing system					
Type of floor	Solid/perforated		x	x	
Management					
Age groups per pen	1/>1	x			
Time after birth spent with mother	0/<1/>1 hours	x		x	x
Time after birth spent with mother	Hours			x	
Minimum amount of colostrum	Litres at first meal		x		
Amount of milk per meal	Litres		x		x
Number of milk meals	Number/day		x		x
Criteria for weaning	Weight/feed intake/age		x		
Manner of weaning	Subtle/abrupt	x			
Amount of forage	Kg			x	
Age of receiving forage	Days		x	x	x
Age of receiving concentrates	Days	x			
Age of receiving water	Days	x	x		x
Measures					
Hay after milk meal	Yes/no			x	
Concentrates after milk meal	Yes/no			x	
Administering of selenium	Yes/no			x	x

Table 16 shows risk factors for diseases in weaned calves, which were obtained from the initial selection step ($p<0.2$ in univariate analysis). Potential risk factors for REC DIARR and REC RESP were mainly associated with housing and management factors. For REC UMB and REC TOTAL management factors were mainly considered for inclusion in the model, but also measures and one housing system factor for REC UMB.

Table 17. Risk factors for diseases in the final model for weaned calves

Risk factor	Estimate	SD	p-value
REC DIARR (n=17)			
Intercept	39.30	8.37	0.0007
1 vs >1 age group per pen	-25.38	6.04	0.0015
Abrupt vs subtle weaning	-19.61	6.71	0.0139
REC RESP (n=17)			
Intercept	11.51	11.54	0.3385
Solid vs perforated floor	-14.37	5.88	0.0309
Age of receiving forage	1.39	0.53	0.0220
REC TOTAL (n=17)			
Intercept	-40.48	80.28	0.6233
Number of milk meals per day	59.68	27.02	0.0474

Table 17 outlines significant risk factors (P<0.2) included in the final model for diseases of calves weaned off milk. The incidence of REC DIARR decreased with little age difference within the pen and with weaning calves abruptly. Solid floor and a lower age of receiving forage decreased REC RESP. Furthermore the incidence of REC TOTAL was positively associated with the number of milk meals per day.

5.4. Correlations of non-nutritive sucking and diseases

There were no significant correlations ($p<0.05$) between non-nutritive sucking and diseases. Incidences of CROSS, INTER, INTERCROSS and PEN were not significantly correlated with the number of veterinary treatments for diarrhoea, respiratory diseases, umbilical infections and diseases in total in any of the age categories. Nevertheless some correlations between non-nutritive sucking and diseases tended to be significant ($p<0.1$) as outlined in Table 17. In calves younger than eight weeks of age PEN appears to correlate with REC_DIARR. A high incidence of PEN occurs with a high incidence of REC_DIARR. The incidence of REC_TOTAL increased with an increased performance of INTER in calves older than eight weeks of age and with INTERCROSS in weaned calves.

Table 18. Coefficients of correlation of incidence of behaviour and health in all age groups

Coefficients	Estimate	p-value
<8W (n=14)		
PEN - REC_DIARR	0.48	0.0846
>8W (n=15)		
INTER - REC_TOTAL	0.44	0.0988
WEANED (n=17)		
INTERCROSS - REC_TOTAL	0.44	0.0746

6. Discussion

6.1. Descriptive data

The purpose of the present on-farm study was to assess the current situation of non-nutritive sucking, calf housing and rearing in group-housed Austrian Fleckvieh dairy calves. The farms included in the study (mean herd size 30.5 cows) were larger than the average dairy farm in Austria (13 cows; Grüner Bericht 2012). This is due to the selection criterion of having a minimum herd size of 20 cows, in order to assure that there is an adequate number of calves present while conducting the farm visits. Therefore visited farms might not be a true representative sample of organic dairy farms in Lower and Upper Austria. Then again group housing of calves becomes more imminent with a higher number of calves possibly resulting in farmers with larger herds being opinion leaders. Thus the situation on farms with larger herd sizes than the average is absolutely relevant.

6.1.1. Housing

In contrast to the organic farming regulations (C. 2, Art. 11, Commission Regulation (EC) No 889/2008), the mean age of calves entering group-pens was 2.7 weeks as opposed to eight days after birth. This is however covered by an exemption issued by the Austrian Federal Ministry of Health allowing keeping calves in single-housing up to an age of eight weeks for 'health or behaviour reasons' (Circular of BMGFJ 75340/0038-IV/B/7/2007). At one farm, calves were in single housing when older than eight weeks of age and thus the farmers violated the law. A questionnaire survey of organic dairy farms in Lower Austria showed that around 54% of farms held their calves in group housing from the first or second week of life and 24% of farms from between the third to eighth week of life, leaving about one third of calves in single housing, when older than eight days of age (Gugatschka, 2008). These results were similar to findings from the current study with one third (37%) of farms keeping some of their calves in single housing when older than eight days of life. Furthermore organic farming regulations (C. 2, Art. 14, lit. b, Commission Regulation (EC) No 834/2007) demand access to open air areas, preferably pastures, with exemptions until 31.12.2013 (Circular of BMG-75340/0049-II/B/7/2009). About two thirds of farms (68%) provided an outdoor run and one quarter of farms (24%) provided pasture for calves, although not always allowing permanent access and at a young age, leaving 8% of farms applying the exemption. The number of farms providing an outdoor run for calves decreased with age while the older the calves the more farms offered pastures.

6.1.2. Colostrum and milk feeding practices

Details of the colostrum management are similar to results of a questionnaire survey in Austria with all calves receiving colostrum within the first six hours (Gugatschka, 2008). However in the current study it was stated that calves received an average of 2.4 litres of colostrum compared to 2 litres reported in the previous survey (Gugatschka, 2008). These

numbers are higher than findings of a Norwegian survey, where 65% of farmers (81 out of 125 farms) fed their calves between 1.1 and 2 litres of colostrum and only 11% of farmers (14 out of 125 farms) fed their calves more than 2 litres of colostrum at the first feeding (Gulliksen et al., 2009b). The average time after birth calves spent with their mothers (11.2 hours) differed strongly from other results where in 42% of farms calves were separated from their mothers right after birth and only in 5% of farms calves spent between 6 to 24 hours or more with their mothers (Gugatschka, 2008). However in the current study there is a high variation in time with a maximum of 120 hours that calves spent with their mothers, which might have affected the mean. Management practices with regard to cow-calf contact also differ from those reported from other countries. In Sweden, calves were with their mothers for one to four days (Lidfors and Isberg, 2003) while on the contrary in Norway 70% of farms (87 out of 125 herds) separated calves and dams right after birth. In 22% of farms (27 out of 125 herds) calves spent up to 24 hours with the dams and in only 8% of farms (10 out of 125 herds) the calves stayed with their mothers for more than 24 hours (Gulliksen et al., 2009b).

Concerning milk feeding procedures, the use of automatic feeders is not very common with only 2 farms having established these systems. The majority of farms (95%) were feeding calves by hand with teat buckets or normal buckets. By comparison, a Swedish study reported the use of automatic feeders on 37% of farms, use of open buckets on 68% of farms and use of teat buckets at 27% of farms (Lidfors and Isberg, 2003). This high use of teat buckets on Austrian farms may be due to relatively small herd sizes compared with other countries e.g. Sweden, where the herd size of most farms was between 56 and 200 cows and use of automatic feeders is more widespread (Lidfors and Isberg, 2003). Details of the milk feeding practices were revealed in the interviews with the farmers. The calves got an average of 7.8 litres of milk per day when younger than eight weeks of age and 7.3 litres of milk per day when older than eight weeks of age. These results confirm findings by a survey in Austria where the majority of farms fed their calves eight litres of milk per day (Gugatschka, 2008). However, the amount of milk fed per day is higher compared to milk feeding practices in other countries. In Switzerland, calves were fed an average of 5.9 litres of milk per day (an average of 730 litres of milk per calf in total for an average age of 17.7 weeks) (Keil and Langhans, 2001) and in Sweden only 26% of farms fed their calves more than 6 litres of milk per day (Lidfors and Isberg, 2003). The average number of milk meals per day is 2.2 for <8W and 2 for >8W. This is due to feeding three meals per day at some farms when the calves are very young. While these findings correspond to results by other studies (Gugatschka, 2008), calves suckled by their mothers would receive an average of six milk meals per day in their first month of life, one milk meal lasting approximately 10 minutes. In this study one milk meal lasted about 3 minutes, thus a calf spent six minutes a day with sucking milk whereas a calf suckled by its mother spent 60 minutes sucking milk. This results in a shortcoming of time spent sucking (Sambraus, 1985). Another matter with corresponding results was the average weaning age of 14.6 weeks in this study and 14.5 weeks in the study by Gugatschka (2008). In a Swiss study the average weaning age is even

higher with 17.7 weeks of age (Keil et al., 2000) while in a Swedish study 44% of farms weaned their calves before eight weeks of age (Lidfors and Isberg, 2003). In both studies the ratio of organic farms is not stated.

6.2. Behavioural measures

6.2.1. Assessment Methods for behaviour

Unlike many other studies dealing with non-nutritive sucking of calves, the behaviour was not assessed with video observation but with direct continuous observation. Although it is argued that video recording prevents animal-observer-interactions, indirect observations reveal a lower frequency of oral stereotypies. Oral behaviours such as licking, biting and nibbling structures or other calves are more clearly visible in direct observation (Tosi et al., 2006). Bokkers et al. (2009) evaluated behavioural observations of calves on their reliability and found high correlations between observers as well as high correlations within pens and farms when tests were repeated. Thus, this supports the overall conclusion that direct observations are an appropriate and reliable method to observe non-nutritive sucking in calves.

There are clear definitions and distinctions between cross-sucking, describing sucking on the entire body including the navel except for the udder area, and intersucking, meaning sucking only in the udder area, that were applied in this study and also in other studies e.g. Keil and Langhans (2001). However, some studies defined CROSS or INTER in calves as sucking under the belly of another calf and reaching its teats, navel or scrotum (De Passillé et al., 2010, De Passillé et al., 2011, Laukkanen et al., 2010, Lidfors and Isberg, 2003). There are interrelations between sucking under the belly and intersucking in heifers and cows, however sucking under the belly and sucking on the mouth of other calves are not related. Furthermore sucking on the mouth does not induce intersucking in heifers and cows (Lidfors and Isberg, 2003). Therefore it may have made more sense to distinguish between sucking under the belly and sucking at the entire body except under the belly.

6.2.2. Incidences of non-nutritive sucking

Two thirds of farmers (65%) reported to face a problem with cross-sucking and intersucking in their cattle herd. These results correspond to findings by previous studies with 68% of conventional farms having a problem in Austrian Fleckvieh cattle (Rinnhofer, 2008) and 64% of organic farms having a problem in calves (Gugatschka, 2008). The main problem was in heifers, with half of the farmers (50%) reporting issues in that age group. Numbers in Sweden were slightly higher with 60% of farmers having observed intersucking heifers (Lidfors and Isberg, 2003). In this study about one third of the farmers reported having issues in non-weaned and weaned calves. When comparing these findings to the percentage of farms where non-nutritive sucking was observed, only percentage of farms where INTER was

observed corresponded to the percentage of farmers reporting problems in calves. This may indicate that farmers don't consider CROSS a problem, but only INTER. Another possible explanation for this misjudgement may relate to the farmer's daily routine in leaving the barn after feeding his animals and therefore simply not observing this behaviour. Hence in further studies a clearer distinction between observed performance of non-nutritive sucking and perception of non-nutritive sucking as a problem by farmers is recommended.

Our findings of observed CROSS and INTERCROSS confirm results of a Swiss study reporting cross-sucking in calves in 93% of farms and in 50% of calves per farm (Keil et al., 2000). Observed percentages of calves affected strongly differ from farmers' estimates. Farmers reckoned that around 30% of non-weaned and weaned calves per farm performed non-nutritive sucking while INTER occurred in around 10% of non-weaned and weaned calves per farm and INTERCROSS occurred in around 50% of non-weaned calves and 17% of weaned calves. To explain this situation it might be necessary to differentiate between milk-dependent and milk-independent cross-sucking and intersucking. In the present study calves were observed for only a short period of time and statements can be made for one hour after the milk meal. Results of another study demonstrated that only 28% of sucking bouts were performed within 15 minutes after milk ingestion, leaving 72% of sucking bouts not induced by intake of milk occurring either before or more than 30 minutes after the milk meal (Roth et al., 2009). Therefore farmers might primarily observe milk-independent cross-sucking and intersucking, resulting in a distinction between farmers' estimates and the performed observation. In this study the number of events per calf and hour as well as the number of affected calves numerically decreased with age and weaning in CROSS, INTERCROSS and PEN. The lower frequency of events and number of calves performing CROSS after weaning is in accordance with a Swedish study where after weaning the occurrence of CROSS was significantly reduced (Lidfors, 1993). PEN was also reduced by age and weaning. On the contrary, the number of INTER events levelled off while the number of calves performing INTER increased numerically. These results cannot be confirmed by other studies.

The results regarding the use of preventive measures differ substantially from other studies. A high level of nose clips is reported to be in use (82%) but it was actually seen on only one calf. This can be explained by farmers referring to heifers and cows instead of calves. Rinnhofer (2008) reports the use of nose clips and isolation with 35% and 10% of farms, whereas in this study isolation was more frequently reported to be used. Keil et al. (2000) give account of calves being restrained during milk feeding at 92% of farms, calves being offered hay or concentrate after the milk meal at 99% of farms and use of nose rings at 22% of farms. In comparison to that, fixating (71%) and provision of hay (59%) and concentrates (53%) after milk feeding as counter measures were reported in our study at lower percentages.

6.2.3. Risk factors for non-nutritive sucking

Although risk factors were determined for different age groups, findings of some of the risk factors considered in the pre-selection were similar to one another. Thereby calves younger and older than eight weeks of age had more in common than non-weaned and weaned calves. In general, findings indicate that the motivation for performing CROSS and INTER is rather different from the motivation for PEN. In the following chapter results of risk factors for all age groups will be discussed according to their arrangement in groups for housing system, management and measures. It is pertinent to note that determined risk factors indicate associations rather than causal relationships.

6.2.3.1. Risk factors related to housing systems

Type of housing was a potential risk factor in the pre-selection step in all age groups but it was only significant in non-weaned calves. Results for type of housing were contradictory for INTER and PEN in calves younger than eight weeks of age and for INTERCROSS in calves older than eight weeks of age. The occurrence of INTER in <8W was significantly lower in calves housed in calf hutches than in modified housing and significantly higher in warm housing compared to modified housing. There was no significant difference between cold housing and modified housing, possibly indicating only minor differences in the two housing systems. Similar results were obtained by Keil et al. (2000) where INTER was raised in heifers when they were kept in enclosed buildings during the rearing period. The authors also make the point that INTER is decreased by environmental enrichment and therefore possibly reduced in calf-hutches. These findings were not confirmed by a Finnish study comparing the occurrence of oral behaviour in different housing systems. They found no significant difference in the occurrence of CROSS between group-housing of calves indoors and outdoors with and without heated shelter. Nevertheless they argue that the variety in environmental stimuli was higher in outdoor housing and therefore explorative behaviour was stimulated (Hepola et al., 2006). It may thus be concluded that also the motivation to perform oral behaviours such as INTER may be stimulated and diverted by a stimulating environment. These findings are contradictory to results for calves older than eight weeks of age. They had a reduced performance of INTERCROSS when housed in warm housing compared to cold housing. This cannot be explained and might be related to other factors. Concerning performance of PEN, the housing system seemed to play a major role. Compared to modified housing, occurrence of PEN was highest in calf hutches followed by warm housing. These findings are only partly in agreement with other studies. According to a Finnish study, risks of licking and biting of structures are higher in indoor housing compared to outdoor housing. They argue that in calves housed outdoors the motivation to perform explorative oral behaviour is stimulated by the environment. Then again they report that calves in outdoor housing guide their oral behaviour towards the straw bedding inside their shelters (Hepola et al., 2006). These observations could also apply to this study.

In weaned calves INTERCROSS and PEN were associated with flooring and bedding. The odds for INTERCROSS were lower when calves were housed on a solid floor compared to a perforated floor. Performance of PEN was reduced when the floor was fully covered with straw instead of only partly covering. Possibly the motivation for both behaviours was connected since straw bedding is usually combined with a solid floor. Therefore straw could function as environmental enrichment and thus reduce the performance of non-nutritive sucking.

A high number of waterbowls per calf increased the risk of displaying PEN in calves younger than eight weeks of age. This result is contradictory to findings by Gottardo et al. (2002). They observed differences in oral behaviours of veal calves with or without access to drinking water, finding a lower frequency of non-nutritive oral behaviour when water was provided to calves. They reasoned water functioned as environmental enrichment. Then again in this study the basic provision of water was not investigated, but the effect of the number of waterbowls provided on the performance of non-nutritive sucking.

Another factor affecting PEN in calves older than eight weeks of age was the number of feeding places per calf. When more than one feeding place per calf was offered, odds for PEN were reduced. This might be an indirect effect of space allowance since a higher number of feeding places indicates the pen was built for more calves than currently housed. Larger lying areas lead to more simultaneous lying (Færevik et al., 2008) and thus calves might spend more time resting rather than sucking and licking parts of the pen.

Access to an outdoor run was considered as a risk factor in INTER in calves younger and older than eight weeks of age but its effect was different. According to expectations, having access to an outdoor run at a young age decreased the performance of INTER in calves older than eight weeks of age while the contrary happened in calves younger than eight weeks of age. A decreasing effect might be explained with environmental enrichment gained when having access to an outdoor run (Keil et al., 2000), although the age of having access to an outdoor area was not reported in previous studies. Furthermore when having access to an outdoor run, calves can escape more easily when approached by a sucking calf. For PEN an association with the number of hours spent in the outdoor run was found. The occurrence is lowest for calves having 24 hours access to the outdoor run and highest for calves having access for 2-18 hours, with calves having no access showing an intermediate level of the behaviour. Keil et al. (2001) found a decreasing effect of the access to an outdoor area for INTER and it is not clear if the same motivational background applies for PEN; indeed access to an outdoor run as such was not identified as influencing factor for INTER in the present study.

6.2.3.2. Risk factors related to management

Details of the milk meal appeared as risk factors in CROSS and INTERCROSS in calves older than eight weeks of age. Both behaviour categories were positively associated with a high

amount of milk per meal and a low amount of milk per day. These results suggest feeding of small amounts of milk several times per day. These findings indicate a trend towards a natural nursing situation where cows suckle their newborn calves five to ten times a day with numbers decreasing to three to six times per day in six months old calves (Fraser and Broom, 1997). Although the results of this study suggested feeding of a higher amount of milk per day, in other studies the odds to perform sucking under the belly were decreased when calves were fed less than 6 litres of milk (Lidfors and Isberg, 2003) and 7 litres of milk per day (Keil et al., 2000), compared to an average of 7.3 litres of milk fed to calves older than eight weeks of age in this study. These differences can perhaps be explained by a difference in age. In the study of Lidfors and Isberg (2003) nearly half of the farms weaned their calves before eight weeks of age while Keil et al. (2000) don't provide information on what age calves received this amount of milk. Rushen and De Passillé (1995) observed a higher duration of sucking and butting when calves were fed only 75% of the recommended amount of milk compared to 100%. Furthermore they argue that performance of non-nutritive sucking was higher when calves were fed on a low level due to an amplified response to ingestion of milk. In addition they mention a trend that the impact of feed level was growing with age. Therefore restricted milk feeding might have deprived calves of milk and induced non-nutritive sucking.

Likewise this study found a high rate of drinking the milk meal to increase PEN in calves younger than eight weeks of age. According to Jensen (2003), the natural motivation to suck is encouraged during the milk meal and this motivation to perform PEN can be prevented by lower milk drinking rates and longer milk feeding times. These results can be confirmed by various studies. For example Haley et al. (1998) demonstrated that a higher milk flow resistance resulted in less non-nutritive sucking.

Another risk factor affecting CROSS in calves older than eight weeks of age was age at offering water. Performance of CROSS was increased when calves received access to water at a younger age. Although Gottardo et al. (2002) found provision of water to represent environmental enrichment and decrease non-nutritive sucking, de Passillé et al. (1997) reviewed that drinking water did elicit non-nutritive sucking, however at a lower rate than drinking milk.

Age at offering concentrates affected INTER and PEN in calves older than eight weeks of age. While INTER increased when calves were offered concentrates before ten days of age, PEN increased with age of calves when offered concentrates. The mean age of offering concentrates was 18 days, thus the critical age of starting to offer concentrates might be between 11 and 17 days of age. When calves are fed concentrates at a very young age, development of their rumen might be deferred (Keil et al., 2000). On the other hand calves need energy for growth and inappropriate energy supply might induce non-nutritive sucking (Roth et al., 2009).

Time after birth spent with their mothers seemed to have an effect on PEN in weaned calves. There were higher odds of PEN when calves did not spend any time with their mothers. These findings are not obviously linked since a long duration of time passed between them. After birth the mother is licking her calf and thereby stimulating its physiological functions and also the calf is seeking the cows' teats to drink. While searching for the teats, calves may lick and suck other body areas of the cow (Fraser and Broom, 1997). If separated right after birth the newborn calf might still have the motivation to perform this behaviour but no object to perform it on and therefore it starts sucking and licking parts of the pen. While intersucking in weaned calves developed when the calves were still fed milk (Keil and Langhans, 2001), this might also be true for PEN and may become a habit when learned at a young age.

Age at weaning affected INTERCROSS in weaned calves. A higher age of weaning resulted in higher odds to perform these behaviours. In other on-farm studies the age of weaning did not have a significant effect on non-nutritive sucking (Keil et al., 2000, Keil and Langhans, 2001, Lidfors and Isberg, 2003). This result is unexpected since in a natural situation calves would be nursed by their mothers for a maximum of ten months (Sambraus, 1991) while on farms included in this study calves were weaned at an average age of 15 weeks. Therefore age of weaning might indicate indirect factors. Although it could also be the case that farms with problems of non-nutritive sucking weaned their calves at an earlier age.

Another risk factor affecting the occurrence of INTER in calves younger than eight weeks of age is the age difference of calves within the pen. A high age difference in weeks led to an increased performance of INTER. One explanation for this observation could be a high difference in age within the calves of a pen, leading to an inappropriate diet (Keil et al., 2000) and thus to an inadequate energy supply resulting in higher risks of non-nutritive sucking (Roth et al., 2009).

6.2.3.3. Risk factors related to measures to reduce non-nutritive sucking

Concerning measures to reduce non-nutritive sucking, fixating during the milk meal was negatively associated with CROSS in calves younger than eight weeks of age while isolating reduced the odds of INTERCROSS in calves older than eight weeks of age. These management practices however only retain the animals from performing the behaviour rather than effectively treating possible underlying causes. Lidfors (1993) reported the highest occurrence of CROSS directly after the milk meal in contrast to Roth et al. (2009) who observed two thirds of cross-sucking bouts not being related to milk ingestion. Therefore restraint may be seen as an effective counter-measure against CROSS but only when the behaviour is related to the ingestion of milk. Restraint ensures an undisturbed milk meal allowing complete ingestion of milk and counteracting sucking motivation of calves (Rushen and De Passillé, 1995). Similar effects may apply for isolation.

Feeding hay directly after the milk meal could reduce the performance of CROSS and INTERCROSS in calves older than eight weeks of age. This is in accordance with another study where odds of non-nutritive sucking were lower when calves were provided with hay after the milk meal (Haley et al., 1998). The authors argued that provision of roughage might be an effective measure, in older calves in particular, since younger calves might have a lower ingestion of hay. Houpt (1987) reasoned that performance of ruminating might inhibit the development of stereotypic behaviour. This might also apply for redirected behaviours such as non-nutritive sucking. Otherwise feeding hay directly after the milk meal might simply occupy the calf until the motivation to perform non-nutritive sucking fades.

Administration of selenium lowered the risks of calves performing INTER when younger than eight weeks of age. A possible reason behind this might be a better health status of calves receiving this treatment. Calves not receiving selenium might suffer from a poor state of health e.g. diarrhoea. Similar to previously discussed risk factors the resulting energy-imbalance might induce non-nutritive sucking (Roth et al., 2009). On the other hand administration of selenium might indirectly indicate improved care and management of calves and thus resulting in a lower occurrence of INTER.

6.3. Health measures

6.3.1. Assessment methods of diseases

To determine the health status of calves, farmers were asked for their estimates of diseases, calves were physically examined and veterinary records were assessed. Risk factors were determined data from veterinary records, because these data seemed to give the most accurate picture throughout the year. Nevertheless there are some points of criticism. Some farmers wished not to conceal their veterinary records and therefore were excluded from the evaluation, limiting sample size. Also the age of calves could not be determined for the veterinary records, including all calves up to an age of six months. This might have reduced the level of accuracy. The variable ‘other diseases’ was not included in the risk factor evaluation for its variety and respective possible causes.

6.3.2. Incidences of diseases

Farmers’ estimates for diseases in non-weaned calves mostly reflect the incidences obtained from veterinary records, with the exception of health issues categorized as other diseases that were underrated. However the number of calves affected from diseases at the time of the farm visit did not correspond to the farmers’ estimates. Although incidence rates for a one-year period cannot be directly compared with prevalences obtained from a single snapshot farm visit, for example the proportion of calves observed with diarrhoea was moderate with 15-20% of calves showing symptoms, but incidence rates seem to indicate a less frequent problem with an average of 9 treatments per 100 calves and year. On the

contrary, the number of veterinary treatments is more likely to only correspond to serious health issues rather than less severe levels of symptoms. All three tools to assess incidence of diseases - farmers' estimates, health examination and veterinary records - showed a similar trend with diarrhoea and respiratory diseases representing more common problems. This corresponds to findings by a Swedish study with highest incidence risks (%) and rates (cases per calf-month at risk) of diarrhoea and respiratory diseases (Svensson et al., 2003). When comparing results of the health examination between the different age groups, symptoms associated with respiratory disease numerically decreased with age. Coughing decreased from roughly 25% of calves showing coughing before weaning to 6% after weaning, while percentage of calves showing nasal discharge numerically decreased when older than eight weeks of age. Level of dirt, number of hairless patches and lesions numerically increased with age, being highest in weaned calves. During the milk-feeding period all calves were housed in a deep litter system while some weaned calves were housed in cubicles. Therefore this increase will most likely be due to changes in housing system and different housing conditions for weaned calves.

6.3.3. Risk factors for diseases

When assessing risk factors for diseases it is difficult to determine whether the evaluated factors cause the disease or are the reaction of the farmer to prevent already existing issues. In the following, factors for all age groups will be discussed according to their association with disease category.

6.3.3.1. Risk factors of diarrhoea

Diarrhoea is one of the main issues in calf rearing with an average incidence rate of nine veterinary treatments per 100 calves and year and 97% of farmers reporting problems with this disease in calves fed milk. Probably due to the variety of potential causes, evaluated risk factors only partly correspond to findings of other studies. Housing factors seem to be significantly associated with the incidence of diarrhoea. In calves older than eight weeks of age a small size of lying area in total increased the odds of diarrhoea. This can be confirmed by Svensson et al. (2006) finding lower odds of diarrhoea in larger pens. A reason therefore might be that a small size of lying area affects hygiene of the pens adversely. Torsein et al. (2011) argue that a high number of faecal pathogens correlate with a high mortality within the herd. In addition a high number of waterbowls per calf increased the odds of diarrhoea in calves younger than eight weeks of age. This effect remains difficult to explain, but could also be linked with hygiene issues.

In weaned calves prevalence of diarrhoea increased with a high age difference of calves within the pen. This result can be confirmed by a study comparing stable groups using an 'all in-all out' system with dynamic groups, where calves are continuously introduced. The prevalence of diarrhoea was less than half in stable group systems and the authors argue

that this might have been caused by a shorter cleaning interval resulting in a decreased pathogen load in the stable group with a positive effect on health (Pedersen et al., 2009). It may also be argued that because of their high variety in age, animals are in different stages of their development, resulting in younger animals being more prone to diseases and falling ill more easily.

Other factors associated with diarrhoea concern management, although they might not induce diarrhoea but were the reaction of the farmer to an existing problem. The odds of diarrhoea were increased when two milk meals per day instead of three were fed, when selenium was administered and when calves were weaned subtle instead of abrupt. It can be reasonably assumed that those are measures of the farmer to prevent issues with diarrhoea rather than factors causing this disease.

In general these findings do not correspond to results of other studies. Svensson et al. (2003) report incidence of diarrhoea to be mainly associated with colostrum management, breed and group size. Lundborg et al. (2005) report breed, origin of colostrum and proximity of the calf pen to outer walls to be associated with diarrhoea. In our study colostrum management and group size had no effect on diseases and proximity of calf pen to outer walls was not assessed. The only partial corresponding of findings of this study to other studies confirms the multifactorial conditioning of diarrhoea. Thus they should be seen as addition to already known parameters.

6.3.3.2. Risk factors of respiratory diseases

A variety of risk factors appeared to have significant influence on the prevalence of respiratory diseases. Similar to diarrhoea, a high number of waterbowls increased the odds of respiratory diseases in calves younger than eight weeks of age. As with diarrhoea this may be seen as an indirect effect of other unknown factors or as hygiene problems associated with a higher number of water points.

In weaned calves the odds of respiratory diseases were reduced when calves were housed on a solid floor compared to a perforated floor. Although a slatted concrete floor was assessed as a variable in a questionnaire study on respiratory diseases in Norwegian dairy herds, it was not determined as a significant factor (Gulliksen et al., 2009b). It could be argued that flooring type is linked to bedding and calves housed on solid floors likely have straw bedding. Svensson et al. (2006) argue that straw bedding is often combined with cold housing and thus with higher air volume and better air quality, reducing the risks of respiratory diseases. In beef calves risks of incidence of respiratory diseases were lower in completely straw-bedded pens rather than partly straw-bedded pens (Assié et al., 2009). This may also apply to dairy calves. To continue this thought, draught was one of the risk factors to induce increased respiratory sounds in a Swedish study (Lundborg et al., 2005), which might have a higher impact on calves housed on perforated floors. Furthermore their alternative reasoning included cold radiation, higher humidity and damp bedding conditions

(Lundborg et al., 2005). Whether this is actually the case in the farms investigated in the present study, is however not clear and would have to be further studied in more details.

The occurrence of respiratory diseases in calves younger than eight weeks of age is also affected by quantity of milk. The findings showed a significant decreasing effect of high quantity of milk per meal on respiratory diseases, however this cannot be confirmed by other studies. Lundborg et al. (2005) and Svensson et al. (2003) found no effect of milk allowance on respiratory diseases. It may be hypothesized that a low milk allowance led to reduced growth and development, making calves more prone to diseases.

Feeding of forage seemed to be another factor affecting REC RESP. In calves older than eight weeks of age the odds for REC RESP were lower when calves were offered hay after the milk meal and in weaned calves the occurrence of respiratory diseases was decreased when calves received forage at a young age. In veal calves feeding of solid feeds improved the development of the rumen. As a result calves had a better health status and a reduced number of veterinary treatments concerning respiratory diseases among other things (Cozzi et al., 2002). Therefore it can be reasoned that a promoted development of the rumen leads to lower risks of respiratory diseases in dairy calves.

In calves older than eight weeks of age a high amount of colostrum seemed to increase the odds for respiratory diseases. While amount of colostrum is not mentioned in other studies, colostrum management is a crucial factor in calf rearing. The risk of respiratory diseases is increasing with time after birth when colostrum is fed. Risks of respiratory disease can be decreased when calves are fed colostrum within the first thirty minutes after birth (Gulliksen et al., 2009b). Therefore this contradictory result can be explained by being the reaction of the farmer to an existing problem. Farmers may feed a high amount of colostrum when they have had issues with respiratory diseases before.

In addition respiratory diseases can be prevented by using homoeopathic treatment in all animals. Since the effect of homoeopathic treatments is controversially discussed, it can be argued that this might be an indirect effect indicating improved care and observation by the farmer.

6.3.3.3. Risk factors of umbilical inflammation

With about one treatment per 100 animals and year and only half of the farmers reporting occasional problems, umbilical inflammation is the rarest disease assessed in this study. In the following, umbilical inflammation will be discussed in non-weaned calves only, regardless that it is uncommon in older calves.

Housing seemed to have a major impact on the occurrence of umbilical inflammation. Risks of REC UMB were increased in warm housing compared to cold housing in calves older than eight weeks of age. This cannot be confirmed by other studies. It could be argued that

increased cross-sucking and intersucking in warm housing (Keil et al., 2000) induced umbilical inflammations. Furthermore bedding influenced REC UMB. In calves younger than eight weeks of age the odds of umbilical inflammation could be decreased with housing on fully deep bedding and a high amount of straw covering the floor completely. These findings correspond to findings for respiratory diseases and therefore possible explanations might also apply for umbilical inflammations.

Further factors affecting the occurrence of umbilical inflammation were related to the feeding management. Odds for REC UMB in calves older than eight weeks of age were lower when temperature of the milk was controlled before feeding. Lundborg et al. (2005) found the same effect for diarrhoea, although it can be assumed that this measure indicates improved care of calves. Furthermore a higher age of receiving forage increased the risks of umbilical inflammations. Similar to REC RESP, a better rumen development might induce an improved health status (Cozzi et al., 2002).

6.3.3.4. Risk factors of diseases in total

Due to the fact that the parameter 'total diseases' is the accumulation of all veterinary records per 100 calves and farms, risk factors mainly correspond to previously mentioned considerations. Similar to REC DIARR and REC RESP, the total number of veterinary treatments increased with a high number of waterbowls in calves younger than eight weeks of age. This is likely due to indirect effects and possibly hygiene reasons as mentioned above.

Also, the odds for REC TOTAL were increased with feeding a higher number of milk meals per day. As mentioned earlier, it can be reasoned that the farmer is feeding more milk meals per day as a reaction to an existing health issue.

In addition, the number of veterinary treatments was reduced with treating all animals homoeopathically. On the one hand usage of homoeopathic medicine might have prevented outbreak of diseases, while on the other hand this might have indicated better care and observation of calves.

6.4. Correlations of non-nutritive sucking and diseases

This study did not reveal significant relations between non-nutritive sucking and diseases, likely due to limited sample size. Nevertheless some parameters tended to be related. Sucking and licking parts of the pen tended to correlate with diarrhoea in young calves. It can be argued that when calves perform PEN, they ingest pathogens inducing diarrhoea. Then again calves suffering from diarrhoea might have an increased energy demand and compensate this with performing PEN.

In addition the total number of veterinary treatments appears to be associated with the performance of INTER and INTERCROSS. These behaviours might result in the ingestion of

pathogens of the sucking calf, or induce diseases in the sucked calf. Then again calves might perform these behaviours because of a reduced well-being. Indeed, in a study by Lidfors (1993) cross-sucking in calves was negatively correlated with the frequency of antibiotic treatments against cough, fever and reduced general health, possibly indicating that when sick calves were treated and hence their well-being improved, their motivation to perform cross-sucking was reduced.

7. Conclusion

Non-nutritive sucking such as cross-sucking, intersucking and sucking and licking parts of the pen can indeed be regarded a problem in group housed calves on organic dairy farms in Austria. However, the occurrence of non-nutritive sucking is underrated by (some) farmers. The reason for this may be either seen in the farmers' daily schedule which may prevent them from observing calves performing non-nutritive sucking or in their attitudes to not regard the behaviour as a problem. It must be mentioned that generalisation of results of this study must be done with caution, due to the limited sample size.

The evaluated risk factors are not always in accordance with findings from other studies and expected outcomes. This substantiates its multifactorial causation and indicates a wide variety of different factors interrelating with each other. While cross-sucking and intersucking seem to be related to each other, sucking and licking parts of the pen appears to be less linked with the other behaviour categories. Thus, underlying causes and motivations to perform non-nutritive sucking towards a pen mate or aimed at the inanimate surrounding seem to be diverse. Furthermore risk factors vary with the age of the calves. Non-nutritive sucking in very young calves seems to be triggered by different factors than in calves older than eight weeks of age and in weaned calves.

Concerning risk and success factors of non-nutritive sucking, age of entering groups had no significant effect on performance of cross-sucking, intersucking or sucking and licking parts of the pen in any of the evaluated age categories. Thus, it cannot be argued that group housing of calves at a young age should be obviated because it induces non-nutritive sucking.

The following recommendations can be given to reduce the performance of non-nutritive sucking: In calves younger than eight weeks of age an effective measure was restraining the calves after the milk meal for a short period of time and thereby simply inhibiting performance of this behaviour. Furthermore it is advantageous to keep them in calf hutches and ensure a similar age of calves within the pen. Performance of PEN can be reduced by providing calves with 24 hour access to an outdoor run and ensuring a low drinking rate and thereby a long duration of drinking the milk meal. When calves are older than eight weeks of age, issues in cross-sucking can be prevented by serving small milk meals several times per day. Also providing calves with hay directly after the milk meal has a decreasing effect on cross-sucking, possibly due to distraction and enhanced rumen development. Also environmental enrichment is essential to prevent non-nutritive sucking in calves, such as access to an outdoor run, preferably at a young age. Not only does it provide occupation, but access to an outdoor run gives calves the opportunity to avoid and escape sucking calves. Sucking and licking parts of the pen can be prevented with sufficient space available in the pen. In weaned calves only few and contradictory risk factors for non-nutritive sucking were determined, one of them being straw bedding, possibly functioning as environmental

enrichment, reducing all forms of non-nutritive sucking. Allowing calves to spend some time with their mothers after birth can reduce sucking and licking parts of the pen.

However, farms having problems in weaned calves should consider factors affecting non-nutritive sucking in non-weaned calves. It is well known that sucking in young calves can lead to sucking in weaned calves, heifers and cows. Therefore acquiring this behaviour at a young age and habit formation must be prevented.

Falling ill with diseases is a major welfare risk of calves, though farmers are aware of that issue. Especially respiratory diseases and diarrhoea are major health problems in young calves. Risk factors inducing diseases substantially differ between the various age groups. Similar to non-nutritive sucking, age of entering groups has no significant effect on occurrence of diseases.

To prevent calves falling ill with diseases, consideration of the following aspects can be recommended: A large size of lying area and thus a high space allowance and therefore presumably lower disease pressure can reduce the occurrence of diarrhoea in calves older than eight weeks of age. In weaned calves diarrhoea can be obviated by little age difference within the pen and by abrupt weaning. Respiratory diseases in very young calves can be prevented by offering a sufficient amount of milk per meal, thereby enhancing growth and development. Furthermore homoeopathic treatment could reduce falling ill with respiratory diseases in young calves, although it might indirectly indicate greater care and attention paid to calf rearing. In calves older than eight weeks of age, providing hay after the milk meal had a positive effect on respiratory health, possibly due to enhanced development of the rumen and prevention of ingesting pathogens by non-nutritive sucking. Also in weaned calves early provision of forage and thus improved rumen development is essential to prevent respiratory diseases. Umbilical inflammations in young calves can be reduced by housing in deep bedding with sufficient amount of straw. When calves are older than eight weeks of age, umbilical inflammations can be prevented in cold housing and with providing forage at a young age and thus enhancing rumen development and inhibiting non-nutritive sucking. In weaned calves housing with solid flooring and presumably straw bedding can prevent umbilical inflammation. To reduce the number of veterinary treatments, these previous recommendations should be considered.

In this study certain risk and success factors for non-nutritive sucking and diseases in group-housed calves could be assessed, providing farmers with criteria to consider in calf rearing practices. Certainly not all of these recommendations can be followed at once. Thus, careful monitoring of behaviour and health of calves is essential, so farmers can identify critical areas in calf rearing on their farms and avoid them by taking specific precautionary measures.

8. Summary

Group-housing of calves allows calves to display normal social behaviour, as well as cross- and inter-sucking, which is often considered a problem especially in breeds such as Fleckvieh. The aim of this on-farm study is therefore to assess the incidence of non-nutritive sucking and the health status of group-housed calves in Austria and to identify related risk factors. 37 organic dairy farms were visited between April and June 2012. Calves were directly observed for 1.5 hours followed by a clinical examination. After a preliminary selection step ($P<0.2$), risk factors were evaluated in a general linear model when $P<0.2$. The following risk factors for increased occurrence of cross-sucking and intersucking were determined: warm housing and perforated flooring, high age difference within the pen, high age of access to outdoor run, high amount of milk fed per meal, low age of offering water and concentrates and high age of weaning. Furthermore cross-sucking and intersucking could be reduced by the following measures: restraint during milk feeding, isolating, administering selenium and providing hay after the milk meal. Sucking/licking parts of the pen was decreased by modified housing, having 24 hours access to an outdoor run, offering more than one feeding place per calf and a high number of waterbowls per calf. Furthermore sucking/licking parts of the pen could be reduced by a high amount of straw bedding, low age of offering concentrates, low rate of drinking the milk meal and by calves spending time after birth with their mothers. Main risk factors for increasing the incidence of diseases were warm housing, perforated flooring and low amount of straw bedding, high number of waterbowls per calf, high age difference within the pen and subtle weaning. Providing hay after milk feeding, feeding roughage at an early age and treating calves homoeopathically had a decreasing effect on diseases. Sucking/licking parts of the pen was positively associated with the incidence of respiratory diseases and intersucking and cross-sucking were related to diseases in total. These results offer concrete areas to avoid problems or to improve the situation, if non-nutritive sucking and diseases are observed.

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10. List of references

Abou-El-Ella, A. G. 1999. Surgical treatment of anomalous milk sucking in Friesian dairy cattle. *Assiut. Vet. Med. J.,* 42**,** 260-270.

Assié, S., Bareille, N., Beaudeau, F. & Seegers, H. 2009. Management- and housing-related risk factors of respiratory disorders in non-weaned French Charolais calves. *Preventive Veterinary Medicine,* 91**,** 218-225.

Berger, G. 1989. Langjährige Beobachtungen zur Milchsaugerproblematik in einer großen Milchviehherde. *Mh. Vet. Med.,* 44**,** 101-103.

Boissy, A., Manteuffel, G., Jensen, M. B., Moe, R. O., Spruijt, B., Keeling, L. J., Winckler, C., Forkman, B., Dimitrov, I., Langbein, J., Bakken, M., Veissier, I. & Aubert, A. 2007. Assessment of positive emotions in animals to improve their welfare. *Physiology & Behavior,* 92**,** 375-397.

Bokkers, E. A. M., Leruste, H., Heutinck, L. F. M., Wolthuis-Fillerup, M., Van Der Werf, J. T. N., Lensink, B. J. & Van Reenen, C. G. 2009. Inter-observer and test-retest reliability of on-farm behavioural observations in veal calves. *Animal Welfare,* 18**,** 381-390.

Broom, D. M. & Leaver, J. D. 1978. Effects of group-rearing or partial isolation on later social behaviour of calves. *Animal Behaviour,* 26**,** 1255-1263.

Bøe, K. 1990. Sugeproblemet i løsdriftsfjøs. Aktuelt fra statens fagtjeneste for landbruket. *Informasjonsmøte teknikk,* 7**,** 348-353.

Circular of BMG No 75340/0049-II/B/7/2009 vom 23.4.2010, „Biologische Produktion, Weidezugang bei Pflanzenfressern"; C. 2, Art. 14, lit. b of Commission Regulation (EC) No 834/2007.

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 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91. Official Journal No L189/1, on 20.07.2007.

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.

Cozzi, G., Gottardo, F., Mattiellot, S., Canali, E., Scanziani, E., Verga, M. & Andrighetto, I. 2002. The provision of solid feeds to veal calves: I. Growth performance, forestomach development, and carcass and meat quality. *Journal of Animal Science,* 80**,** 357-366.

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. *Applied Animal Behaviour Science,* 133**,** 137-143.

De Passillé, A. M. & Rushen, J. 1997. Motivational and physiological analysis of the causes and consequences of non-nutritive sucking by calves. *Applied Animal Behaviour Science,* 53**,** 15-31.

de Passillé, A. M. & Rushen, J. 2006. What components of milk stimulate sucking in calves? *Applied Animal Behaviour Science,* 101**,** 243-252.

De Passillé, A. M., Rushen, J. & Janzen, M. 1997. Some aspects of milk that elicit non-nutritive sucking in the calf. *Applied Animal Behaviour Science,* 53**,** 167-173.

De Passillé, A. M., Sweeney, B. & Rushen, J. 2010. Cross-sucking and gradual weaning of dairy calves. *Applied Animal Behaviour Science,* 124**,** 11-15.

de Passillé, A. M. B., Metz, J. H. M., Mekking, P. & Wiepkema, P. R. 1992. Does drinking milk stimulate sucking in young calves? *Applied Animal Behaviour Science,* 34**,** 23-36.

Debrecéni, O. & Juhás, P. 1999. Milk-sucking in dairy cattle in loose housing in Slovakia. *Livestock Production Science,* 61**,** 1-6.

Fraser, A. F. & Broom, D. M. 1997. *Farm animal behaviour and welfare,* Third edn. CAB International, Wallingford Oxon.

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.

Fürst-Waltl, B., Rinnhofer, B., Fürst, C. & Winckler, C. 2010. Genetic parameters for abnormal sucking traits in Austrian Fleckvieh heifers. *Journal of Animal Breeding and Genetics,* 127, 113-118.

Gottardo, F., Mattiello, S., Cozzi, G., Canali, E., Scanziani, E., Ravarotto, L., Ferrante, V., Verga, M. & Andrighetto, I. 2002. The provision of drinking water to veal calves for welfare purposes. *Journal of Animal Science,* 80**,** 2362-2372.

Grüner Bericht 2012. Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft. Abteilung II 5. AV+Astoria Druckzentrum GmbH, Vienna.

Gugatschka, M. 2008. Erhebung zur Haltung, Gesundheit und Verhaltensproblemen von Kälbern anhand von Fragebögen. *Department for Farm Animals and Veterinary Public Health.* University of Veterinary Medicine, Vienna.

Gulliksen, S. M., Jor, E., Lie, K. I., Hamnes, I. S., Løken, T., Åkerstedt, J. & Østerås, O. 2009a. Enteropathogens and risk factors for diarrhea in Norwegian dairy calves. *Journal of Dairy Science,* 92**,** 5057-5066.

Gulliksen, S. M., Jor, E., Lie, K. I., Løken, T., Åkerstedt, J. & Østerås, O. 2009b. Respiratory infections in Norwegian dairy calves. *Journal of Dairy Science,* 92**,** 5139-5146.

Haley, D. B., Rushen, J., Duncan, I. J. H., Widowski, T. M. & De Passillé, A. M. 1998. Effects of Resistance to Milk Flow and the Provision of Hay on Nonnutritive Sucking by Dairy Calves. *Journal of Dairy Science,* 81**,** 2165-2172.

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.

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

Houpt, K. A. 1987. Abnormal behavior. *The Veterinary clinics of North America. Food animal practice,* 3**,** 357-367.

Hänninen, L., Hepola, H., Rushen, J., De Passillé, A. M., Pursiainen, P., Tuure, V. M., Syrjälä-Qvist, L., Pyykkönen, M. & Saloniemi, H. 2003. Resting behaviour, growth and diarrhoea incidence rate of young dairy calves housed individually or in groups in warm or cold buildings. *Acta Agriculturae Scandinavica - Section A: Animal Science,* 53**,** 21-28.

Illés, A., Horváth, S. & Kishonti, L. 1981. Examinations on the reasons of and prevention from abnormal suckling of cattle. *Állattenyésztés és Takarmányozás,* 30**,** 413-420.

Jackson, P. & Cockcroft, P. 2002. *Clinical Examination of Farm Animals*. Blackwell Science Ltd, Oxford.

Jaksch, W. & Glawischnig, E. 1990. *Klinische Proprädeutik der inneren Krankheiten und Hautkrankheiten der Haus- und Heimtiere*. Parey, Berlin Hamburg.

Jensen, M. B. 2003. The effects of feeding method, milk allowance and social factors on milk feeding behaviour and cross-sucking in group housed dairy calves. *Applied Animal Behaviour Science,* 80**,** 191-206.

Jensen, M. B. & Budde, M. 2006. The effects of milk feeding method and group size on feeding behavior and cross-sucking in group-housed dairy calves. *Journal of Dairy Science,* 89**,** 4778-4783.

Jensen, M. B. & Kyhn, R. 2000. Play behaviour in group-housed dairy calves, the effect of space allowance. *Applied Animal Behaviour Science,* 67**,** 35-46.

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. *Applied Animal Behaviour Science,* 72**,** 201-213.

Keil, N. M., Audigé, L. & Langhans, W. 2000. Factors associated with intersucking in Swiss dairy heifers. *Preventive Veterinary Medicine,* 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? *Journal of Dairy Science,* 84**,** 140-146.

Keil, N. M. & Langhans, W. 2001. The development of intersucking in dairy calves around weaning. *Applied Animal Behaviour Science,* 72**,** 295-308.

Kelz, L. R. 1977. Saugen bei Rindern - nicht bloss eine dumme Gewohneheit. *Allgäuer Bauernblatt,* 45**,** 1991-1992.

Kursa, J. & Kroupová, V. 1976. KpříČinám sání mléka u dojnic. *Veterinarství,* 77**,** 24-26.

Laukkanen, H., Rushen, J. & de Passillé, A. M. 2010. Which dairy calves are cross-sucked? *Applied Animal Behaviour Science,* 125**,** 91-95.

Lidfors, L. & Isberg, L. 2003. Intersucking in dairy cattle - Review and questionnaire. *Applied Animal Behaviour Science,* 80**,** 207-231.

Lidfors, L. M. 1993. Cross-sucking in group-housed dairy calves before and after weaning off milk. *Applied Animal Behaviour Science,* 38**,** 15-24.

Loberg, J. & Lidfors, L. 2001. Effect of milkflow rate and presence of a floating nipple on abnormal sucking between dairy calves. *Applied Animal Behaviour Science,* 72**,** 189-199.

Lund, V. & Mejdell, C. M. 2009. Calf welfare in organic herds - planning for the future. *Proceedings from an ANIPLAN workshop, 30.March-1.April 2008.* National Veterinary Institute.

Lundborg, G. K., Svensson, E. C. & Oltenacu, P. A. 2005. Herd-level risk factors for infectious diseases in Swedish dairy calves aged 0-90 days. *Preventive Veterinary Medicine,* 68**,** 123-143.

Lupoli, B., Johansson, B., Uvnäs-Moberg, K. & Svennersten-Sjaunja, K. 2001. Effect of suckling on the release of oxytocin, prolactin, cortisol, gastrin, cholecystokinin, somatostatin and insulin in dairy cows and their calves. *Journal of Dairy Research,* 68**,** 175-187.

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. *Applied Animal Behaviour Science,* 80**,** 277-286.

Martin, P. & Bateson, P. 2007. *Measuring Behaviour: An Introductory Guide*. Cambridge University Press, Cambridge.

Mácha, J., Dvořák, J., Mašek, N., Kalina, J. & Kimpl, M. A. 1981. Studies in sucking behaviour of dairy cows on large-capacity farms. *Acta Univ. Agric. (Brno), Fac. Agron.,* 29**,** 211-218.

Nielsen, P. P., Jensen, M. B. & Lidfors, L. 2008. Milk allowance and weaning method affect the use of a computer controlled milk feeder and the development of cross-sucking in dairy calves. *Applied Animal Behaviour Science,* 109**,** 223-237.

Pedersen, R. E., Sørensen, J. T., Skjøth, F., Hindhede, J. & Nielsen, T. R. 2009. How milk-fed dairy calves perform in stable versus dynamic groups. *Livestock Science,* 121**,** 215-218.

Peterse, D. J., Rutgers, B., Schaftenaar, W. & Grommers, F. J. 1978. Studies on intersucking in dairy cattle (author's transl). *Een onderzoek naar melkzuigen bij runderen.,* 103**,** 485-489.

Rinnhofer, B. 2008. Einflüsse der Haltungsumwelt und der Genetik auf das gegenseitige Besaugen beim Rind. *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. *Applied Animal Behaviour Science,* 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. *Applied Animal Behaviour Science,* 119**,** 137-142.

Rushen, J. & De Passillé, A. M. 1995. The motivation of non-nutritive sucking in calves, Bos taurus. *Animal Behaviour,* 49**,** 1503-1510.

Sambraus, H. H. 1985. Zur Beurteilung von Haltungssystemen für Kälber. *Tierärztliche Umschau,* 40**,** 758-767.

Sambraus, H. H. 1991. *Nutztierkunde. Biologie, Verhalten, Leistung und Tierschutz*. Ulmer, Stuttgart.

Schlüter, H., Teuffert, J., Lender, S., Friedrich, J. & Leunert, G. 1976. Erhebungen zum Milchsaugerproblem bei Rindern. *Tierzücht,* 29**,** 447-451.

Schlüter, H., Teuffert, J. & Von Burmeister, F. 1981a. Massnahmen gegen das Milchsaugen der Rinder. *Mh. Vet. Med.,* 36**,** 925-929.

Schlüter, H., Teuffert, J. & Von Burmeister, F. 1981b. Untersuchungen zum Saugverhalten, zur Häufigkeit und zu den Ursachen des Milchsaugens Massnahmen gegen das Milchsaugen der Rinder. *Mh. Vet. Med.,* 36**,** 403-407.

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. *Preventive Veterinary Medicine,* 74**,** 162-179.

Svensson, C., Lundborg, K., Emanuelson, U. & Olsson, S. O. 2003. Morbidity in Swedish dairy calves from birth to 90 days of age and individual calf-level risk factors for infectious diseases. *Preventive Veterinary Medicine,* 58**,** 179-197.

Tapki, I. 2007. Effects of individual or combined housing systems on behavioural and growth responses of dairy calves. *Acta Agriculturae Scandinavica A: Animal Sciences,* 57**,** 55-60.

Torsein, M., Lindberg, A., Sandgren, C. H., Waller, K. P., Törnquist, M. & Svensson, C. 2011. Risk factors for calf mortality in large Swedish dairy herds. *Preventive Veterinary Medicine,* 99**,** 136-147.

Tosi, M. V., Ferrante, V., Mattiello, S., Canali, E. & Verga, M. 2006. Comparison of video and direct observation methods for measuring oral behaviour in veal calves. *Italian Journal of Animal Science,* 5**,** 19-27.

Ude, G., Georg, H. & Schwalm, A. 2011. Reducing milk induced cross-sucking of group housed calves by an environmentally enriched post feeding area. *Livestock Science,* 138**,** 293-298.

Vavak, V. 1990. Ethological regime and frequency of occurrence of mutual milk sucking out in cows from the standpoint of individual pathoethology. *Acta Zootechn.,* 46**,** 187-197.

Veissier, I., De Passillé, A. M., Després, G., Rushen, J., Charpentier, I., Ramirez De La Fe, A. R. & Pradel, P. 2002. Does nutritive and non-nutritive sucking reduce other oral behaviors and stimulate rest in calves? *Journal of Animal Science,* 80**,** 2574-2587.

Weary, D. M., Jasper, J. & Hötzel, M. J. 2008. Understanding weaning distress. *Applied Animal Behaviour Science,* 110**,** 24-41.

Wood, P. D., Smith, G. F. & Lisle, M. F. 1967. A survey of intersucking in dairy herds in England and Wales. *Veterinary Record,* 81**,** 396-398.

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13. Appendix

13.1. Guidelines for health assessment

Disease characteristics	Assessment
Hairless patches	
Spot with little or no hair but the skin is not damaged. Hornification of skin is possible.	Number of hairless patches is counted on one side and on the inner side of the opposing legs. Patches with a minimum diameter of two centimetres are included in the assessment. The highest score of 20 is gained when 20 or more hairless patches are numbered or when the area exceeds the size of a hand palm.
Lesions	
Patch with damaged skin showing scabs, sores or inflammation of the skin e.g. because of ectoparasites. Swelling possible.	Number of lesions is counted on one side and on the inner side of the opposing legs. Patches with a minimum diameter of two centimetres are included in the assessment. The highest score of 20 is gained when 20 or more hairless patches are numbered or when the area exceeds the size of a hand palm.
Joint inflammation	
Swelling of joints, feeling of heat and fluid. The calf puts little or no strain on its leg.	1 = no symptoms, calf puts strain on its legs equally 2 = one symptom, slightly inflamed (e.g. swollen but not sensitive to pain) 3 = multiple symptoms
Coughing/Sneezing	
Calf is coughing or sneezing.	1 = no symptoms 2 = calf is coughing or sneezing 1-2 times, rather dry, no symptoms 3 = calf is coughing or sneezing multiple times, signs of secretion
Respitatory rate	
Normal respiratory rate for a calf is 25-35 breaths per minute.	Assessment from angular to the right behind the calf. Observation of thorax, coastal arch, abdominal wall and motion of flanks of thorax. Counting the intake of breath for half a minute and multiply by two. 1 = no symptoms 3 = increased respiratory rate, abdominal or oral respiration, coastal arch expanded
Nasal discharge	
Nostrils display visible discharge, clear to opaque (white, yellow, green) and mucous.	1 = no symptoms 2 = one symptom e.g. colour or volume 3 = marked discharge, more than one symptom
Ocular discharge	
Eyes are clotted, signs of secretion.	1 = no symptoms 2 = one symptom, slight scabs 3 = multiple symptoms, marked secretion (minimum of three centimetres), irritated conjunctiva and eyelid

Umbilical infection	
Umbilicus is swollen, infected and touch-sensitive.	Assessment only in calves up to 4 weeks of age. Visual inspection and palpation of umbilicus if necessary. 1 = no symptoms 2 = one symptom, umbilicus is touch-sensitive, slightly enlarged 3 = multiple symptoms, umbilicus is markedly swollen and infected
Mastitis	
Teats are touch-sensitive, warm, enlarged, swollen, signs of secretion.	Visual inspection and palpation of udder if necessary. 1 = no symptoms 2 = one symptom, udder is touch-sensitive, slightly enlarged 3 = multiple symptoms, udder is markedly swollen and infected
Diarrhoea	
Faeces is loose and watery, strong smell, calf seems low, week, doesn't want to stand, hanging ears	Assessment of the tail, deposition of wet or dry faeces around tail, observing of defecation 1 = no symptoms 2 = one symptom e.g. colour, odour or consistency altered 3 = multiple symptoms
Level of dirt	
	Assessment on one side including the inner side of the opposing legs and the lower abdomen, without head and legs below ankles. 1 = calf is hardly dirty except hind quarters in case of diarrhoea 2 = layers of dirt on less than 25% of coat 3 = 50% of coat is dirtied or layers of dirt on more than 25% of coat

13.2. List of all potential risk factors

Risk factors	Observation unit
Interview	
Experience with group housing	Number of years group housing was established
Age of entering groups	Number of weeks
Access to outdoor run	Yes / no
Age of access to outdoor run	Number of weeks
Hours of access to outdoor run	Number of hours per day
Access to pasture	Yes / no
Age of access to pasture	Number of weeks
Hours of access to pasture	Number of hours per day
Time of year of access to pasture	Which months
Time until feeding of first colostrum	0-2 hours / 2-6 hours / >6 hours after birth
Time of feeding colostrum	Number of days calves receive colostrum
Amount of colostrum at first meal	Litres
Origin of colostrum	Own mother / own herd / artificial colostrum
Temperature control of colostrum	Temperature control with thermometer / with hand / no control
Precautionary freezing of colostrum	Yes / no
Inspection of quality of colostrum	Yes / no
Time after birth spent with mother	Hours
Type of milk feeding	Automatic feeder / bucket / teat bucket / bucket with floating teat /other
Amount of milk per meal	Litres per meal
Amount of milk per day	Litres per day
Number of milk meals	Number per day
Temperature control of milk meal	Temperature control with thermometer / with hand / no control
Offering artificial teat	Yes / no
Age of receiving forage	Days
Amount of forage	Ad libitum / restricted (kilogram per day)
Age of receiving concentrates	Days
Amount of concentrates	Ad libitum / restricted (kilogram per day)
Type of feeding concentrates	Bottle / trough / other
Age of receiving water	Days
Age of weaning	Weeks
Criteria for weaning	Feed intake / age / live weight

Manner of weaning	Abrupt / subtle
Amount of concentrates after weaning	Kilogram per day
Amount of hay after weaning	Ad libitum / restricted (kilogram per day)
Amount of gras silage after weaning	Ad libitum / restricted (kilogram per day)
Minerals after weaning	Yes / no
Vaccination of cow	All animals / individual animals / no animals
Vaccination of calf	All animals / individual animals / no animals
Homoeopathic treatment	All animals / individual animals / no animals
Administeriung selenium	All animals / individual animals / no animals
Other preventive health measures	All animals / individual animals / no animals
Preventive measures against non-nutritive sucking	Yes / no
Restraining during milk meal	Yes / no
Use of nose clips	Yes / no
Regrouping of calves	Yes / no
Isolating of calves	Yes / no
Feeding hay after milk meal	Yes / no
Feeding concentrates after milk meal	Yes / no
Observation	
Duration of milk meal	Minutes
Rate of drinking milk meal	Litres per minute
Duration of sucking at teat bucket	Minutes
Duration of non-nutritive sucking at teat bucket	Minutes
Duration of restraining during milk meal	Minutes
Environmental assessment	
Group size	Number of animals per group
Age difference within group	Number of age classes within group
Type of housing	Warm housing / cold housing / calf hutches / modified housing
Type of deep bedding	Fully deep litter bedding / partly deep litter bedding / cubicle housing / other
Type of flooring	Solid / perforated
Type of bedding material	Straw / sawdust / other
Amount of bedding material	Floor covered fully / partly / rarely
Lying area in total	m^2 per group
Lying area per calf	m^2 per calf
Feeding places per calf	Number of feeding places per calf
Water bowls per calf	Number of water bowls per calf

13.3. Data entry form of observation

Gruppe	Anzahl Tiere in Gruppe (insgesamt, zu Beginn und zu Ende)		Anfang - Ende	Beobachtungsdauer (min)	Tränkedauer (min)	Nuckeln am Eimer (min)	Fixierung n Tränke (min)	Beobachtung		
								Cross-sucking	Inter-sucking	Besaugen von Gegenständen

13.4. Data entry form of barn evaluation

Skizze

Ammoniak	Min.	Max.
Staub	Min.	Max.
Luftfeuchtigkeit	Min.	Max.
Licht	Min.	Max.

	Gruppe …..	Gruppe …..	Gruppe …..	Gruppe …..
Anzahl Tiere:				
1 W				
2-4 W				
5-8 W				
9 W - 6 M				
Haltung:				
Einzelhaltung				
Gruppenhaltung				
Warmstall				
Kaltstall				
Umbaustall				
Kälberiglu				
Anderes				
Einflächentiefstreu				
Zweiflächentiefstreu				
Tretmist				
Anderes				
Bei Einzelhaltung:				
Sichtkontakt möglich				
Sicht- u Berührungskontakt möglich				
Einstreu:				
Stroh/Heu				
Anderes				
Einsteumenge:				
sehr signifikant *(bedeckt Boden ganz)*				
signifikant *(B. großteils bedeckt, tw. sichtbar)*				
nicht signifikant*(Boden großteils sichtbar)*				
Bodenbeschaffenheit Laufbereich				
planbefestigt				
perforiert				
Platzangebot:				
Länge				
Breite				
Fütterung				
Anzahl Fressplätze				
Länge Fressplätze				
Wasserversorgung				
Anzahl Wasserkübel				
Anzahl Schalentränken				
Anderes				

13.5. Data entry form of health assessment

Gruppennummer	Tiernummer	Altersklasse	abgesetzt am	Haarlose Stellen	Läsionen	Gelenksentzündung	Husten/Niesen	Atmung	Nasenausfluss	Augenausfluss	Behornung	Nabelentzündung	Euterentzündung	Durchfall	Verschmutzung	**B**auch, **F**lanke, **O**berschenkel	Anmerkungen

13.6. Data entry form of questionnaire

A. Allgemeine Daten zum Betrieb

Herdengröße: Kälber (0-6M)……. Kalbinnen (6M-1.Abkalbung) ……. Milchkühe (trocken+lakt.) …….

Haltung von: O Aufzuchtkälbern O %..... O Mastkälber O %.....

Seit wann wird Gruppenhaltung durchgeführt: ……..

Ab welchem Alter in Gruppenhaltung gehalten: …….. Wochen

B. Haltung von Kälbern

Auslauf: O ja O nein

Weide bzw. Grünauslauf: O ja O nein

Von ……..(Monat) bis ……..(Monat)
O Ganztags O Halbtags

Stunden pro Tag	ab welchem Alter (W)

C. Fütterung

Wann und wie lange erhalten die Kälber Biestmilch? O 0-2 h O 2-6 h O > 6h

Stunden nach der Geburt für ……. Tage

Welche Mindestmengen an Kolostrum werden bei der Erstversorgung verabreicht? …….. L

Woher stammt das Kolostrum? O eigene Mutter O eigene Herde O künstlich hergestellt

Wird das Kolostrum aus der eigenen Herde routinemäßig eingefroren? O ja O nein

Wird die Qualität des Kolostrums untersucht? O ja O nein

Wird die Temperatur des Kolostrums kontrolliert? O ja O nein

Bei welcher Temperatur wird das Kolostrum verfüttert? ……..

Wie lange bleiben Kuh und Kalb nach der Geburt zusammen? ……..

Welche Tränkeform wird verwendet? O Eimer O Zitzeneimer O Eimer mit Schwimmsauger O Tränkeautomat

Wie hoch sind Tränkehäufigkeit und Tränkemenge pro Tag?

Von ….. bis ….. Woche O 2 mal O 3 mal O rechnergestütze Fütterung ….. Mahlzeiten Menge/Mahlzeit ……. L

Von ….. bis ….. Woche O 2 mal O 3 mal O rechnergestütze Fütterung ….. Mahlzeiten Menge/Mahlzeit ……. L

Von ….. bis ….. Woche O 2 mal O 3 mal O rechnergestütze Fütterung ….. Mahlzeiten Menge/Mahlzeit ……. L

Von ….. bis ….. Woche O 2 mal O 3 mal O rechnergestütze Fütterung ….. Mahlzeiten
Menge/Mahlzeit ……. L

Wird die Temperatur der Milch kontrolliert? O ja O nein
Bei welcher Temperatur wird die Milch verfüttert? ……..

Steht den Kälbern außerhalb der Tränkezeit ein Nuckel zur Verfügung? O ja O nein
Wenn ja, handelt es sich dabei um einen O leeren Nuckel O Nuckel mit Kraftfutter O Nuckel mit Wasser

Werden die Kälber nach der Tränke fixiert? O ja O nein ……..min

Ab welchem Alter wird den Tränkekälbern Grundfutter angeboten? ……. Wochen O ad libitum
O rationiert …….kg/Tag

Ab welchem Alter wird den Tränkekälbern Kraftfutter angeboten? ……. Wochen O ad libitum
O rationiert …….kg/Tag

Wie erfolgt die Kraftfutterverabreichung? O Flasche O Trog O Anderes……..

Ab welchem Alter werden die Kälber ständig mit Wasser versorgt? ……. Wochen

Wann werden die Kälber abgesetzt? …….. Wochen

Was ist das Entscheidungskriterium zum Absetzen (1-3 reihen)? ….. Gewicht ….. Futteraufnahme
….. Alter

Wie werden die Tiere abgesetzt? O abrupt O ausschleichend über …… Tage
/ Wochen

Wie werden die Kälber nach dem Absetzen gefüttert?

	Kraftfutter	Heu	Grassilage	Maissilage	Mineralstoff	Anderes
kg/Tag						

D. Gesundheit

Treten Erkrankungen bei Tränkekälbern gehäuft auf? Wenn ja, welche? O ja O nein

	nie	selten	manchmal	häufig
Durchfall				
Nabelinfektionen				
Atemwegserkrankungen				
Anderes				

Ergreifen sie vorbeugende Maßnahmen gegen Erkrankungen?

Impfungen bei Mutter	O nein	O ja, bei Einzeltieren	O ja, für alle Kühe
Impfungen bei Kalb	O nein	O ja, bei Einzeltieren	O ja, für alle Kälber
Homöopathische Begleitung	O nein	O ja, bei Einzeltieren	O ja, für alle Kälber
Vitamin E/Selen bei Geburt	O nein	O ja, bei Einzeltieren	O ja, für alle Kälber
Anderes……..	O nein	O ja, bei Einzeltieren	O ja, für alle Kälber

E. Verhalten

Stellt Besaugen im Betrieb ein Problem dar? O ja O nein

Tränkekälber	O ja	O nein	Wenn ja, bei wievielen Tieren? ……..
Nach dem Absetzen	O ja	O nein	Wenn ja, bei wievielen Tieren? ……..
Kalbinnen	O ja	O nein	Wenn ja, bei wievielen Tieren? ……..
Milchkühe	O ja	O nein	Wenn ja, bei wievielen Tieren? ……..

Wenn ja, bei welchen Tieren bei den Tränke- und Absetzkälbern?

Ergreifen sie Maßnahmen gegen Besaugen? Wenn ja, welche? O ja O nein

O Nasenklammer O Fixieren nach Tränke O Umgruppierung O Isolation O ……

O Heu direkt nach Tränke O KF direkt nach Tränke

→ Aufzeichnungen von Stalltagebücher/Abgabebelege 1 Jahr zurück

Wie beurteilen Sie die Gruppenhaltung von unter 8 Wo alten Kälbern? (z.B. im Hinblick auf Entwicklung der Kälber, Tiergesundheit, Arbeitswirtschaft etc.)