Calf health before and after change in housing system – isolated barn vs. hutches

Kalvhälsa före och efter byte av inhysningssystem – isolerat stall i jämförelse med hyddor

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FÖRORD

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1 Abstract

Calf health is of importance both from a financial perspective and from an animal welfare point of view. Housing system and environment are factors affecting the calves' health. The objective of this project was to make a review of literature on calf health and housing and to perform an observational study on calf health at Nötcenter Viken, Research Dairy Farm, Lantmännen Sweden that changed calf housing system; from a traditional indoor system (Group IN) to outdoor hutches (Group OUT). It was only the housing system that was changed; the routines and feed were the same in both systems. Frequencies of pneumonia and diarrhoea, and the use of antibiotics in the different systems were compared in this study. Pneumonia was the most common registered disease followed by diarrhoea. More than twice as many diagnoses of pneumonia were registered in Group IN (255 diagnoses) compared to Group OUT (114 diagnoses). The percentage of calves diagnosed with pneumonia in Group OUT was still high compared to earlier Swedish studies. There was a significant difference in diarrhoea between the groups ($p=0.0016$), although the difference was not as large as in pneumonia (30.5% of the calves in Group IN was diagnosed with diarrhoea compared to 21.3% in Group OUT). Diarrhoea as well as pneumonia was diagnosed in a higher proportion of calves compared to earlier Swedish studies. One reason for the higher percentage of registered diarrhoea could be the problem with coccidian parasites that exists on the farm, but the same proportion of treated and untreated calves was later diagnosed with diarrhoea. More antibiotics were used for treatments in Group IN than in Group OUT; 63% and 37% respectively of the total use of antibiotics during the study period. Most of the antibiotics were used for treatment of pneumonia. Age at diagnosed diarrhoea was usually between 5 and 18 days of age with the highest number of calves at 9 days of age in Group IN and 11 days in Group OUT. Age at diagnosed pneumonia was more evenly spread in ages and did not have a peak at a specific age, but both groups seemed to follow a similar trend.

2 Introduction

Rearing healthy dairy heifer calves is of importance to be able to replace less productive cows (Wathes et al., 2008). From a financial perspective, mortality and sick calves leads to losses in income because of lost future production, costs of veterinary treatments and drugs, need of extra labour etc. (Mee, 2008; Nonnecke, 2009). Enteric and respiratory disorders are the main hazards to calf health (Roy, 1990; Svensson et al., 2006b). Disease morbidity and mortality in calves varies between countries and between farms of the same size in the same country. There are thus no standard values that can be used for comparison even at herd size level. Mortality and morbidity in a herd cannot be completely avoided but high levels can be reduced by strategies and simple protocols (Mee, 2008). Farmers and animal keepers who are looking after their calves routinely to see the early symptoms of illness, register them and then start treatment usually improve their calves' health (McGuirk, S.M. 2008). Some infectious diseases of the calf are zoonoses and can also affect humans. The microorganisms that cause such diseases can be transmitted to humans by contact with the calf or by food and water supplies (Nonnecke, 2009).

There are many factors affecting calf health, for instance colostrum feeding, parity of the dam, bedding material, genetic effects, season and environment. After birth, the neonatal calf has to adapt to a new environment where it is exposed to several disease causing agents. For the neonatal calf to stay healthy, housing and a good environment is essential (Lundborg et al., 2005). An indoor housing system may have negative effects on calf health due to many animals sharing the same airspace which in turn leads to an increased risk for transmission of air-borne diseases. An unfavourable environment is related to both health problems and reduced growth. Housing of calves in hutches with outdoor pens can be one alternative in avoiding spreading of air-borne infectious agents and reduce unfavourable gases. However, out-door housing leads to a larger variation in the environment caused by weather. The calf housing has to protect the calf from cold-stress during winter and heat-stress during summer (Vasseur et al., 2010). It is not obvious which housing system suits the calf best.

This study consists of two parts. The first part is a review based on literature on calf health and housing, and the second part is an observational study based on registrations of calf health in a Swedish dairy herd where the housing system was changed. The two housing systems observed were a traditional indoor system (an isolated barn) and an outdoor system with calf hutches. In this study, the health of the calves is based on whether they were treated for diseases or not. The comparison was made to investigate if there were any differences in the frequency of pneumonia, diarrhoea and the frequency in use of antibiotics in the two housing systems. The hypothesis, based on the calf caretakers' opinions, was that the calves were less sick when they were housed in the hutches.

3 Literature review

The neonatal calf is sensitive to infections and the risk of death is highest during the first three weeks of life (Svensson et al., 2006b). Housing and environmental factors are important and has a large impact on the calf's health (Panivivat et al., 2004). Environmental factors also seem to have an influence on the development and severity of diseases during infections (Gulliksen et al., 2009b).

3.1 Group vs. individual calving pens

In a Swedish doctoral thesis presented in 2004 were only 40% of the 122 participants using special maternity pens at calving of the herds included in the study, of these 18% were group calving pens (Lundborg et al., 2004). Swedish dairy herds must have one calving pen for every 45 cows, according to the Swedish animal welfare legislation (SJVFS 2010:15). One advantage with group calving pens is that they are less expensive to build and needs less space per cow compared to single calving pens (Fredriksson et al. 2006). Cleaning and disinfection of the calving pen is needed in order to prevent spreading of infectious agents. In the previously mentioned doctoral thesis 74% of the single calving pens were cleaned between calvings and the group calving pens were almost never cleaned between the calvings. Secundines and fluids from birth that are left in the calving pen lead to a favorable environment for infectious agents (Lundborg, 2004). Another important factor in the early life of the calf is the availability and quality of colostrum. A calf born in a group calving pen can easily suckle a cow that is not its mother but going to calve or has calved earlier and it is also possible that another calf has already consumed the colostrum of the dam (Michanek & Ventorp, 1993). Lundborg therefore recommends that group calving pens should be avoided (Lundborg, 2004).

3.2 Group vs. individual calf pens

Calves are social animals that under natural conditions live in groups. Housing calves in groups provides more space which makes it easier for the calf to move and it also allows the calf to social opportunities and to express play behavior. There can also be advantages with group housing that benefits the producer. For example, it may require less labor time for feeding and cleaning of pens (Chua et al., 2002). Results from a study made by Gulliksen et al. (2009a) indicates that individual housing is preferable for the calves from a health point of view compared to group housing during the first four weeks of life. Svensson and Lidberg (2006) recommend not housing calves in larger groups than 10. Calves in larger groups have a higher risk of respiratory tract illness and a lower daily weight gain. Group housing of calves in larger groups is increasing in Sweden (Svensson and Lidberg 2006). Lundborg (2004) recommends strict routines to avoid health problems and that hygienic routine is of great importance in this systems. Lundborg (2004) also recommends keeping the number of calves in each group as low as possible.

Chua et al. (2002) compared weight gain, behaviour and health effects on calves housed individually or in pairs. There was no difference in weight gain before and after weaning

between the individually housed and the pair-housed calves. The only difference in weight gain observed were at the week of weaning when the individually housed calves experienced a growth check while the pair-housed calves continued growing as before weaning. In behaviour, there was no difference in suckling or self-grooming. Pair-housed calves were spending more time standing inactive, moving and spending less time standing with their head out of the pen. A health problem observed was diarrhoea, but there were no differences between the groups.

Virtala et al. (1999) state that calf mortality is usually high when the preweaned calves are kept in an environment contaminated by older calves or other cattle. Grouping calves by age and their history of respiratory infections could be one way to reduce cases of respiratory infections. Bach et al. (2011) discovered that calves with a history of respiratory infections are more likely to relapses after grouping than those with no previous record. They also found that morbidity increases when calves with and without previous records of respiratory infections are grouped together.

3.3 Herd size

There is a trend of increasing herd size in Swedish dairy herds (Swedish Dairy Association, 2011). Herd size has been shown to be one of the factors effecting mortality rate (Gulliksen et al. 2009a). The higher mortality in larger herds has been shown to be related to a higher risk of respiratory infections. The cause is believed to be dual. An increased traffic of people from different farms may lead to failure in biosecurity and biosafety routines should therefore be prioritised higher in larger farms compared to smaller. Secondly, calves are usually more densely housed on larger farms and infection agents are then more easily spread (Gulliksen et al., 2009b). Calves, heifers or cows are often bought into the existing dairy herd during an expansion of the farm or when the farm has health problems that lead to a reduction of the number of available replacement heifers. By this mix of animals, both the animals that are bought and the ones that are already at the farm get in contact with new pathogens that their immune defence are not used to. There can be expensive consequences through an increased mortality and morbidity rate on the farm which leads to that even more animals has to be bought (Bendali et al., 1999).

3.4 Ventilation

The efficiency of the ventilation in the housing system has a large impact on the environment. The ventilation regulates the exchange of air. It brings in new fresh air and removes water vapour, heat, airborne microorganisms, ammonia etc. New air that comes into the building should be spread evenly to assure an air exchange that reaches all the animals. Movement of cold air from the outside directly down to the animal's level should be avoided. It is recommended that incoming air is first heated up (by the existing air) before it reaches the animals (Nordlund, 2008). Insufficient ventilation in the stable is often associated with poor calf health (Nordlund, 2008). A high count of airborne bacteria in the pens has been found to be associated with an increased frequency of calves with respiratory diseases (Lago et al., 2006). The risk of infection by airborne microorganisms can never be eliminated but efficient

ventilation reduces the risks. Optimal ventilation is of importance to prevent calves developing respiratory symptoms and pneumonia (Okamoto et al., 1993).

In naturally ventilated calf barns air quality can be effectively improved with an increase in ventilation rate (Lago et al., 2006). The increase in air quality differs depending on where in the barn it is measured and depending on how the inside of the barn is shaped. Solid panels and hovers are sometimes recommended to avoid drafts and chilling but will reduce the exchange of air at animal level (Lago et al., 2006). Draught is technically defined as an air speed above 0.5 m/s (Nordlund, 2008). In a study by Lago and co-workers (Lago et al., 2006) it was found that the increased ventilation will only benefit the air in the alleys and does not improve air quality in pens if they have solid panels. Based on this, they recommend solid panels between the pens to avoid contamination by calves from other groups and mesh panels in the front and rear to improve air movement in the pens. The position of the calf's pen has also been shown to affect the health of calves. For example, Lundborg et al. (2005) demonstrated a significant correlation between placing the calves' pens against an outer wall and occurrence of diarrhoea.

Barns ventilated with negative pressure mechanical systems can result in problems during the winter. The air exchange is usually reduced during the cold season in order to keep a higher temperature in the barn to prevent freezing of water pipes and manure scrapers. It is difficult to develop inlets that can distribute small volumes of fresh air in the whole building. Proper functioning mechanical ventilation under these conditions requires personnel that know how to manage it. A broken window or a slightly open door can be enough to reduce the airspeed through the inlets and the air is then not spread evenly in the barn (Nordlund, 2008).

3.5 Temperature and humidity

In a study of calf health and housing by Nonnecke et al. (2009), a warm environment, with an average of 15.5° C, was compared to a cold environment with an average of 4.7° C and a 10% higher humidity. In general, the differences in diseases due to climate are not only caused by temperature. High humidity is another factor and it can cause water vapour in the air and is a combination of moisture from sweat, exhaled air, evaporation from floors, water bowls etc. The humidity is regulated by the water-carrying capacity of the air and by the ventilation rate (Roe, 1982). In the study by Nonnecke et al. (2009) the higher relative humidity in the cold environment was achieved by wetting the fur of the calves twice a day. In addition, no bedding material was used. The results showed that the calves in the warm environment had lower respiratory disease scores and had fewer symptoms that needed treatment with antibiotics than the calves in the cold environment. In this study, the incidence of diarrhoea was unaffected by the two environmental temperatures.

It has been shown that it is possible to maintain calf growth at temperatures as low as -20° C in open sheds or hutches compared to indoor housing as long as the calves have access to enough feed and bedding material for thermal comfort (Okamoto et al., 1993).

Bedding material reduces heat loss as the calf lies down, and it can nest to get a layer of warm air around itself. Hutches compared to most other housing systems, give the calf a possibility

to move between different thermal environments, i.e. between the outdoor pen, the front of the hutch and the rear of the hutch (Nordlund, 2008). Næss et al. (2007) registered the temperature in hutches during autumn and winter. The temperature in the hutches followed the outdoor temperature but was 1-3° C higher.

3.6 Seasonal differences

There are studies showing seasonal differences in morbidity and mortality rates related to calf diseases. The results between studies differ and different age groups have been investigated. Gulliksen et al. (2009a) demonstrates a higher mortality rate in the first week of life during winter compared to summer. The mortality rate at the first month of life during winter was also higher than during autumn. The study is based recordings from 125 Norwegian dairy farms with different housing systems. Svensson et al. (2003) demonstrated a seasonal difference in diarrhoea and respiratory diseases in calves from birth up to 90 days of age. The incidence of respiratory disease was higher during the cold season. One explanation to these results can be the higher relative humidity in the stables during the autumn and winter. In the same study, summer was related to a higher risk of diarrhoea. The seasonal effects are supported by a study where calves in the age range of 91 to 210 days of age were observed (Svensson et al., 2006a). In contrast to this, Olsson et al. (1993) showed that the frequency of diarrhoea was lowest during the summer months, May to September. A study made by Gulliksen et al. (2009c) showed a higher risk of diarrhoea during the winter season and supports the results of Olsson et al. (1993). The higher animal density per housing unit during the winter compared too summer can be one explanation and the cold and higher humidity that benefit the survival of several infectious agents. Overcrowding was significantly associated with morbidity which may be explained by an increase in pathogens and induced stress (Bendali. 1999). Poor climatic condition like draught and a higher humidity are two causes of diarrhoea and group housing of calves is another (Perez et al., 1990).

3.7 Mortality and morbidity rates

The rate of mortality and morbidity related to calf diseases varies considerably between countries and even between herds in the same region. Usually the mortality rate is caused by a combination of different parameters that affect the calves' health (Olsson et al., 1993). Olsson et al. (1993) showed results from 131 Swedish herds and 5050 calvings in total. The mortality altogether was 2.6% and the morbidity rate was 11% of calves in the age range of 0 to 90 days. The average frequencies of pneumonia and enteritis were 0.8% and 7.2%. There was a large variation in morbidity and mortality between the herds. Factors affecting the mortality and morbidity were: herd size, whether the calf was allowed to suckle or not, the formation of the calf pens, and previous infections in the herd (especially enteritis). In another Swedish study, by Svensson et al. (2003), calves of the same age range was found to suffer a mortality rate of 3% and morbidity rate of 23%. Lung auscultation was performed and remarks were recorded in 19.4% of calves where 5.7% were diagnosed with moderate to severe respiratory sounds. Diarrhoea was registered in 10.3% of the calves. Calves that have a history of respiratory diseases are more likely to be infected again after grouping than the calves with no previous reported respiratory diseases. The mortality rate increases when calves with or

without history of respiratory diseases are mixed in groups (Bach et al., 2011). Perez et al. (1990) found that calves that already have had diarrhoea had a higher risk of respiratory disease. The risk of diarrhoea is also higher in those calves that already shown it once (Perez et al., 1990; Svensson et al., 2006b).

In a Norwegian study made by Gulliksen et al. (2009a), pneumonia was the major cause of death in calves, followed by enteritis. Enteritis was the most frequent diagnosed illness in calves while pneumonia was the most common cause of death. Svensson et al. (2006b) showed results that support the previous mentioned study. They found that pneumonia was the most common cause of death, but diarrhoea were the most common disease in calves under 31 days of age. Perez et al. (1990) showed that the peak age for diarrhoea in heifers occurred in the first 14 days of life and then dropped dramatically almost down to zero at 30 days of age. Respiratory diseases had the peak age at 30 days and then dropped at 40 days of age and then continued to occur sporadically. According to Roy (1990), The age period with the highest risk for mortality from enteric disorders is the first 14 days of life, and for mortality from respiratory infections from 6-8 weeks of age and forward. Waltner-Toews et al. (1986b) found that the peak of respiratory diseases occurred during the sixth week of life which is supported by Lagos et al. (2006) that did not report any incidence during the first week of life and a peak at the seventh weeks of age. In other studies the incidence of enteritis in calves between 36 hours and 14 days of age were 7.2% (Viring et al., 1993) and the incidence in calves between 8 and 30 days old were 3.5% (Olsson et al., 1993). The reason for the different results can be the different ages or that the disease recording was done by veterinarians in one study and by farmers in the other. It is possible that the veterinarians noticed lighter symptoms that the farmers did not see (Viring et al., 1993). Pneumonia typically occurs shortly after weaning or when housing is changed from individually to groups and they get in contact with other calves, but this health problem can also occur among neonatal calves (Leslie and Todd, 2009).

Diarrhoea is the most common disease described in the studies included in this literature review. It is not only causing economic losses for the farmer, but it also brings other negative consequences. It should be avoided from an animal welfare perspective and some of the microorganisms causing diarrhoea have shown to be zoonotic (Björkman et al., 2003). They can infect calf caretakers and some of them have been associated with food borne diseases. In addition, antibiotic and other drug treatments of the disease can cause trace of the drugs in human food. The use of antibiotic also enhance to the antibiotic immunity against bacteria (Frank and Kaneene, 1993).

3.8 Treatment

Use of antibiotics in calves between 0 and 90 days of age were investigated in a Swedish study presented in 2004 (Ortman and Svensson, 2004). In this study the largest amount of antibiotics used were penicillin-dihydrostreptomycin followed by Penicillin. The main mode of distribution of antibiotics was injections, with exceptions for 182.7 grams of penicillin-dihydrostreptomycin and sulphonamide that were given orally. Most of the antibiotics were used as treatment of pneumonia followed by diarrhoea.

Table 1. Total use of antibiotics in a study performed by Ortman and Svennson (2004). The study included 3081 Swedish dairy heifers

Antibiotics	**Total amount**
Amoxicillin	47.3 g
Fluoroquinolone	15.6 g
Macrolides	5.0 g
Penicillin	230.7 g
Penicillin-dihydrostreptomycin	1124 g
Tetracyclines	170.7 g
Trimethoprim-sulphanomides	96.5 g
Sulphanomide	15.0 g

In Sweden all antibiotics used for treatments of animals must be prescribed by a veterinarian surgeon. Animal keepers are allowed to continue the treatment that a veterinary surgeon started or prescribed. Ortman and Svensson (2004) found that, in spite of this, farmers often treat calves with antibiotics without consulting with a veterinary surgeon. These reasons are believed to be the expenses of veterinary costs, and that the animal keepers may use leftovers of antibiotics instead of consulting a veterinarian in order to save these expenses.

In a Swedish study performed by Lundborg (2004) 30% of the calves diagnosed with enteritis were treated with antibiotics while 19% of the calves were given oral electrolyte solutions. Practical recommendations in the mentioned study are to use electrolyte solutions as treatment in the first place and antibiotic treatment if investigations conclude that a bacteria is the cause of the diagnosed enteritis. This recommendation is supported by Björkman et al. (2003) where viruses and parasites were the major cause of enteritis. Björkman et al. (2003) demonstrates results supporting that rotaviruses are the most common infectious cause of diarrhoea in neonatal calves in Sweden.

3.9 Calf hutches

Calf hutches are four sided structures (Stull and Reynolds, 2008) or igloo shaped (Marcé et al., 2010) and should be placed on well drained soil (Stull and Reynolds, 2008) or solid concrete (Mohler et al., 2008). When the calf is moved from the hutch, the hutch should be cleaned and moved to a new place before the new calf moves in (Mohler et al., 2008) or the concrete should be cleaned. In the United States, hutches are usually constructed of fiberglass, polyethylene or wood. It is common that the calf has access to an outside pen or is tethered to the hutch (Stull and Reynolds, 2008).

Hutches are usually a less expensive system of calf housing than conventional barns. It is less expensive to build and do not require any mechanical ventilation (Sanders, 1985). There are different opinions on whether calves kept in hutches need more or less labour time (Jorgenson et al., 1970; McKnight, 1978). A study made on an agricultural school in Norway registered 26 minutes for the daily work with 22 calves in group hutches. Days when some of the calves needed orally treatment for diarrhoea in form of electrolyte solutions and when new calves

needed help to learn how to drink from the automatic milk feeder, the work could take up to 80 minutes (Næss et al., 2007). Feeding the calves outside can be less comfortable depending on the weather (McKnight, 1978; Murley and Culvaitouse, 1958). During cold seasons, the water supply may be a problem that needs special attention. In case freezing of water cannot be avoided, calves may need to be watered by hand which require more labour time (Jorgenson et al., 1970). Næss et al. (2009) had problems with freezing pipes in their automatic milk-feeders and recommend storing them in a frostless place. Another observed problem was that calves did not want to leave the hutches to eat in the outdoor pen when there was a high wind velocity during winter. The calves needed to be herded to the feed a few times a day to assure that their nutrient requirement was covered. Evidently, this required extra labor. Næss et al. (2009) suggests that wind textile as walls may be one solution to this problem. It has been shown that calves require more energy to keep warm in an outdoor housing system during winter compared to when in an isolated barn (Sanders, 1985). According to previous studies, calves tend to eat more starter and hay but have the same growth rate as in indoor barns (McKnight, 1978; Murley and Culvaitouse, 1958). Næss et al. (2007) registered the air quality in hutches and found that relative humidity, air speed, carbon dioxide and ammoniac were all under the recommendations for housing of calves.

Mohler et al. (2008) experienced that it can be extremely hot in the hutches during summer. The design of the hutch is important to prevent heat-stress during summer and protect the calf from draft and cold during the winter (Mohler et al., 2008). The position of the hutches during summer affects the calves. If the hutch is placed in the sun during the warmest time of the day, calves were more heat stressed with higher skin temperature and respiration rate than those kept in the shade. Placing the hutches in the shade reduces the risk of heat stress for the calves (Spain and Spiers, 1996). In a study by Næss et al. (2007), it was found that, during warm days in summer, the calves preferred to lay in the outdoor pen if bedding material was provided.

3.10 Hutches vs. indoor

Hill et al. (2011) compared calves' health housed in translucent polyethylene hutches or wire mesh pens in a curtain sided nursery. They also compared sand versus straw as bedding material in the two housing systems. There were no significant difference between frequency of diarrhoea between the two housing system when straw was used as bedding material, but the calves had a greater daily weight gain in the nursery system. A difference in frequency of diarrhoea was found between calves kept in the nursing system with straw used as bedding material and calves kept in the hutches bedded with sand. There was a larger frequency of diarrhoea in the hutches. On the other hand, there are other studies that show that individual housing in hutches are preferred to individual housing in pens in a stable when looked at diarrhoea, daily weight gain (Gutzwiller and Morel, 2003) and pneumonia (Lorenz et al., 2011).

Waltner-Toews et al. (1986b) experienced a lower mortality during the summer months when calves were reared in hutches compared to when reared indoors. In a different study by Waltner-Toews et al. (1986a), it was shown that calves raised in hutches are 25 times less

likely to be treated for pneumonia and 8 times less likely to be treated for enteric diseases compared to calves housed individually indoors. An early study by McKnight (1978) also supports this. He found that calves housed in outdoor hutches required less medical treatment compared with calves kept in indoor housing. Already in the 1950's, Davis et al. (1953) compared conventional indoor housing to outside portable pens. The results showed a large difference in pneumonia. All calves that were housed indoor had respiratory problems and only one calf kept in the hutches showed these symptoms. The calves housed in hutches also had less coccidian and worm parasites, a greater daily weight gain and less diarrhoea. Coccidian infections in cattle are very common in Europe including the Scandinavian countries (Nielsen, 2007). The severity of symptoms varies from subclinical infections without symptoms to severe diarrhoea or even death. Sporulated oocytes from the environment infect the animal orally. Severity of the infection depends on the status of the calf's immune defence, age and the amount of oocytes ingested. The parasite cannot be eliminated from the herd but Nielsen (2007) state that the risk of spreading can be reduced by an "all-in all-out" strategy, with emptying, cleaning and disinfection before new calves are let in. The calves should not share airspace with older cattle. Traditionally, sulphonamides have been given orally for treatment of acute coccidiosis. Baycox is given as a single oral dose and is considered to give efficient long time protection. Baycox contains Toltrazuril which kills all the stages of coccidian in all parts of the intestine (Nielsen, 2007).

Jorgenson et al. (1970) could not find any difference in weight gain when comparing individual indoor versus outdoor housing in hutches. They also compared three different weaning ages 3, 5 and 7 weeks and there were no significant difference in weight gain between the ages. As regards disease occurrence, there were no differences in incidence of pneumonia or diarrhoea between the housing systems. However, the group of calves that were weaned at 7 weeks had a higher frequency of diarrhoea compared to the other groups. Næss et al. (2007) showed that the average daily weight gain of calves housed in hutches is between 622 g/day and 1104 g/day in the age range from 2 weeks until 16 weeks of age. Calves in the age of 2 to 4 weeks had a low daily weight gain or even lost weight. This could be explained by the fact that the calves were born indoor and usually moved out at that particular age and that they then had to adapt to the new environment. On average, the calves were laying down 18 h/day and only one calf had unfavorable behavior in form of cross suckling which it already had before it was moved to the hutch.

4 Field Study: Change of housing and calf health at a large dairy farm

5 Background

In June 2009, the housing system of the calves was changed at Nötcenter Viken, Dairy Research Farm in Falköping, Sweden. It was changed from a traditional indoor system to a system with outdoor hutches and one reason for this was that the farm had experienced problems concerning calf health for a long period of time. The aim of this study was to compare the frequencies of pneumonia and diarrhoea, and the use of antibiotics before and after the change of system. The hypothesis, based on the opinion of the calf caretakers, was that the calves were less sick when they were housed in hutches.

The farm Nötcenter Viken is owned and operated by Lantmännen. The number of cows at the farm increased during the study period: In August 2007 there were 300 dairy cows in production in the herd and by May 2011 herd size had been increased to 377 milking cows. The mean milk production in the herd during the study period was 34 kg energy corrected milk (ECM) per cow and day. The breeds in the herd were approximately equal numbers of Swedish Red and Swedish Holstein cattle.

6 Material and methods

6.1 Animals and data

The study is based on information on calves and registrations of diseases and treatments collected from the dairy herd at Nötcenter Viken. The study includes all heifer calves present in the herd 23 months before to 23 months after the system change in June 2009, i.e. from August 1st 2007 to May 31st 2011. Bull calves are not kept at the farm and were therefore excluded from the study. In order to secure complete data from the study period, information on all heifer calves born alive between June 5th, 2007 and June 15th 2011 was retrieved. In total, 793 calves were included in the study. The numbers of calves born each month at the farm during the study period are shown in figure 1.

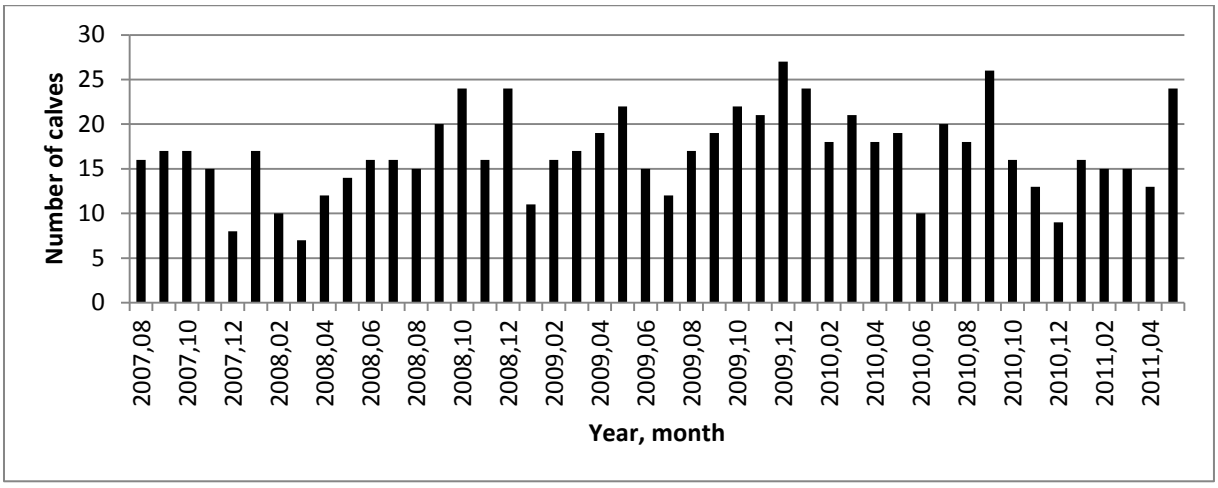

Figure 1. Number of heifer calves born each month during the study period.

The data used in the study were retrieved from the farm's digitalized database which is managed through the computer software 'Vikendata', which has been developed specifically for Nötcenter Viken. Through this software, the animal keepers register information on all animals and events, such as dates of births, health status, inseminations, milk production etc. The information retrieved for the purpose of this study included animal identity, date of birth, sex, breed, dates of presence in different pens, dates and reasons for calves leaving the herd, cases of disease, date of disease, treatments, date of treatments, and person performing the treatment.

6.2 Weather

As mentioned in the literature review, weather conditions during the study period can be expected to have an impact on frequencies of diseases. Registered data demonstrated in figure 2 and 3 are collected from a weather station in Skara and data in diagram 4 is collected from a weather station at Jönköping airport. The weather stations are operated by the Swedish meteorological and hydrological institute (SMHI, 2011). There was no weather station on the farm. There was no apparent difference between the years in temperature during the summer periods (June until August). The average temperature during the winter season (December until February) was lower the last two years compared to the first two years. It can be noted that the first winter (2007 to 2008) the average temperature was never below 0°C.

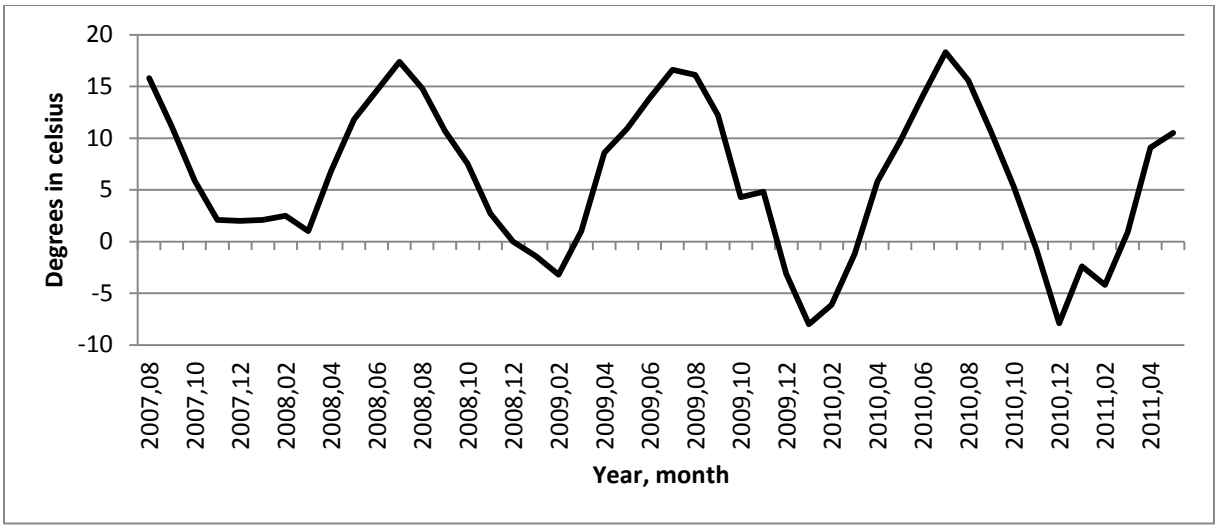

Figure 2. Average outside temperature per month throughout the study period.

Atmospheric precipitation during the study period was highest in July to September and lowest in April except for 2007 where October had the lowest amount.

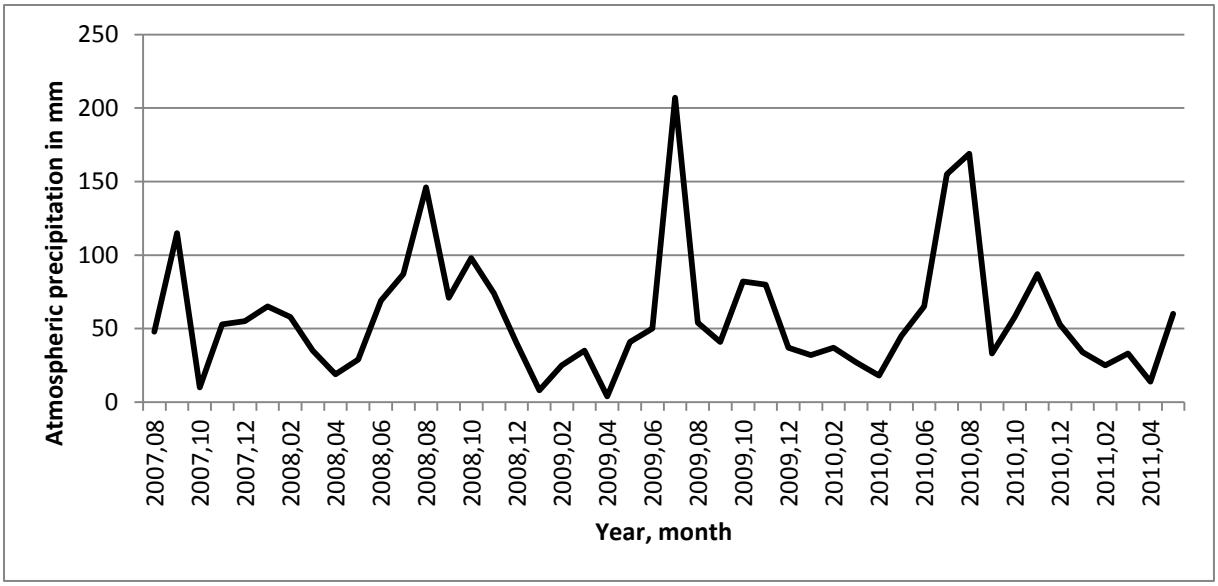

Figure 3. Average atmospheric precipitation in mm per month during the study period.

The relative humidity is shown as percentage of the absolute humidity which is depending on the air pressure and temperature. The relative humidity was higher during the winter which is an effect of the colder temperature.

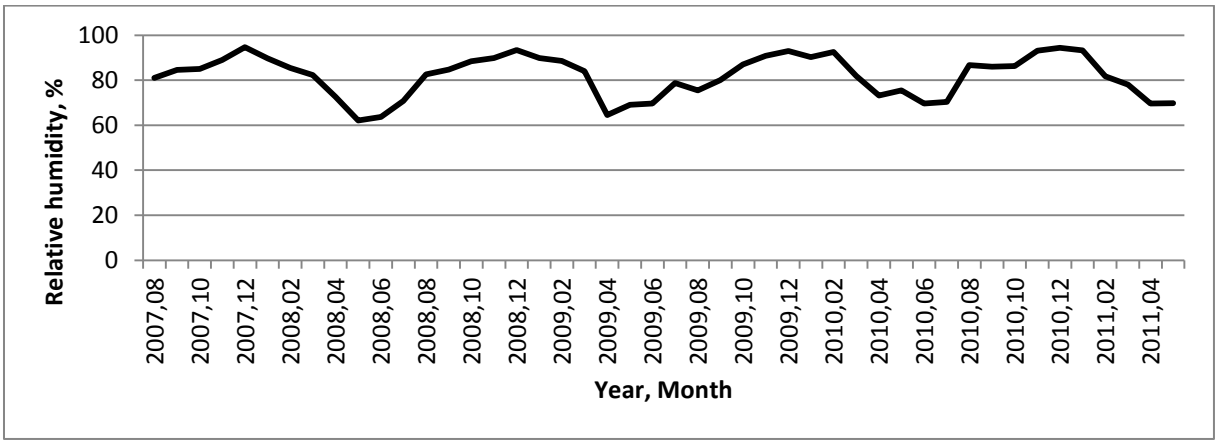

Figure 4. Relative humidity per month during the study period at Jönköping airport.

Data on air quality in the isolated barn and in the hutches were unfortunately not available in this study.

6.3 Housing

6.3.1 Calving pens

During the whole study period, the routine was that calves were born in a group pen or in a single calving pen. All cows in the group pen were dry cows close to calving. Straw were used as bedding material on the whole floor area of the calving pens. By accident, a small number of calves in the study were born in the manure alley in groups with dairy or dry cows. The calves were housed in single calving pens with their dam between 1 and 3 days.

6.3.2 Indoor system

Until June 27th, 2009, all calves were kept in the same building as they were born. The barn was isolated with natural ventilation that was regulated automatically. The inlets were placed right under the eaves and the air went out at the open ridge. There were dry cows and older calves in the same building.

At 1 to 3 days of age the calves were separated from their dam and moved from the calving pen to a single calf pen. The cow was moved to the milking herd. The calf pen was a conventional pen with wooden panels and drained floor. The pen was placed on four legs which lifts the pen up from the barn floor. Straw were used as bedding material covering the floor in the pen. After 10 to 17 days, the calves were moved to group pens with 10 to 14 calves in the groups of similar age. The floor in these pens was concrete covered with straw as bedding material. At the age of approximately 70 days the calves were moved to a non-insulated building with natural ventilation, where they stayed until a few days before calving.

6.3.3 Outdoor hutches

After June 27th, 2009, all calves were moved to outdoor hutches. The new housing system consisted of a concrete floor with a metal roof and open sides. Single hutches were placed in the middle from one long side to the other. Group hutches were placed along the long sides and had pens towards the middle. Calves were grouped 10-14 calves to each group hutch. The single hutches were made of polyethylene while group hutches were made of fiberglass. In both types of hutches, fresh air entered from the opening for the calves. In the single hutches, ventilation was regulated through its outlets in the top front and top back. Group hutches were igloo shaped and had four outlets placed on the top. Bedding material in the hutches and pens was straw. Between the group pens were three small houses where the automatic milk-feeders were placed to avoid freezing during winter.

6.3.4 Routines

The routines have been the same in both systems. Calves were moved to single pens or hutches between 1 and 3 days of age and housed individually until between 10 and 17 days of age. Calves were fed colostrum during the first 4 days of life in a teat-bucket. At the 5th day of life until 55 days of age the calves were fed milk replacer. Calves were fed twice a day in a teat-bucket as long as they were kept individually. The calves were moved to group pens or group hutches at the age between 10 and 17 days. Automatic milk-feeders were used as feeding system in the group housing systems. The feeding ratio was 5 liters per day at the start of feeding milk replacer. This was gradually increased to 9 liters per day. At the time of weaning the milk ratio was gradually decreased down to zero at 55 days of age. The calves housed in group pens or group hutches were fed concentrate and silage.

Figure 5. Calves housed in individual hutches

Figure 6. Calves housed in group hutch

6.4 Diseases and treatments

All cases of disease and treatments registered in Vikendata for the calves included in the study were categorized based on the categories reported by the caretakers. The categories used were

pneumonia, diarrhoea, fever, vitamin treatment, bloat, navel infection, colic, interdigital phlegmone, and unidentified diseases. Unidentified diseases were set to include treatments of calves that did not show any specific disease. The common reasons for treating calves in this category were that they did not seem healthy, did not eat properly etc. Vitamin treatments were selenium, vitamin E or vitamin B. Selenium and vitamin E were used as treatment in calves that could not stand properly or had shaking muscles. Vitamin B was mostly used as treatment in calves with diarrhoea. However, vitamin B was usually combined with other treatments and therefore, these cases were included in the diarrhoea category. The vitamin B treatments included in the vitamin treatment category did not have any registered reason for the treatment. Treatments included in the category fever are the one that did not show any other symptoms that could explain the fever.

The medical preparations used for treatments were grouped in ten different categories presented in table 2.

Table 2. Categories of medical preparations used for treatment of the registered diseases.

Categories	**Medical preparation used**
Penicillin	Penovet, Ethacillin, Bimoxyl, Streptocillin
Tetracyclines	Engemycin
Aminoglycoside	Dihydrostreptomycin, Streptocillin
Macrolides	Draxxin
Fluoroquinolone	Advocin
Trimethoprim-sulphonamides	Bimotrim, Hippotrim
Sulphonamide	Socatil
NSAID	Metacam, Rimadyl
Cortisone	Vorenvet
Vitamin treatment	Selevitan, Beviplex
Amoxicillin	Bimoxyl

Diseases and treatments were calculated for the whole study period and also separately by the time periods before and after the change in housing system, i.e. separately for calves housed in the isolated stable (Group IN) and for calves housed in hutches (Group OUT). Use of antibiotics was calculated in the different categories and as a sum for Group IN and Group OUT.

6.5 Statistical analysis

For statistical comparison of occurrence of disease and treatments between housing systems, all registered events were categorized as Group IN or Group OUT, depending on whether the date of the event was before (Group IN) or after (Group OUT) the change of housing system. The total number of calves during the study period was 793, and 380 of these had events in Group IN and 413 had events in Group OUT. When the housing system was changed, calves that was already present on the farm (n = 33) was moved to the outdoor system and these had events in both Group IN and Group OUT. To demonstrate the change in numbers over time, the number of calves present in the herd each month of the study period is presented in Figure 7.

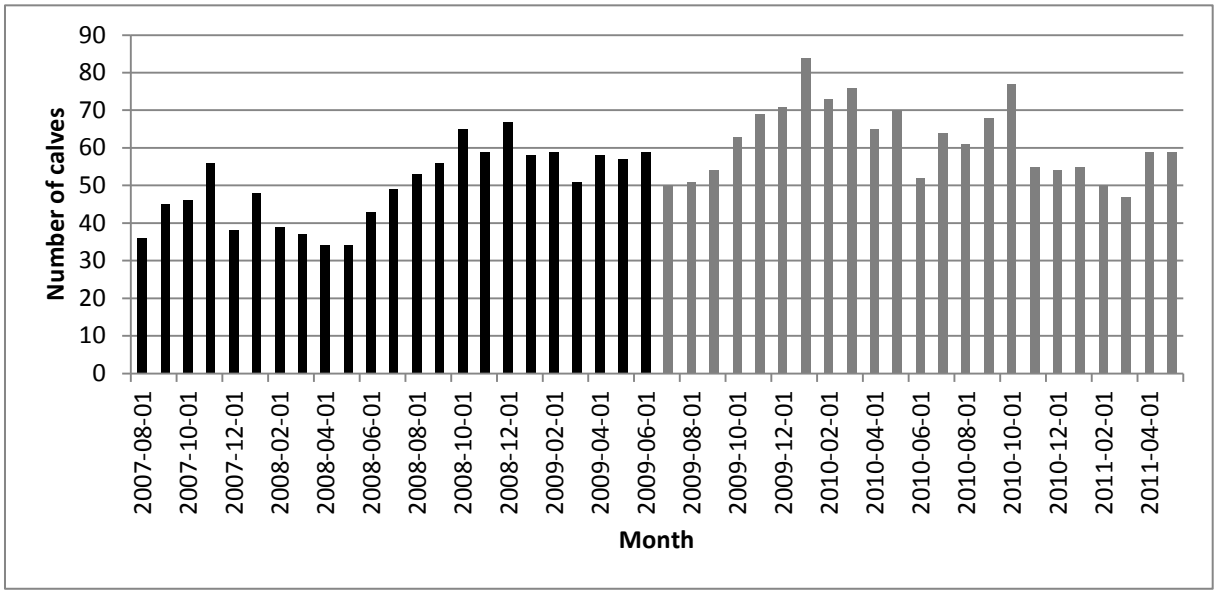

Figure 7. Number of calves included in the study each month

One day's presence within a month was enough for a calf to be included in the total number of calves for that month. One calf could be included in the total number of up to four months, depending on how long time they were kept in each housing system. This was done to be able to compare the number of sick calves to the total number during the month.

The number of registered diseases and treatments were summarized by month. Both overall numbers and numbers by group were calculated. It was the number of diagnosed diseases that were counted and one calf could be counted as many times as it was registered as sick. Numbers were also compared to the total number of calves by dividing the number of events each month by the total number of calves present in the herd the corresponding month. When number of sick calves was compared to number of calves in the housing systems each month, the sick calves were only counted once per month even if they had more than one disease during the month.

Diagnosed diseases were looked at in total and separately as pneumonia and diarrhoea. Diarrhoea and pneumonia are the most frequent registered diagnoses in the literature reviewed and were therefore selected for separate analysis. The age of the calf when diagnosed as a case of pneumonia or diarrhoea used in this study was the number of days from birth until diagnosis. Use of antibiotics was calculated in total use, for Group IN and Group OUT, respectively.

For continuous outcomes, differences between groups were tested using student t-tests. Differences in occurrence of pneumonia and diarrhoea were tested by chi-square testing.

6.5.1 Software

Data management was performed using Microsoft Excel version Office home and student 2010.

7 Results

7.1 Mortality rate

During the study period, 28 calves died or had to be put down; 15 of these were in Group IN and 13 were in Group OUT. No cause of death was registered for any of these cases. The age when the calves died was between 1 and 75 days of age. The mean value of age when the calves died was 23 days during the study period, 19 days in Group IN and 27 days in Group OUT. Mortality during the study period was 3.5%, in Group IN 3.9% and in Group OUT 3.1%.

7.2 Diagnosed diseases in total

The total number of diagnosed diseases during the study period was 730. Of these, 472 were diagnosed in Group IN and 258 in Group OUT. These are sorted by month and presented in figure 8.

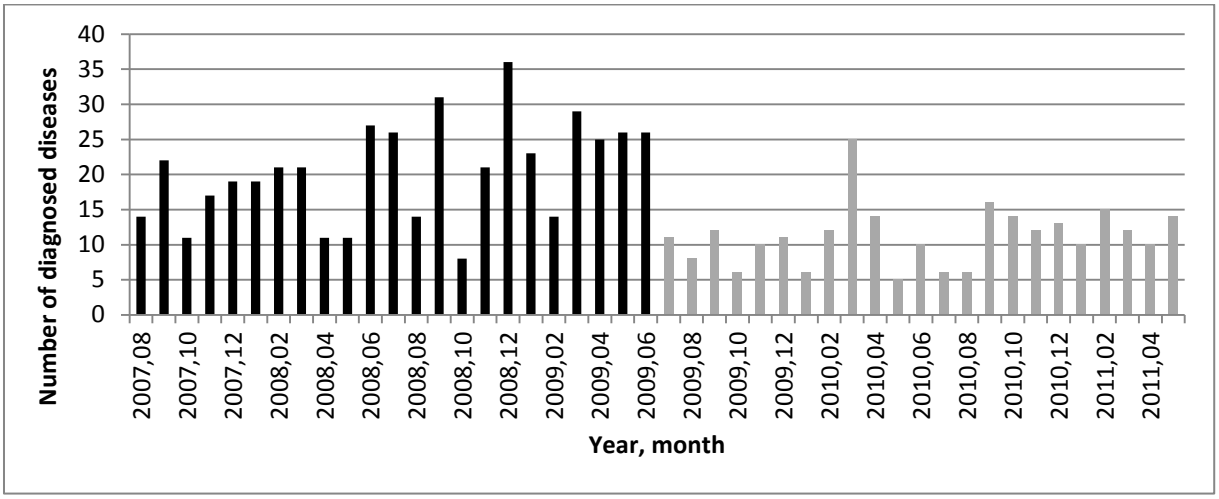

Figure 8. Total number of diseases during the study period for the month it was diagnosed. Group IN: 2007,08 – 2009,06 Group OUT: 2009,07 – 2011,04.

The proportion of sick calves (all diseases) each month varied over time and is shown in Figure 9. Group IN had an average of 32% diagnosed calves each month while the corresponding percentage in Group OUT was 17%. The highest percentage (47%) was in June 2008 and the lowest (7%) was in January and May 2010.

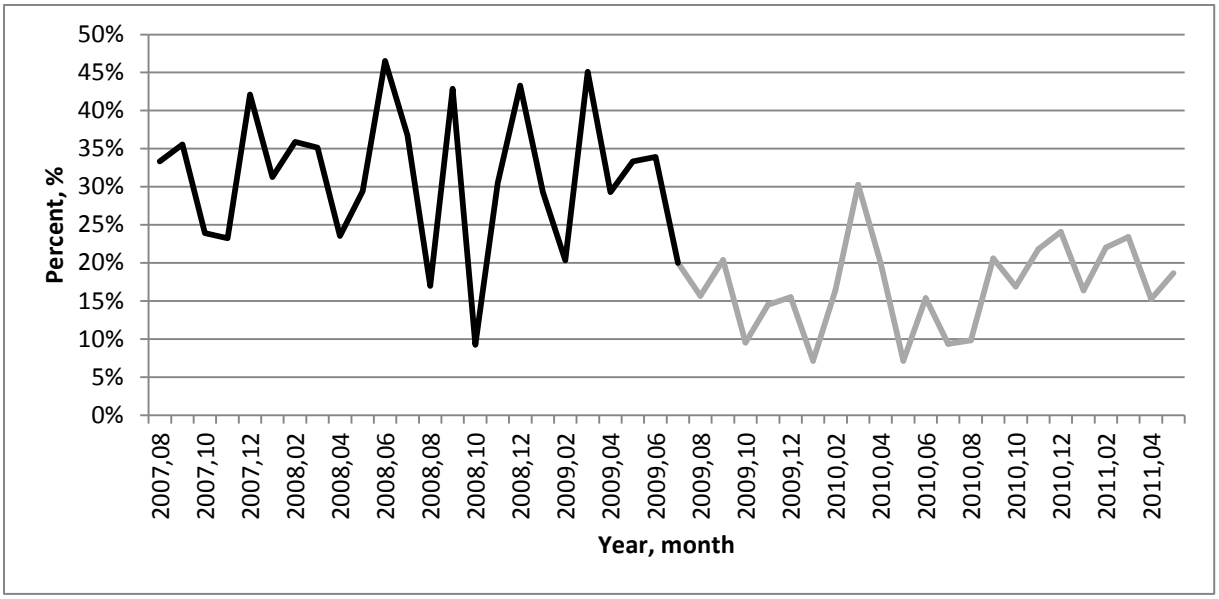

Figure 9. Diagnosed diseases in percentage of number of calves in the housing systems during each month.

Percentages of diagnosed diseases in 2008 and 2010 are compared in figure 10. There were a higher percentage of sick calves during 2008 in all months except for October.

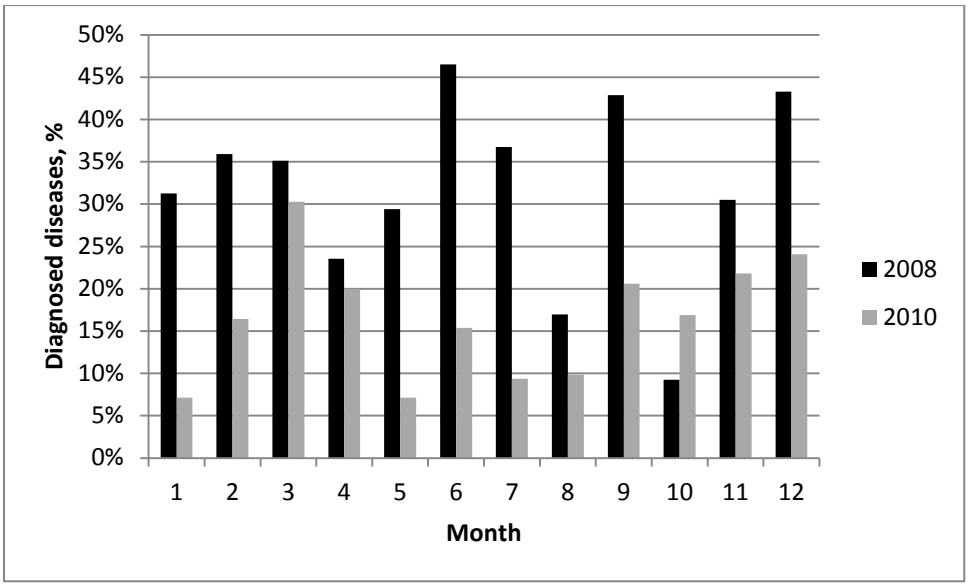

Figure 10. Percentage of diagnosed diseases per month is compared between 2008 and 2010.

During the study period 394 (49.7%) of the 793 calves in total had a disease diagnose. Of these, 242 calves got sick in Group IN, while 152 calves got sick in Group OUT. The percentage of calves that developed a disease was 63.7% in Group IN and 36.8% in Group OUT. On average, calves that had a disease diagnose had 1.85 registered disease events.

The age when the calves in Group IN and Group OUT got sick are presented in figure 11. In Group IN, the number of diagnosed diseases peaked at 9 days of age. Group OUT had the highest number at 11 days of age and had a less pronounced peak.

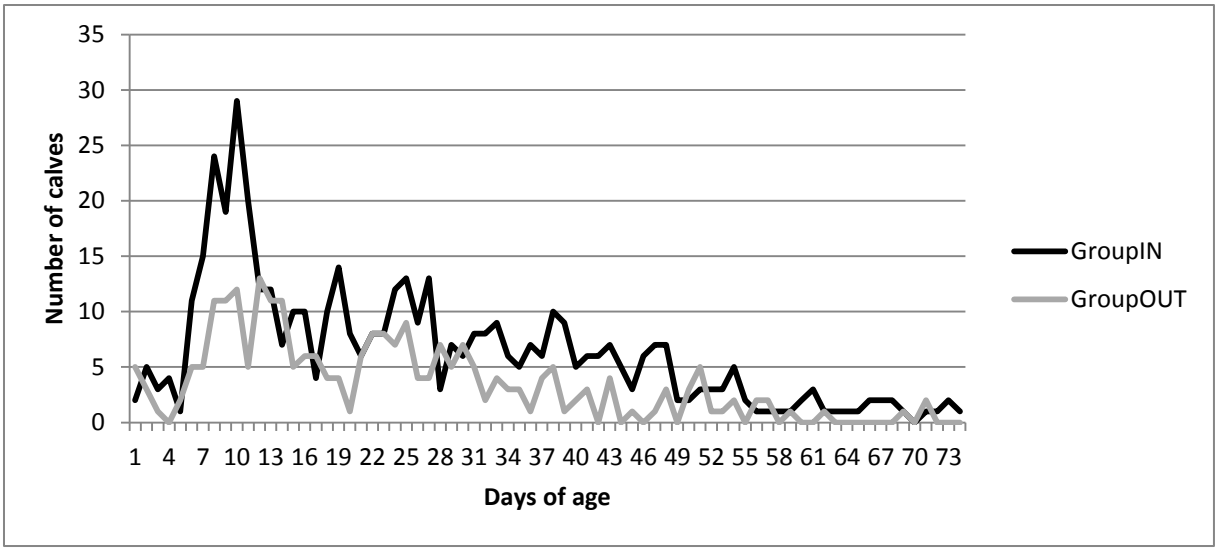

Figure 11. Age at diagnosed diseases in Group IN and Group OUT.

Pneumonia was the most common diagnose followed by diarrhoea which is shown in table 3.

Table 3. Number of diagnosed diseases in total, and by housing category.

Diseases	Total	GroupIN	GroupOUT
Pneumoni	369	255	114
Diarrhoea	220	127	93
Unidentified diseases	75	52	23
Vitamine treatment	30	14	8
Fever	23	17	6
Bloat	5	2	3
Navel infection	4	2	2
Colic	3	1	2
Interdigital phlegmone	1	1	0

7.3 Pneumonia

Pneumonia was diagnosed 369 times during the study period, 255 of those were in the Group IN while 114 were in Group OUT. The number of pneumonia cases over time is demonstrated in figure 10. Based on proportions, 40% of the calves were diagnosed with pneumonia during the study period; 56% of calves in Group IN and 25% of calves in Group OUT. There was a significant difference between the groups (chi-square test; $P<0.001$). Calves with pneumonia were diagnosed between 1 and 3 times and treated 1.16 times in average during the study period; 1.2 times in Group IN and 1.1 times in Group OUT.

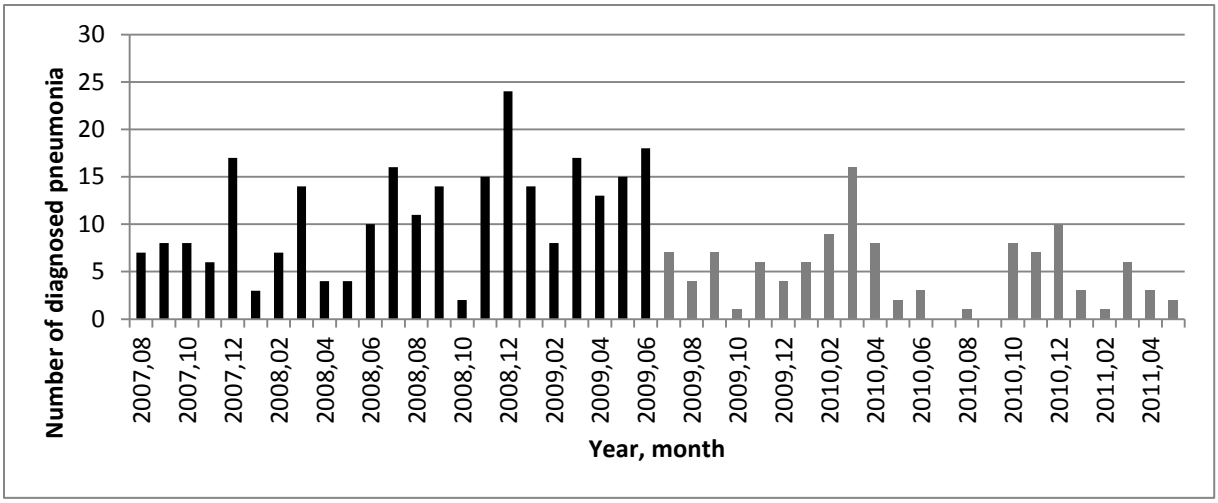

Figure 12. Number of diagnosed pneumonia per month throughout the study period in the two groups.

There was no significant difference in age at diagnosed pneumonia between the groups (student t-test; P=0.575). Both groups seemed to follow a similar trend which is demonstrated in figure 13.

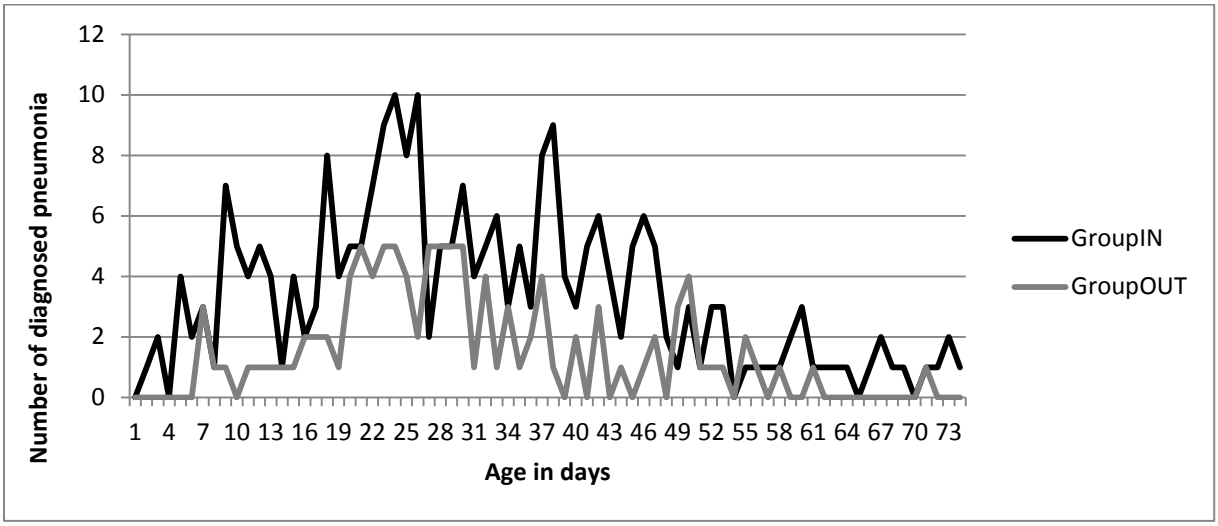

Figure 13. Age at diagnosed pneumonia in the two groups.

7.4 Diarrhoea

There were 220 diagnosed cases of diarrhoea during the study period and 127 of these were in Group IN and 93 were in Group OUT, which is presented per month in figure 14. There was a significant difference between the groups (chi-square test; P=0.0016). Highest number of diarrhoea per month was 12 diagnoses in June 2008, September 2008 and September 2010. Twenty-six percent of the calves in the study were diagnosed with diarrhoea; 30.5% of calves in Group IN and 21.3% of calves in Group OUT. Few calves were diagnosed twice with diarrhoea. The average number of diagnoses per sick calf was 1.07; 1.09 in Group IN and 1.06 in Group OUT.

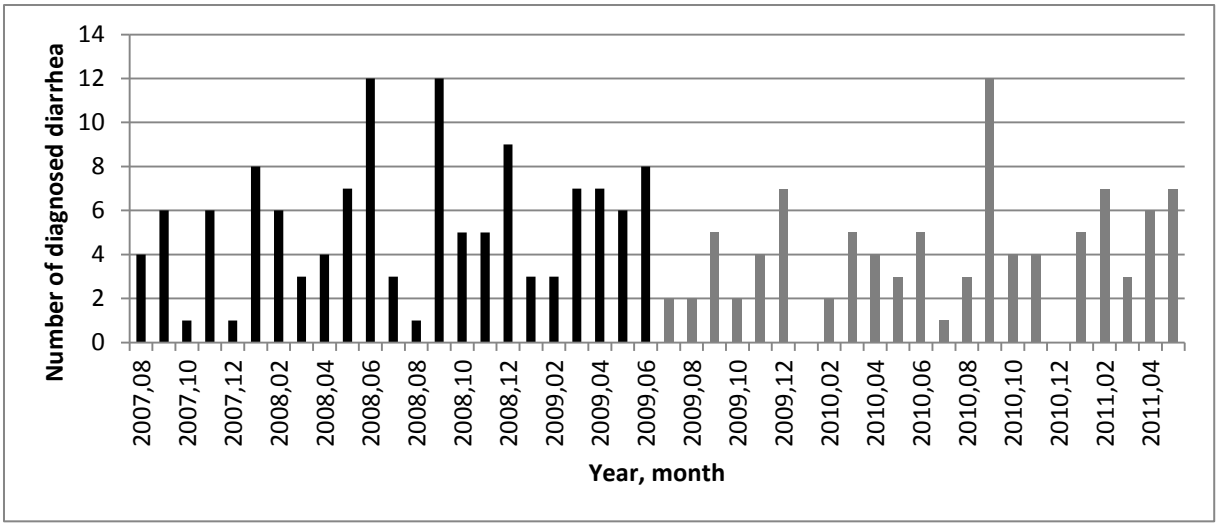

Figure 14. Number of diagnosed diarrhoea per month during the study period.

During the whole study period, 385 of the 793 calves were treated with Baycox at the birth date or the day after. Baycox is an anticoccidial parasiticide which is used on new born calves for prevention of coccidiosis (through contamination of coccidian spp shed by older calves). Of the 385 calves that were treated, 98 got diagnosed with diarrhoea.

Age at diagnosed diarrhoea was more common between 5 and 18 days of age with the highest number of calves at 9 days of age in Group IN and 11 days of age in Group OUT (figure 15). There was a tendency, however not significant, for a difference in age between the groups (student t-test; P=0.0996).

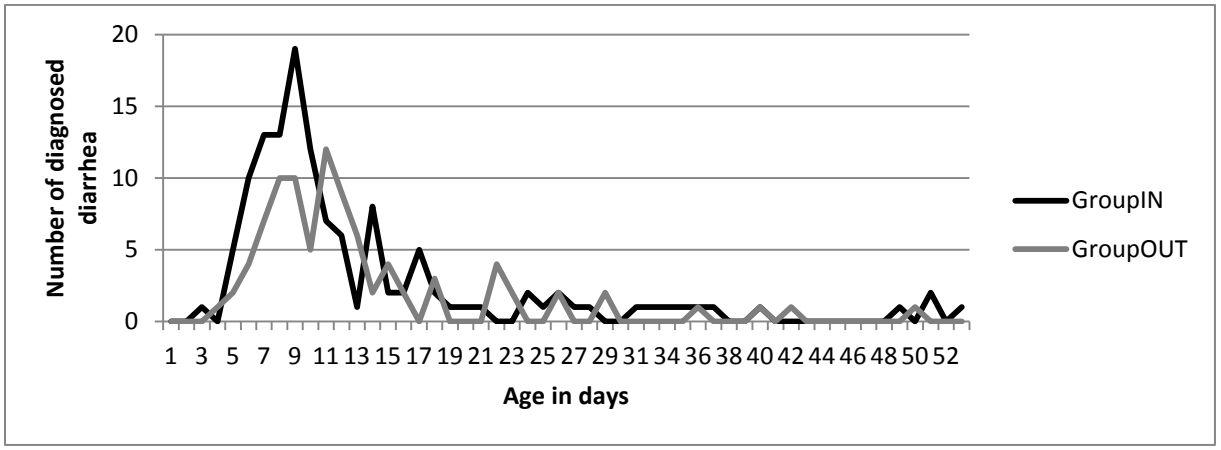

Figure 15. Number of diagnosed calves at different ages in days, for Group IN and Group OUT.

7.5 Use of medical drugs

Use of medical drugs is shown in table 4. The total use of antibiotics during the study period was 1.875 kg which is 2.36 g per calf. More antibiotics were used for treatments in Group IN than in the Group OUT; 63% (3.12 g per calf) and 37% (1.68 g per calf) respectively of the total use during the study period. This difference between the groups was significant (student t-test; $p<0.001$). The most commonly used antibiotic was Engemycin which contains tetracycline as active substance. Most of the antibiotics were used for treatment of pneumonia

while most of the sulfa were used for treatments of diarrhoea. Use of antibiotic for treatments of pneumonia and diarrhoea was 0.997 kg and 0.118 kg in Group IN and 0.512 kg and 0.075 kg in Group OUT.

Table 4. Use of categorized drugs in total during the study period, for pneumonia and diarrhoea in the two groups.

			Pneumonia			Diarrhoea	
	Total		**GroupIN**	**GroupOUT**		**GroupIN**	**GroupOUT**
Penicillin	0.086	0.052	0.029	0.023	0.034	0.034	0.000
Tetracycline	1.483	1.381	0.892	0.489	0.011	0.008	0.003
Aminoglycoside	0.095	0.021	0.021	0.000	0.038	0.038	0.000
Amoxicillin	0.071	0.025	0.025	0.000	0.000	0.000	0.000
Macrolides	0.001	0.001	0.001	0.000	0.000	0.000	0.000
Fluoroquinolone	0.029	0.029	0.029	0.000	0.000	0.000	0.000
Trimethoprim - sulphonamides	0.110	0.000	0.000	0.000	0.109	0.037	0.072
Sulphonamide	8.110	0.305	0.120	0.185	7.725	4.325	3.400
NSAID	0.009	0.004	0.003	0.001	0.002	0.000	0.001
Cortisone	0.000	0.000	0.000	0.000	0.000	0.000	0.000

8 Discussion

The results in this study demonstrate significant differences in the frequency of pneumonia and diarrhoea between calves housed in a traditional indoor system and a system with outdoor hutches. Group IN had twice as many diagnoses of pneumonia compared to Group OUT, even though there were more calves in Group OUT than in Group IN. These results are supported by earlier studies where a large difference in respiratory problems was found between calves that were housed in conventional indoor housing and calves housed in outside portable pens (Davis et al., 1953; Lorentz et al., 2011). Compared to earlier Swedish studies, the percentage of calves diagnosed with pneumonia was relatively high in Group OUT (25%), even though this was low compared to Group IN (56%). In a study published in 1993, where calves between 0 and 90 days of age were studied, the frequency of diagnosed pneumonia was 0.8% (Olsson et al., 1993). This is lower compared to results presented in an more recent study published in 2003 where 19.4% of the calves had remarks at lung auscultation and 5.7% of the calves were diagnosed with moderate to severe respiratory sounds (Svensson et al., 2003).

In this study, the highest numbers of diagnoses of pneumonia were in the age range of 21 to 30 days of age. There was a large variation in the groups and no significant difference between the groups. In the reviewed literature included in this report, all studies demonstrate a peak age of pneumonia later in the calves' life. Lagos et al. (2006) found a peak of pneumonia around 49 days of age and Waltner-Toews et al. (1986b) found the peak to be around 42 days of age. Leslie and Todd (2009) showed results that coincide better with the results in this study. Their results showed a peak at 30 days of age which dropped at 40 days of age and later continued to occur sporadically. They also concluded that pneumonia typically occurs shortly after weaning or when the form of housing is changed from individual housing to group housing. In groups, the calves come into physical contact with other calves which increases the risk of spreading diseases. In this study calves were housed individually at first and then grouped at 10-18 days of age. The grouping could perhaps be one reason for the increase of pneumonia. However, no clear conclusions can be drawn from this, as there was a large variation in days of age. The variation was larger in Group IN than Group OUT which can be explained by the fact that there were more than twice as many diagnoses of pneumonia in Group IN than in Group OUT.

There was a significant difference in number of diarrhoea cases between the groups, even though the difference was not as large as for pneumonia cases. 30.5% of the calves in Group IN got diarrhoea compared to 21.3% in Group OUT. Diarrhoea as well as pneumonia was diagnosed in a higher proportion of calves compared to previous Swedish studies. Olsson et al. (1993) reports a frequency of 7.2% and Svensson et al. (2003) 10.3%. One reason for the higher percentage could be the problem with coccidian parasites that exists on the farm. As mentioned earlier the calves have been treated with Baycox during periods of time when the animal keepers have seen an increase in diagnosed diarrhoea. During these periods of time, not all of the calves have been treated because they have been included in different ongoing studies. The same proportion of treated and untreated calves was later diagnosed with diarrhoea (~25%). I.e. there were no significant difference in occurrence of diarrhoea between calves that were treated with Baycox and calves that were excluded from treatment. Since

there are many factors affecting calf health and only a few of these were measured in this study, it is difficult to draw conclusions about the reason for the high percentage of diarrhoea. Diarrhoea occurred in a more defined age range than pneumonia, between 5 and 18 days and with a peak at 9 days of age. Peak age in this study occurred when the calves were housed individually. The effect of contact between calves on diarrhoea did not seem to be the biggest issue. Perez et al. (1990) showed that the peak age for diarrhoea in heifers occurred in the first 14 days of life and then dropped dramatically almost down to zero on 30 days of age. The results from Perez et al. (1990) demonstrates a wider age range than in this study but both shows a more or less defined age range. It seems reasonable that the change in housing system from an isolated barn to hutches could have had effects on the calves' health. In addition, there are no apparent negative effects on their health caused by the change.

There were no obvious seasonal differences in occurrence of pneumonia and diarrhoea. To be able to make a more reliable comparison the study period should have been longer and data from weather reports should have been taken into consideration. The weather reports that are included in this study are not placed at the farm; there could be differences between the reported weather and the actual weather at the farm at the registered time. On average, the last two winters have a colder temperature compared to the first two. The effect of the difference in temperature is hard to tell since the calves were in Group IN during the winters with warmer temperature and in Group OUT during the winters with colder temperature. Murley and Culvaitouse (1958), as earlier mentioned in the literature review, could not find any differences in calves' health caused by differences in temperature. They compared conventional indoor housing to portable pens and open sheds. The relative humidity was slightly higher in the closed barn which they believed to be the cause of the cases of pneumonia during the study period. A higher relative humidity in the closed barn could be one of the reasons for a higher frequency of pneumonia in Group IN than in Group OUT. Unfortunately, the relative humidity in the isolated barn or the hutches was not measured in this study.

There was a significant difference in use of antibiotics between groups. More antibiotics were used for treatments in Group IN than in the Group OUT; 63% and 37% respectively of the total use during the study period. This result are supported by McKnight (1978) who found that calves housed in outdoor hutches required less medical treatment compared with calves kept in indoor housing. Most of the antibiotics in this study were used for treatment of pneumonia. Waltner-Toews et al. (1986a) showed that calves raised in hutches are 25 times less likely to be treated for pneumonia and 8 times less likely to be treated for enteric diseases compare to calves housed individually indoors. The most frequent used antibiotic was Engemycin in form of injections. In this study, the amount of Engemycin was summarized in the group tetracycline as oxytetracycline is the active substance in this medical drug. Engemycin is a broad-spectrum antibiotic and should for that reason not be used as a first hand alternative, unless considered necessary. Penicillin is in most cases good enough for treatments of pneumonia. There is a growing problem with microbial resistance all over the world which is a threat to humans and animals (Ortman and Svensson, 2004). However, in this study, only low doses of antibiotic were used as treatment in cases of diarrhoea. In a

Swedish study presented in 2004 (Ortman and Svensson, 2004), recommendations included that treatments of diarrhoea should be performed by electrolyte solutions because the most common infectious reason for diarrhoea in neonatal calves in Sweden is rotavirus. Antibiotics should be used if investigations show that a bacteria is the cause to the diarrhoea and with no larger doses than necessary. In addition, the types of antibiotics that are suitable for the identified bacteria should be used, instead of using a broad spectra type of antibiotics and a just in case strategy (Ortman and Svensson, 2004).

The calf mortality during the study period was 3.5%. This is higher than the 2.6% that Olsson et al. (1993) found in their study performed in Swedish herds. However, Olsson et al. (1993) also found a large variation between farms. The mortality was slightly lower in Group OUT (3.1%) compared to Group IN (3.9%). Group OUT showed results close to another Swedish study where the mortality rate was 3% (Svensson et al., 2003). The disease morbidity during the study period was 50%, 64% in Group IN and 37% in Group OUT. This is higher compared to the earlier Swedish studies mentioned above, where 11% and 23% was reported (Olsson et al., 1993; Svensson et al., 2003). In contrast to most studies included in the literature review, pneumonia rather than diarrhoea was the most common disease in this study; 40% of the calves were diagnosed with pneumonia and 26% with diarrhoea. Some studies show an association between mortality and increased herd size (Gulliksen et al., 2009a; Hartman et al., 1974). This was not found in this study. At the time when the herd was increasing in size, the farm also expanded the buildings for housing of the cattle, and because of that the calves were not more densely housed. The animal density has been shown to be one of the reasons for a higher mortality. Traffic of people was the same before and after the expansion of the herd which is another factor that may affect mortality when herd size is increased.

The calves in Group IN were housed in the same building as older cattle, however, younger and older animals did not come into physical contact with each other. Virtala et al. (1999) state that mortality is usually high when the preweaned calves are kept in an environment contaminated by older cattle. In this study there was automatic natural ventilation in the isolated barn where Group IN was housed. Opinions from animal keepers were that it was not functioning properly and that snow came in through the open ridge during winter. Nordlund (2008) has concluded that it is important to have personnel that knows how to handle the ventilation and knows what to do when it does not function properly. It is possible that the exchange of air in the indoor system described in this study was not optimal and that there were unfavorable amounts of airborne bacteria and gases present. Measures of air quality would have been needed to draw any conclusions on this.

There are many factors affecting the calves' health (Lundborg et al., 2005). The possibility that other factors than the housing system may have caused the difference in calf health before the change of system is restricted by the fact that the same animal keeper, routines, breeds and feedstuffs were used in both systems. However, there are other important factors, such as quality of colostrums, which was not taken into account and may have influenced the results.

In this study, the number of calves born each month differed and the calves were not removed from the housing systems at the exact same age. This leads to a different number of calves each month and makes it harder to compare number of cases between months and seasons. Calves housed in the isolated barn and hutches were moved when all of the calves in the same group were weaned. The farm was also expanding during the study period and because of this more calves included in Group OUT than in Group IN. It can be noted that even though there were more calves in Group OUT, there were more cases of diseases registered in Group IN. Calculation of cases and calves for each month was based on the calves that were present in the housing systems more than one day during each month. Other ways to decide the number of cases and totals could be considered but this was the method chosen here. The years 2008 and 2010 were compared to see the differences in diagnosed diseases between Group IN and Group OUT per month during a whole year. These two years were the only years where all 12 months were included in the study period and where calves were all in the same group (Group IN or Group OUT). There was a higher percentage of sick calves in all months in 2008 except for October where 2010 got the highest percentage.

As already mentioned, effects of weather conditions on air quality in the isolated barn and in the hutches were not investigated. According to official registrations of weather, Group OUT had on average colder winters compared to Group IN. Svensson et al. (2003) showed a higher frequency of respiratory diseases during the cold season. In spite of this, the calves were healthier the last two years when the winter was colder. This indicates that, compared to weather conditions, housing system has a larger impact on calves' health.

Animal welfare was not specifically included in this study and the behaviour of the calves was not registered. However, based on behaviour aspects, the environment in the two housing systems was not very different. Calves were born in single or multiple calving pens and the routines were the same in both systems. Feeding systems and feed were also the same in both system and the calves were allowed to suckle on rubber teats attached to a bucket or an automatic milk-feeder. Play behaviour is one indicator of calves' welfare which was not investigated in this study. Space allowance is of great importance for play behaviour and the pen space was almost the same in both housing systems investigated here.

In conclusion, the results from this study indicate that housing calves in hutches are preferable from a health point of view compared to indoor housing in conventional barns. There were fewer calves sick in Group OUT and less antibiotic were used compared to Group IN. Pneumonia was the most frequent diagnosed disease followed by diarrhoea. Pneumonia was also the most common reason for treatment with antibiotics. Age at diagnosed diarrhoea was more common between 5 and 18 days of age with the highest number of calves at 9 days of age in Group IN and 11 days in Group OUT. Age at diagnosed pneumonia was more spread out but both groups seemed to follow a similar trend. More studies, e.g. with more herds, are needed to confirm these results.

9 Sammanfattning

Kalvhälsa är viktig för att ge kalvarna en god djurvälfärd, dessutom är sjuka kalvar ekonomiskt kostsamt för djurägaren. Det är många faktorer som påverkar kalvarnas hälsa varav inhysnings system och miljön runt kalvarna är två faktorer. Syftet med denna studie var att jämföra kalvhälsan vid inhysning i ett isolerat stall (Group IN) med inhysning av kalvar i hyddor (Group OUT). Studien baserades på data från en mjölkgård som ändrade inhysning av kalvarna från isolerat stall till hyddor. Endast inhysningsform ändrades, rutiner och foder var de samma i båda systemen. Jämförelsen baserades på antalet registrerade lunginflammationer och diarréer samt registrerade behandlingar med antibiotika i de båda inhysningssystemen. Lunginflammation var den vanligast förekommande sjukdomsregistreringen i båda inhysningssystemen följt av diarréer. Andelen kalvar som fick lunginflammation var dubbelt så hög i Group IN (56 %) jämfört med Group OUT (25 %). Trots att andelen kalvar som fick lunginflammation var betydligt lägre i Group OUT så var antalet fortfarande högt jämfört med tidigare svenska studier. Det var en signifikant skillnad mellan andelen kalvar som diagnostiserades med diarré i Group IN (30.5 %) jämfört med Group OUT (21.3 %), men skillnaden i diarré var inte lika stor mellan grupperna som skillnaden i lunginflammationer. Även andelen kalvar som diagnostiserades med diarré var högre i båda grupperna än tidigare svenska studier. En anledning till att det var en högre andel kalvar som registrerades med diarré kan ha varit att det fanns ett problem med koccidier på gården. Vid jämförelse mellan kalvar behandlade med Baycox och obehandlade så var procentsatsen av kalvar som fick diarré den samma. Majoriteten av kalvarna som diagnostiserades med diarré var mellan 5 och 18 dagar med högsta antal vid 9 dagar i Group IN och 11 dagar i Group OUT. Ålder vid lunginflammation var mindre koncentrerad jämfört med ålder vid diarré, men båda grupperna följde ett liknande mönster. Av den totala mängden antibiotika användes 63 % i Group IN och 37 % användes i Group OUT. Majoriteten av antibiotikan användes till behandling av lunginflammationer.

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