Optimal group size for calves fed in transponder-controlled milk feeders

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Institutionen för husdjurens utfodring och vård — **Examensarbete 278**

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Preface

Initially Ida Eriksson, in search of an object for her master thesis, contacted DeLaval International AB. At DeLaval, Product Group Manager Henrik Rosenberg and Product Specialist Lars Arnerup, presented to her the actual question concerning the optimal number of calves in groups fed from transponder-controlled milk feeders. Systems for transponder-controlled milk- and concentrate feeding are marketed world-wide by DeLaval and knowledge concerning the effects of group-size on calf performance is valuable when adapting the recommendations for use of these systems in different markets. The problem was then formulated in more detail by IdaEriksson and the DeLaval representatives, and the undersigned was engaged as supervisor for this master thesis at the Department of Animal Nutrition and Management at SLU. The study was made possible by financial support from DeLaval.

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Ingemar Olsson

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Abstract

Traditionally preweaned calves have been kept in single pens until the time for weaning. However, nowadays the general opinion from both the society and manufactures is that calves should preferable be kept in groups (DeLaval, 2000). There are several reasons why group housing is increasing. This system for rearing calves has many advantages compared with single housing. Group housing give calves opportunity to perform social behaviours (Jensen *et al*. 1998, Jensen, 2004) and stimulates the consumption of forage and grain (Phillips, 2004, Babu *et al*. 2004). The aim of this project was to achieve knowledge about the optimal group size for group housed calves that are fed milk from automatic milk feeders. The project has been conducted in collaboration with Delaval.

Recent literature was reviewed and an interview part was conducted where 7 different farms in the Netherlands, Norway and Latvia was visited. The interviews showed that most farmers were satisfied with their milk feeder and their group housing system. Group housing is more preferable compared to single housing in several aspects. This housing system makes the calves develop a social behaviour which has a positive impact on the ability to function in a group even later in life. The literature study and the interviews also showed that the optimal group size is very much depending on the management system and the presumptions on the actual farm. However, the incidence of disease outbreaks can be greatly reduced and the daily weight gain can be increased if stable groups are kept. This study concludes that calves should preferable be kept in small groups (max 12 individuals) and the age range among them should be as small as possible in order to achieve optimal conditions for the calves.

Sammanfattning

Traditionellt har kalvar fötts upp i enkelboxar under mjölkperioden. Idag är dock den generella uppfattningen från både samhället och tillverkare av kalvtillbehör att kalvar ska hållas i grupper (Delaval, 2000). Det finns ett antal anledningar till att grupphållning av kalvar stadigt ökar. Detta inhysningssystem för kalvar har många fördelar i jämförelse med enkelboxar. Grupphållning ger kalvarna möjlighet att utveckla ett socialt beteende i större utsträckning (Jensen *et al*. 1998, Jensen, 2004) och grupphållning stimulerar även intaget av både grovfoder och kraftfoder (Phillips, 2004, Babu *et al*. 2004). Målet med denna studie var att presentera material angående optimal gruppstorlek för kalvar som utfodras med kalvamma. Detta material ska i sin tur ge vägledning i Delavals management råd angående kalvammor. Detta projekt har utförts i samarbete med Delaval.

En litteraturstudie genomfördes samt en intervjudel där 7 olika gårdar i Holland, Norge och Lettland besöktes. Intervjuerna visade att de flesta bönderna som besöktes var nöjda med sina inhysningssystem och kalvamma. Grupphållningssystem är att föredra jämfört med enkelboxar av många anledningar. Detta inhysningssystem gör att kalvarna kan utveckla ett socialt beteende vilket i sin tur har en positiv effekt på deras förmåga att fungera i en grupp. Litteraturstudien tillsammans med intervjuerna visade att en optimal gruppstorlek är svårt att definiera då detta påverkas till stor del av management systemet som används på gården samt den specifika gårdens förutsättningar. När stabila grupper hålls kan risken för sjukdomsutbrott kraftigt reduceras och den dagliga tillväxten kan ökas. Denna studie konkluderar att kalvar ska föredragsvis hållas i grupper om max 12 individer och åldersspridningen i gruppen ska hållas så låg som möjligt.

1. Introduction

1.1 Background

A trend in modern dairy farming is that an increasing number of calves are kept in group housing systems instead of the traditional single pens (Bøe and Færevik, 2003, Pettersson *et al*., 2001). Pettersson *et al*. (2001) conducted a study where results from interviews with 877 Swedish farmers were presented. This study showed that 68 % of all the Swedish farmers still kept their calves in individual pens during the milk feeding period. On the other hand, 13 % of the approached farmers kept their calves in group pens using automatic milk feeding. Since this study was performed in the year of 2000, the number of farms that keep their calves in group housing systems is probably larger today.

Traditionally preweaned calves have been kept in single pens until the time for weaning. However, nowadays the manufactures recommend calves to be kept in groups (DeLaval, 2000). The use of single pens to calves is according to them not the future and many studies support this conclusion. There are several reasons why group housing is increasing. This system for rearing calves has many advantages compared with single housing such as opportunity for the calves to perform social behaviours (Jensen *et al*. 1998, Jensen, 2004) and a stimulated consumption of forage and grain (Phillips, 2004, Babu *et al*. 2004). Group housing is nevertheless also associated with several drawbacks. There is for example an increased risk of respiratory diseases in group housing systems compared with single housed calves (Svensson *et al*. 2003). The higher risk of diseases in group housing systems is though strongly correlated with the size of the group.

1.2 Purpose

The objective of this study is to review the recent literature on how the group size of calves affects performance, mortality, calf health and workload, and how the relative importance of these parameters could differ between different markets. The aim is to achieve knowledge about the optimal group size for loose-housed calves that are fed milk from automatic feeders. The aim is also to present information around this subject so that DeLaval can use this paper in order to give management advice concerning automatic milk feeders to their customers. This paper is created in cooperation with DeLaval, Sweden.

2. Literature review

2.1 Different calf management systems

2.1.1 Calving pens

The calving pen should provide the dam with a good environment so that the calving is not obstructed in any way (Ventorp, 2003). The pen must make the observation of the calving cow uncomplicated for the herdsman. The calving pen should be provided with a generous bed of straw or comparable material to provide a comfortable lying area for the cow. The calving pen should also be easy to clean and be made of material that is easy to disinfect. The walls of the pen should be closed so that draught is minimized.

Swedish legislation

In herds where there are heifers and cows it should be calving pens available (DFS, 2007:5). A cow should be held in a calving pen by the time for calving but if the cow is held in a tied up stall and the calving pen is occupied by another cow for the moment it is then allowed to let the cow calve when she's tied up. The minimum space allowance for a single calving pen must be at least 10 m^2 and 8 m^2 per cow in a group calving pen.

EU legislation

According to the EU councils recommendations there should be a calving pen available in a cattle breeding herd (EU recommendations, 1988). There is however neither any regulations concerning the minimum area in a calving box nor other more exact description of how the calving pen should be constructed.

2.1.2 Single pens

Single pens for housing of calves are common practice and are traditionally used in many countries (Fredriksson *et al*., 2006). In the single pen the feeding of milk to calves are handled with buckets with or without teats, see figure 1. Individual housing has many advantages. The most pronounced advantage is the reduction of disease transmission between calves. This is explained by the fact that calves in single pens have very limited physical contact with each other. In addition, single kept calves are easier to monitor in order to detect signs of illness and they are also easier to treat with for example antibiotics if necessary. Single pens are however connected with several possible drawbacks. The most noticeable is the limitation of physical space and the fact that this housing system does prevent the calves from social contact with each other and develop a normal behaviour. The advantages and disadvantages with different housing systems will be further discussed in this paper.

Figure 1. *Single pen for calves (DeLaval, 2008).*

Swedish legislation
A calf is defined as cattle up to 6 month of age; this is also according to the EU legislation. It is not allowed to tie calves up (DFS, 2007:5). It has to be a special pen available in an insulated and heated stable for sick or injured calves. Pens for calves younger than 1 month must be provided with straw or other comparable material (SFS, 2007:1395). Single pens must have closed walls up to 0.80 m and the rest of the wall shall be open so that eye contact and head to head contact is possible between calves (DFS, 2007:5). The minimum allowed space in a single pen is showed in table 1.

Table 1. *Minimum space allowance for calves in single pens (DFS, 2007:5).*

Maximum weight (kg)	Length of the pen (m)	Wideness of the pen (m)
60	1.20	1.00
90	1.40	1.10

EU legislation
A calf may not be kept in a single pen when it is older than 8 weeks, unless other has been ordered from a veterinarian (Council directive 97/2/EEC). The wideness of the pen should at least correspond with the withers height of the calf and the length of the pen must at least correspond with the body length of the calf measured from nose tip to the rear point of the *tuber ischi* multiplied with 1.1.

2.1.3 Calf hutches
Calf hutches are kept outdoors and are not insulated, see figure 2 (DeLaval, 2009). The manufactures recommend that you complement the hutch with a surrounding fence so that the calves get access to more space and so that they get the opportunity to be outdoors more. The hutches should be provided with straw, this is particular important when the outdoor temperature is low (Fredriksson *et al*., 2006). A big advantage with hutches is that they often provide very good air quality, with respect to its concentration of potential pathogenic microbes, for the calves which can reduce the incidences of respiratory diseases. The feeding of milk in a hutch is performed in the same way as in a single pen, which is with buckets with or without teats. Hutches are more work demanding compared to other systems but this drawback is often defended by healthier calves. It is important to situate the hutches so that rainwater doesn't run in

to the hutches. A way for solving this problem is to make a hard-surfaced passage with a light V-shape in the middle of all hutches so that all the rain water drains to the middle.

Figure 2. *Calf hutch with a surrounding fence (DeLaval, 2008).*

2.1.4 Group pens

The manufactures nowadays recommended calves to be kept in groups from the second week of age (DeLaval, 2009). This is also recommended in several studies which emphasize the positive effect of group rearing (Svensson *et al*., 2003; Babu *et al*., 2004 *et al*.). This housing system promotes social contact and lets the calves perform many behaviours that are inhibited in traditional single pen systems. Fore example are play behaviour more often seen in group housing systems compared to single housing systems (Jensen *et al*. 1998). Group housing also promotes social interactions and this can have a positive impact on for example feed intake (Phillips, 2004). The advantages and disadvantages with group housing in combination with computer controlled milk feeding will be further discussed in this paper.

Swedish legislation

It is not allowed to keep calves that are less than 1 month old on barely slatted floor (DFS 2007:5). If slatted floor is used to such calves, they must have access to a lying area which is provided with straw or comparable material. The minimum space requirements for calves in group pens are showed in table 2.

Table 2. *Minimum space requirements for calves according to Swedish legislation (DFS, 2007:5).*

		Straw bedded area (m^2/ calf)	
Maximum weight (kg)	**Slatted floor (m^2/calf)**	**Lying area**	**Total area**
60		1	1.5
90	1.5	1.2	1.7
150	1.5	1.5	2.2

EU legislation
There is no limitation concerning the use of fully slatted floor to young calves according to the EU legislation (Council directive 97/2/EEC). There is however minimum space requirements which are declared in the table below.

Table 3. *Minimum space allowance per calf that is held in group pens (Council directive 97/2/EEC).*

Maximum weight (kg)	Free space per calf (m^2)
≤150	1.5
150-220	1.7
≥220	1.8

2.1.5 Bucket feeding
When bucket feeding is used the milk ration that the calf is offered is restricted (Andrews, 2000). If the bucket is not provided with a rubber teat the ingestion of milk is performed in a less natural way which can have a negative effect on the oesophageal groove reflex. The opportunity for the calf to perform natural sucking behaviour is prohibited if bucket feeding without a rubber teat is used. This can lead to unwanted behaviours, such as cross sucking, which will be further discussed in the text below. Bucket feeding is in many ways a labour demanding feeding system but it on the other hand makes the individual control over the daily feed intake very easy.

2.1.6 Computer controlled milk feeding
Computer controlled milk feeding allows the calves to live in a group which is considered to be more natural and have a positive impact on the social behaviour compared to single pens (Jensen *et al*., 1997). The milk allowance can be individually adjusted and a gradual weaning can easily be conducted when a computer controlled milk feeding system is used (DeLaval, 2009). A computer controlled milk feeder can supply the calves with whole milk, powder milk or a combination of these two. A big advantage with a milk feeder is that the herdsman get full supervision of each calf's milk supply and can easily see when and how much milk the calf is ingesting. This is a very good instrument that can be used to detect illness among calves at an early state.

2.2 The natural and social behaviour of the calf
Hurnik *et al*. (1995) defined a group as "a collection of animals in which the animals are of the same species and the composition of the group is relatively stable over time". Grouping on the other hand can be defined as "the formation of a group by natural means (e.g. herd formation as a result of social attraction), or by human action (allocation of a number of animals to a given pen or grouping of dairy cows according to milk performance)".

Under semi-wild conditions the cow of the Maremma breed keeps the calf hidden for about 5 days postpartum (Vitale *et al*., 1986). During this time the cow stays close to the place were she keeps the calf hidden. The cow-calf relationship seems to be less strong among the Maremma cattle compared with other breeds. Just 10 days postpartum the calf spent much time away from its mother and is socializing with other calves. The calves then form groups of up to 10 individuals that stay together during the day. This indicates that calves have a strong motivation for social contact with other calves.

Cattle are social creatures that show high willingness to form social bond with other individuals of the same species (Esteves *et al*., 2007). Functioning in a group has many benefits but also costs. In the wild, living in a group reduces the risk of being killed by a predator partly due to dilution. However, the main advantage of group living is that the chance of detecting a predator at an early state is enormously much higher in comparison with single living and thus minimizes the risk of individual loss. By living in a group, animals get the opportunity to companionship, something that has been found to be very important and are considered to be a basic need for cattle (Holm *et al*., 2002).

A study by Holm *et al*. (2002) has shown that calves have a higher motivation to work for full social contact compared to only head contact. The aim of this particular experiment was to determine how much the calves were willing to work for social contact. All calves were held in individual pens but when they pushed a panel with their head a gate opened which permitted them to get access to another pen in which there was another calf. The calves were allowed to have contact with the other calf for 3 minutes and then they were placed in individual pens again. Some of the calves in the study could get full social contact with another calf when they pushed the gate whereas other calves only got the opportunity to have head-to-head contact after pushing the gate. As the experiment went on the calves had to work harder to get access to social contact, in other words they had to push the gate several times before they got access to the other calf. The study concluded that the calves were willing to work significantly harder to get access to full social contact compared to head-to-head contact. The calves' strong motivation for social contact may indicate that calves that are housed in groups have better welfare in this specific aspect than calves that are housed in individual pens or hutches.

The main costs of living in a group are competition over resources such as food, water and resting areas (Esteves *et al*., 2007). These costs can be minimized in different ways, for example by giving the animals access to enough space and feeding places. Increased aggression connected with limited resources is also an important cost that must be taken into account. Providing a good environment and resources that fulfil everyone's individual needs can therefore reduce aggression in a group.

Another important cost for farm animals that are kept in groups is the fact that stable groups are seldom formed (Esteves *et al*., 2007). Homogenous and familiar groups throughout the calf's whole life are very unusual. Thus, regrouping and mixing of unknown individuals may induce aggression and fear.

The calf's social behaviour is affected not only by the kind of housing system the calf is brought up in, but also the management system that are used in its surroundings. The traditional way of housing calves, in single pens or hutches prevents the calf's social behaviour in many ways. EU legislation establish that calves over 8 weeks of age must be held in groups and calves younger than 8 weeks should at least be allowed to have social contact (visual and head to head contact) with other calves (Council directive 97/2/EEC).

A calf in a semi-natural environment suckles the dam 4-10 times per day (Webster, 1984). The size of each portion varies between 0.8-2.5 litre per occasion and the average portion size is about 1.5 litre. It is thought that the size of each portion the calf choose to ingest under semi natural

circumstances is well corresponding with the size of its abomasum. In other words, the calf suckles the dam until it is satisfied and the abomasum is full. However, it is worth mentioning that this is only true under semi natural circumstances. Veal calves on the other hand that are raised on a strict milk based diet can stretch their abomasum and ingest considerable larger portions per occasion than mentioned above.

2.2.1 Abnormal behaviour in calves

The most pronounced abnormal behaviour that is seen amongst calves is cross sucking (Jensen, 2003). Cross sucking is a non-nutritive behaviour that is directed towards another calf's body. The most common areas for cross sucking are ears, navel, scrotum, and prepuce or udder base. When the calf has finished its portion of milk and the sucking motivation is not satisfied the sucking is directed towards the empty teat if this is available (non-nutritive sucking), towards other calves (cross-sucking), or towards other objects. Single housing would in some extent prevent cross-sucking, but not reduce the motivation to perform this behaviour.

Under natural conditions it takes around 10-17 minutes for a calf to ingest a meal of milk (Loberg and Lidfors, 2001). In many management systems bucket feeding is used and the amount of time that it takes for a calf to ingest a portion of milk from a bucket is considerable much shorter (often not more than a minute), especially if open bucket feeding is used.

The majority of all cross sucking in group-housed calves occurs within 10-15 minutes after milk feeding (Lidfors, 1993). This strongly suggests that a cross sucking behaviour is linked with the intake of milk. Lidfors (1993) found that the most intense cross sucking were seen just after milk was ingested and that the frequency of cross sucking significantly decreased by the time when the calves were weaned of. Consequently, the ingestion of milk seems to stimulate cross sucking and weaning leads to a significant decrease in cross sucking frequency. This could partly be explained by the fact that milk itself stimulates the motivation to sucking and if no natural or artificial teat is available the calf directs this motivation towards each other or objects in its surroundings. Another explanation for this abnormal behaviour is that the positive feedback the calf gets by sucking at another calf makes the calf continue with this behaviour for some time.

It has been found that a high amount of milk per meal reduces the frequency of cross sucking (Lidfors and Jung, 2001; Passillé and Rushen, 1994). If bucket feeding is used a lower frequency of cross sucking occur when the bucket is equipped with a rubber teat. If the calves are allowed to suck the rubber teat for a period of time after the milk meal has been ingested (non-nutritive sucking) the occurrence of cross sucking can be further reduced. Since a dummy teat (i.e. a rubber teat that is placed in the calf's environment but isn't connected to the milk supply) is less attractive than a teat with the taste of milk, it is of great importance that the calf is allowed to perform this non-nutritive behaviour on the teat bucket or the automatic milk feeder. This to ensure that the calf get the opportunity to express its motivation for sucking and thereby reduce the risk of cross sucking.

If a gradual weaning is used, calves have been found to consume more concentrate than the calves on unchanged milk allowance (Nielsen *et al*., 2008). Thus the calves that were gradually weaned had a higher energy intake 7 days after weaning compared to calves that were abruptly weaned. This indicates that a gradual weaning initiates increased concentrate consumption and thereby eases the transition from a milk-based diet to solid food. It has also been suggested that a

gradual weaning over a 2-week period may have an effect on the occurrence of cross sucking. Gradual weaning resulted in a lower frequency of cross sucking after weaning compared to calves that were abruptly weaned. This may indicate that the gradually weaned calves have a lower risk to develop inter-sucking later in life (also called milk-stealing cows). A high milk allowance has a positive effect on the calves' use of an automatic milk feeder in that sense that the number of unrewarded visits is less compared to a low milk allowance. Therefore the time each calf spends in the automatic milk feeder is less when they are given a high milk allowance.

Cross sucking can be reduced to a great extent if the calves are restrained just after milk feeding for about 10-30 minutes (Bøe and Havrevoll, 1993). However, this method of solving a cross sucking problem doesn't take away the motivation for the behaviour, it just diminish the expressions. Another way of reducing the incidence of cross sucking is to provide fresh concentrate to the calves. Bøe and Havrevoll (1993) showed that the calves´ sucking motivation will to a large extent be satisfied if teat buckets is used and if the calves get the opportunity to perform non-nutritive sucking after the milk ration has been. Consequently teat bucket feeding in combination with the opportunity to perform non-nutritive sucking will reduce the risk of cross-sucking. However if computer controlled milk feeding is used the calves get the opportunity to more frequent meals during the whole day compared to bucket feeding where twice a day feeding often is applied. Bøe and Havrevoll (1993) also concluded that even though the milk ration was quickly ingested the calves often stayed in the computer controlled milk feeder for a while and performed non-nutritive sucking behaviour. The calves visited the milk feeder many times during the day and most often the visits were unrewarded. This illustrates that the motivation for sucking is very high and even though many visits to the feeder didn't result in a milk meal the calves did it just to perform a sucking behaviour. In this study the incidence of cross sucking was low both in the groups that were fed with a computer controlled milk feeder and the calves that were fed in teat buckets. This illustrates that regardless to the feeding system used; cross sucking can to a large extent be minimized if the calves get the opportunity to perform a non-nutritive sucking behaviour.

2.3 Common diseases among calves

The greater part of all calf diseases occur at a very early age in calves (Svensson *et al*., 2003). Sufficient supply with colostrum directly after birth is one of the most important factors when diminishing disease frequency among calves. The herdsman plays an important role in the work of minimizing disease outbreaks (Webster, 1984). The herdsman must be alert and have a very good overview over all the calves every day if he wants to detect an ill calf at an early state. There are many signs that can be useful when you are looking for sick calves. First of all a healthy calf is alert and has bright eyes and shiny coat. The calf's ears are pointed up and it shows interest of what happens in its surroundings. A sick calf on the other hand, shows little interest of other calves or the herdsman and would probably lie down or stand alone while the other calves are standing in groups.

Indifferently of what disease is being addressed there are certain steps the herdsman always needs to fulfil in order to achieve successful disease management at the farm (Apley, 2006). These steps are:

- Isolation of the sick individual.
- Identification of the pathogenic microbes involved in the specific disease.
- Developing a plan which describes exactly how animals are selected for treatment.
- This plan should also include thoroughly described treatment plans (Dose, route, duration, frequency, injection site, volume per site and slaughter withdrawal)
- Establishment of a definition for success or failure for the first treatment. This is very important in order to know if or when a second treatment of the specific disease should be initiated.
- If the first treatment was a failure, a description of a second and possibly a third treatment plan must be conducted.

If these steps are followed it makes it easier to evaluate the disease outbreaks and this will hopefully contribute to a better disease management (Apley, 2006).

2.3.1 Diarrhoea

Diarrhoea that occurs before weaning can be defined and classified in different ways (Kertz and Chester-Jones, 2003, Larson *et al*., 1977). If a definition of the diarrhoea in different stages is done it makes it easier to compare and evaluate diarrhoea outbreaks on farm level as well as in larger contexts. The scale of different diarrhoea stages that is most often used is: 1 (normal), 2 (soft), 3 (runny) and 4 (watery). For more detailed description of classification of diarrhoea, see Larson *et al*., 1977. Svensson *et al*. (2003) showed that the single most common disease in a calf's first week of age is diarrhoea. The risk of diarrhoea slowly reduces with every week as the calf gets older. There are many different organisms that can cause diarrhoea in calves. The most common organisms are *Escherichia coli* (E. coli), *Salmonella* sp, Rotavirus, Corona virus and *Cryptosporidium* (Roy, 1990).

E. coli, salmonella and clostridia infections cause problems for calves in a very early age, often within the first three days of life (Blowey, 2005). Rotavirus, corona virus and cryptosporidium on the other hand, become an important risk at somewhat later age of the calf. Calves that have a lowered immune response and get affected by corona virus or rotavirus will obtain sloughed epithelial cells on the tips of the villi which will contribute to a reduced ability to absorb fluid from the intestine. The reduced absorbing capability leads to a more fluid faeces and will also result in dehydration of the individual. The lowered capability to absorb fluid in the intestine as a consequence of a diarrhoea infection will also affect the ability for the calf to digest milk. This fact is specially pronounced in diarrhoea caused by rotavirus. The faeces from rotavirus diarrhoea are voluminous and pale in colour which indicates that it is containing undigested milk.

The calf can receive a diarrhoea infection either from the dam or from their environment (Blowey, 2005). The risk that the calves get their initial infection from their surrounding environment is increased when hygiene is poor. The infection risk can be minimized with proper cleaning routines and the use of an all-in-all-out system (Engelbrecht Pedersen *et al*., 2008). It is also of great importance to ensure that the calf receive colostrum directly after birth.

Cryptosporidia is a protozoan parasite and can be transmitted from the dam to the calf or from the calf's environment to the calf (Blowey, 2005). This parasite can cause excessive damage, mucous faeces and rather intense abdominal pain. Because of this it is every now and then confused with coccidiosis.

Calves that are suffering of diarrhoea quickly become dehydrated and fluid therapy with an electrolyte solution is therefore most often necessary (Garthwaites *et al*., 1994; Svensson *et al*., 2003). It was earlier thought that milk feeding during the fluid therapy had a negative effect on the treatment of the diarrhoea. The milk itself was thought to worsen the diarrhoea by providing substrate to the intestinal flora and thus a withdrawal of milk for two days was often recommended. This is no longer believed to be the case and a milk withdrawal under the fluid therapy is nowadays not recommended. Therefore a preservation of the milk ration in combination with an electrolyte solution which correlates or is greater to the amount of fluid lost in faeces seems to be the best way of dealing with diarrhoea cases in calves.

2.3.2 Respiratory diseases

Respiratory diseases are a major problem in calf rearing and are often difficult to control (Andrews, 2000, Blowey, 2005). There are many pathogens that can cause these infections, for example: RSV (respiratory synicitial virus), IBR (infectious bovine rhinotracheitis), PI_3 (parainfluenza 3), BVD (bovine viral diarrhoea), mycoplasmas and bacterial infections such as Pasteurella and Haemophilia (Ames, 1997). The two last mentioned can be secondary to viral infections or can cause disease of its own.

Respiratory diseases are associated with a number of different symptoms (Roy, 1990). An infected calf often has a nasal discharge, which can be of various types. Sometimes it is watery and thin but other times it is purulent and thick. A dry cough is most often seen in an infected calf and this cough often continues even though the calf gets better and are most pronounced when the calf are exercising. A respiratory infection is often connected with a high body temperature but this symptom is not always seen in a chronic condition. Respiratory diseases are often followed by diarrhoea.

There are different environmental factors that can have an impact on the prevalence of respiratory diseases (Ames, 1997). One significant factor is ventilation. If the calf building is inadequately ventilated the air quality will be lowered and thereby have an obvious effect on the respiratory condition of the calves due to an increasing amount of pathogens in the air under such conditions. Humidity is also a limiting factor. If the calf stable has a high humidity the survival of pathogenic microbes increases. The optimum zone for limiting survival of bovine pathogens is thought to be 55% to 75% relative humidity. The ventilation in a calf building is therefore a crucial factor in the work of minimizing respiratory disease outbreaks. The ventilation should be directed so that the air flow moves from the young cattle to the older, less susceptible cattle. When doing this it will limit the pathogens from moving from older to young cattle. Overcrowding of the calf facilities will lead to an increased transmission of pathogens and this is particularly pronounced in stables where calves in different ages are mixed in the same group.

2.3.3 Other infectious diseases

Diarrhoea and respiratory diseases are the two most common diseases that occur in young calves (Svensson *et al*., 2003). There are however a number of different infections and diseases that can affect calves. A study done by Svensson *et al*. (2003) showed that incidences of other diseases than diarrhoea and respiratory diseases in calves were unusual. For example; 0.7 % of all the calves in the study developed cheek abscesses, 0.3 % was diagnosed with bloat and 0.7 % of the calves were affected by other non-infectious digestive disorders. Other medical conditions that were observed were malformations (1.1 %), traumatic injuries (0.6 %) and deficiency diseases (0.2 %).

2.3.4 How to prevent diseases among group held calves – the importance of colostrum

Sufficient and successful colostrum supply is the single most important factor which will determine the health status and survival chance of the calf (Godden, 2007). Calves that successfully receive adequate amounts of colostrum get improved pre-weaning health and survival, improved growth rate and feed efficiency, reduced age at onset of puberty, reduced age at first calving and improved first and second lactation.

There are a number of different factors that affect the calf's ability to accomplish a successful absorption of immunoglobulins (IgG) from the intestine into its circulation system (Godden, 2007). The quality of the colostrum is heavily determined by its content of IgG. Some features of the dam such as breed, age of the dam and season can have an impact on the amount of IgG the colostrum contains and cannot be affected by the herdsman. There is however a number of things that the herdsman has control over which affects the IgG level in the colostrum. Such factors are dry period nutrition, vaccination of the dam and the length of the dry period. The concentration of IgG in the colostrum is the highest directly after calving and therefore it is of great importance to control that the calf sucks the dam immediately after birth. If the calf is not willing to suck the dam the herdsman must milk the dam and provide the calf with colostrum as quickly as possible. As mentioned in the text above there are many things that can affect the quality of the colostrum. The quality and quantity of the colostrum the calf ingest will have a direct effect on its future health status (Davis and Drackley, 1998). Consequently, it is of great importance to know of what quality the colostrum that is provided to the calf has. An easy and inexpensive way of determine this is to use a Colostrometer. The size of the colostrum ration that the calf needs to ingest depends on its IgG concentration. When the absorption of IgG is considered to be successful the calf should have a plasma or serum IgG concentration of approximately 15 mg/ml. To accomplish this roughly 100 g of IgG must be supplied to the calf as soon as possible after birth. Since the concentration of IgG in the colostrum can be affected by many factors it is strongly recommended to measure the IgG concentration with a Colostrometer in order to ensure that the calves receive adequate amounts of IgG.

The ability for a calf to ingest large molecules such as IgG or other proteins is only present for about 24-36 hours after birth (Davis and Drackley, 1998). Therefore it is of great importance that the calf is provided with colostrum as soon as possible after birth, otherwise the absorption of Ig will be less successful or even worse, not successful at all. The permeability of large molecules in the intestine gradually decreases after birth and the closure of the intestine are completed after 24-36 hours. During the few hours that the small intestine is permeable to large molecules it is rather unselective in regards to what kind molecules it can absorb. Consequently, the first 24 hours of a newborn calf's life is a very critical period.

2.4 The effect of group size on performance, mortality and health

2.4.1 The effect of group housing on social behaviour

The group size has a great impact on the behaviour of farm animals (Rodenburg and Koene, 2007). However, the most pronounced impact can be observed among individuals where the natural group size differs much from the group size that is used on farms. In cattle very large group sizes can be observed in wild cattle.

Almost 200 calves were included in a study where the effect of number of calves per feeder was investigated (Jensen, 2004). The calves were distributed in groups of 24 or 12 individuals. Within the group the calves were provided with a daily milk allowance in either 4 or 8 portions. In the groups with 24 individuals a significantly higher level of competition was observed compared to the competition level in the groups of 12 individuals. Thus, the duration of both rewarded and unrewarded visits in the automatic milk feeder were shorter in the groups with 24 individuals. The calves in the large groups stood and waited longer by the milk feeder compared to calves in the smaller groups and they were also often disturbed (displaced) when they had entered the feeder. Therefore the calves in large groups ingested their ration faster compared to individuals in the small groups and they also spent less time in the feeder. There was however no difference found in body weight gain between the different group sizes. The calves that were offered their ration of milk in 4 portions compared to 8 portions had a shorter duration of all visits to the milk feeder per day. Consequently, lowering the number of portions may reduce competition among calves due to lower occupancy of the milk feeder per calf.

Webster (1984) suggested that the number of calves per teat should not exceed 10 calves and it would be preferable if the number could be 4-6 calves per teat. This is due to that the competition level is increasing when the number of calves per teat exceeds 10 individuals.

The opportunity to interact with other calves is in many ways impaired if single pens or hutches are used. A study done by Jensen *et al*. (1997) shows that group rearing of calves makes it easier for them to develop a social behaviour. Viesser *et al*., (1994) concluded that group held calves showed less antagonistic behaviour towards other calves compared to calves that previously had been held in individual pens. When the calves were mixed at 14 weeks of age more antagonistic behaviour were seen among calves that had been kept in single pens compared to group housed calves. Jensen *et al*. (1997) confirmed the importance of social interactions between calves in different ages. If calves are kept in groups it makes it possible for them to develop social bonds between each other and perform play behaviour. The importance of play behaviour has been stated in many studies (Jensen *et al*., 1997, Babu *et al*., 2004).

Play is performed as a form of social contact, either in form of locomotion play or as social play, often in form of play fighting (Vitale *et al*., 1986). The locomotion play often involves a group of calves and is carried out without physical contact. The locomotion play involves jumping, kicking and running. Social play on the other hand involves physical contact between two or several calves in form of non-reproductive mounting, pushing and bunting of each other. Play fights is often initiated by approach and rotation of the head.

Play has been suggested to be an indicator of good welfare (Jensen *et al*. 1998). First of all, juveniles are highly motivated to play when there prior needs are met. Therefore, play can be considered to be a sign of good welfare because when an animal suffer from undernourishment, injury, illness or thermal stress their motivation to play is very limited. Secondly, the play in itself is reinforcing and may therefore indicate good welfare and positive feelings.

Space has a very big impact on the amount of play that the calves perform (Jensen *et al*. 1998). Calves that are held in individual pens cannot perform social play because of the very limited contact with other calves and the fact that their surrounding space is very restricted. Locomotion in form of kicking and jumping are seldom seen in single housed calves and running cannot be performed by obvious reasons. Calves that are kept in small group pens (where the space limit per calf is the same as in a single pen) play more compared to calves that are kept in single pens. However, calves in large group pens play even more than calves in small group pens. This implies that a spacious group pen promote play behaviour. As mentioned earlier, play behaviour can be an indicator of a higher level of animal welfare, therefore it could be suggested that a large group pen might contribute to a better welfare.

2.4.2 The effect of group housing on growth and performance

A study done by Jensen (2006) indicates that calves that are introduced to a group at the age of 6 days need more assistance to a computer-controlled milk feeder by a stockperson, in order to be able to ingest their portions of milk, than calves who are introduced to a group at day 14. The calves in this study of the Jersey breed were offered a milk allowance of 5.2 litre per day and the calves of heavier dairy breeds such as Holstein–Friesian and Danish Red were offered 6.4 litre per day. Even though the 6-day old calves were guided to the feeder it was found that these calves ingested less milk than calves that were introduced by the age of 14 days. The 6-day calves also spend less time in the automatic milk feeder after rewarded visits compared to calves introduced at day 14. The 6-day calves also had a lower frequency of unrewarded visits. The number of unrewarded visits can be connected with the milk allowance and are partly motivated by hunger. It can also be explained by the calves' inability to predict when milk is available. This study conclude that calves of the age of 6 days have less ability to compete in large groups in a system where computer controlled milk feeders are used compared to calves of the age of 14 days.

It has been found that calves kept in large (16 individuals) groups are in general more active than calves in smaller (4-6 individuals) groups (Færevik *et al*. 2007). Calves in larger groups are also less competitive around the feeding area, in other words the displacements from the feeding area are fewer than in the smaller groups. In this study a higher activity level could be observed in the larger groups. Færevik *et al*. (2007) indicates that the increased activity of the calves in large groups cannot be explained by more social interactions (i.e. social grooming, social play, mounting or displacements). Færevik *et al*. (2007) therefore suggests that the increased activity in larger groups could be explained by the fact that these calves are exposed to more social stimulation than calves in smaller groups and that they move around more to avoid social conflicts. In this study daily weight gain, social interactions such as social grooming and play behaviour were not affected by group size. However a higher activity level and fewer displacements from the feeding area were observed in the larger groups.

A study was conducted at 6 commercial Danish dairy herds (Engelbrecht Pedersen *et al*., 2008). Both stable (all – in all out systems) and dynamic calf groups were formed on each farm so that full comparability between different systems was created. In the stable group systems a group of six calves in the ages of 3-5 weeks were introduced to a clean empty pen. After six weeks all the calves left the group pen and it was cleaned and was left empty for 1 week before a new group of calves were introduced. In the dynamic group system new individuals were introduced to an already established group at a weekly basis. The calves were three weeks old when they were introduced in the dynamic group pen. This study showed that calves that are raised in stable groups had significantly higher daily weight gain compared to calves that are raised in dynamic groups. Since the feeding levels were the same in all groups the lower live weight gain in the dynamic group system cannot be explained by a lower feed intake in these groups. There must be another explanation for the depressed live weight gain in the dynamic groups and this could possible be either reduced health status, reduced feed conversion rate or other stress factors.

If fresh grass is offered to calves before weaning they will consume a substantial amount, especially if the calves are held in groups (Phillips, 2004). When forage is administrated to calves at an early age it will stimulate rumination and can also decrease behaviours that are considered to be problems, such as sucking and licking at object in the calf's environment and other calves (cross sucking). Forage can also have a positive impact on behaviours that are consider to be connected with a better welfare such as self grooming, tail swishing and self rubbing. Group held calves have been found to consume more forage than single held calves. Because of the reasons mentioned above it is of great importance to offer calves at early age palatable forage. By doing this it can promote growth, natural behaviour and encourage a normal development of the rumen.

The consumption of solid feed has seen to be significantly higher in group-housed calves than in single held calves (Babu *et al*. 2004). Also rumination has a higher frequency amongst group held calves than what is seen in single held ones. This implies that group activity and social contacts makes the calves more eager to try new things and that they learn from each other. The higher frequency of rumination among group held calves suggests that they have a more developed rumen activity.

In a study done by von Keyserlingk *et al*. (2004) it was investigated how the number of calves per teat affected the competition level among group held calves. This study showed that the competition level increases if the number of calves per teat is large. Consequently a less competitive (fewer calves per each teat) environment led to an increase in milk intake. A tendency for more frequent visits to an available teat were seen when the teat ratio were low. Consequently, when the number of calves per each teat is increased, the calves can experience a more competitive environment, reduced feeding time and a lower milk intake for group housed calves.

Calves in groups of 12-18 individuals had a reduced growth rate compared to calves that were held in groups of 6-9 individuals (Svensson and Liberg, 2006). The calves in large groups had approximately 40 g lower growth rate per day than calves in small groups. The calves in this study received a limited ration of whole milk or milk replacer and all the calves had free access to roughage and pelleted calf feed or rolled grain. Jensen *et al*. (1998) showed that the available area for calves has an effect on the level of locomotion and play they perform. A higher intensity of locomotion and play behaviour can have a negative effect on growth due to a slightly higher

energy requirement when more locomotion behaviour is performed. This could possibly to some extent explain the lower growth rate in larger groups. However, if the pen area does not increase in accordance with the group size this explanation cannot be accepted. It is important to remember that diseases reduce growth rate. An increase in diseases frequency has been observed in large groups and this could also be an explanation to the lower growth rate in larger groups (Svensson *et al*., 2003, Svensson and Liberg, 2006).

2.4.3 The effect of group housing on health and mortality

Svensson *et al*. (2003) reported a higher risk of respiratory diseases in group-housed calves with automatic milk feeders compared to single housed calves. Respiratory diseases are often caused by viral infections and spread via direct contact and aerosol. In large group pens a group can consist of calves from 1 week of age up to 3 months. This results in a very large age range, which can have a negative impact on the health situation in the group. Calves are very social with one another and have a natural willingness to lie close to each other and this of course increases the risk of infections to spread. The fact that all the calves in a group often utilizes the same teat on a automatic milk feeder is thought to have a little impact on disease spreading compared to direct contact between individuals.

The health status of more than 3000 calves in 122 herds in Sweden were observed and evaluated under the year of 1998 (Svensson *et al*., 2003). This evaluation showed that diarrhoea was the most common health disorder followed by respiratory diseases. Most of the diarrhoea outbreaks were mild (68%), however 23 % of the total number of diarrhoea cases was considered to be severe. The number of cases with severe diarrhoea in large group pens (6-30 individuals, computer controlled milk feeding) was significantly higher compared to the frequency of severe diarrhoea in single housed calves. However, there was a tendency for a higher number of severe diarrhoea cases in single housed calves compared to calves housed in small groups (6-8 individuals, manual milk feeding).

Svensson and Liberg (2006) concluded that an optimal group size for calves that are fed with an automatic milk feeder is less than 10 individuals. This conclusion was based on a number of things. Their study was conducted in Sweden from September 2002 to February 2004 in nine commercial farms. On each farm there were two group pens with automatic milk feeders. In one of the pens a group of 6-9 individuals were held and in the other pen a group of 12-18 individuals were held and there was no direct contact between the different groups. The study showed that there was an increased risk of respiratory diseases and increased respiratory sounds in the large groups (12-18 individuals). However, the study showed no differences in the risk of diarrhoea between large and small groups. An additional finding in this study was the fact that the age when the calves are placed in a group had an impact on their health. Today, most Swedish farmers move their calves to a group pen when they are around 4-7 days. However, Svensson and Liberg (2006) showed that it might be preferable to delay this with regard to improved calf health. Vitale *et al*. (1986) illustrated that calves under semi-natural conditions began to have social contact with the rest of the herd after 5 days postpartum. The level of social interaction increases with time and after about 2 weeks the calves has full social contact with other calves. This suggests that a calf at 2 weeks age is best prepared to move to a group pen. The optimal age of placing the calf in a group pen is a debated subject and this needs to be further investigated.

The frequency of diarrhoea and respiratory diseases were more than twice as high in dynamic groups compared to stable groups (all in – all out system) (Engelbrecht Pedersen *et al*., 2008). Signs of respiratory diseases such as nasal discharge and elevated and abnormal respiration were significantly more common in dynamic groups compared to stable groups, Table 4.

Table 4. Frequency (%) of calves affected with different disease indicators in stable or dynamic groups, mean prevalence and standard error *(modified from Engelbrecht Pedersen et al., 2008)*

Variable	Stable groups	Dynamic groups	P
Diarrhoea	18.4 (12.8-25.7)	46.2 (40.2-52.2)	< 0,001
Respiratory diseases	19.7 (14.5-26.0)	43.6 (37.2-50.3)	< 0,004
Nasal discharge	39.3 (30.8-48.4)	74.8 (68.8-78.2)	< 0,001
Elevated resp. rate	6.3 (3.2-11.8)	21.7 (16.0-28.6)	< 0,001
Abnormal resp. sounds	3.8 (1.5-9.1)	18.0 (13.0-24.2)	< 0,001
Stool contam. hair coat	16.5 (11.9-22.4)	44.4 (37.7-51.3)	< 0,001
Subnormal hair coat finish	11.9 (7.1-16.4)	29.8 (23.0-37.5)	< 0,001

The information presented in Table 4 indicates that a stable grouping system will have beneficial consequences such as higher live weight gain and lower disease frequency. However, the cleaning interval was slightly shorter in the stable groups compared to the dynamic groups. This might result in a higher level of pathogenic microbes in the dynamic groups which could contribute to the significantly higher disease frequency in these groups. Consequently, it is of great importance to have good cleaning routines and proper "empty-periods" in the group pens in order to keep the virulence level of pathogens low.

2.4.4. The effect of group housing on workload

The manufactures of computer controlled milk feeders' claims that this milk feeding system will reduce the work time spent on feeding the calves (DeLaval, 2009). They also underline that the work with the calves becomes less scheduled if a computer controlled milk feeding system is used compared to traditional bucket feeding. Kung et al. (1997) compared two management systems for calves in a study. 54 dairy calves were used and they were divided in two groups. One of the groups was raised in conventional single hutches where bucket feeding twice a day were used. The other group were housed in a group pen and were fed by a computer controlled milk feeder. The calves in this system had access to the milk feeder 24 h per day. All the calves in this study were given an equal milk ration and had free access to calf starter or grain.

The time spent on the calves in each group was recorded throughout the study and included feeding (preparation, feeding and cleaning) of milk replacer and calf starter, teaching calves to ingest milk, as well as teaching them to eat calf starter/grain. The time spent on cleaning and bedding the hutches and the group pen was also included in the study. Kung *et al*. (1997) concluded that the time spent on calves in hutches were approximately 10 minutes per day compared to less than 1 minute for calves in group housing systems with computer controlled milk feeding. Kung *et al*. (1997) however underline that it is of great importance to frequently observe the calves in a group housing system since this housing system do not allow the same individual supervision as in a single housing system. Thus at least part of the labour that is saved by using a group housing system with a computer controlled milk feeder should preferable be spent on supervision on the calves to achieve a successful calf rearing.

3. Study visits to the Netherlands, Norway and Latvia

The interview part in this thesis has been performed in order to get some practical impressions from three different markets. These markets were The Netherlands, Norway and Latvia and they were chosen to illustrate different conditions for calf rearing. Under the weeks 7-9 2009 seven different farms were visited in The Netherlands, Norway and Latvia. The farms were selected by the sales managers for DeLaval in each country and chosen in regard to geographic location. The presumption was that the farms must be located in reasonable distance so that car transportation from our accommodation would be possible.

The design of the interviews was based on the subjects that are discussed in the literature review in this paper. Two different sets of interview questions were created, one questionnaire for the farmers and one for the DeLaval sales managers in each country, see appendix 2 and 3. Both the farmers and the sales managers in each country were interviewed so that as many opinions as possible were collected.

A description of the two milk feeders that were used by visited farmers is presented in appendix 1. This description will hopefully give the reader more information about the milk feeders and thereby make the interview part easier to read.

3.1 Market descriptions

3.1.1 The Netherlands

The Netherlands produced 10 800 000 tons of milk under the year of 2007 and the number of dairy cows in the country where under the same year 1368 000 heads (DeLaval, 2008). The characteristics of the dairy production in the Netherlands are that the dairy farms are located very close to each other. The most common milking system in this country is parlour milking. The farm structure is characterised by medium large herd, in other words herds with 70-149 milking cows is quite common and approximately 10 % of all the cows in the Netherlands lives in farms were the herd size is 105-499 cows (figure 4).

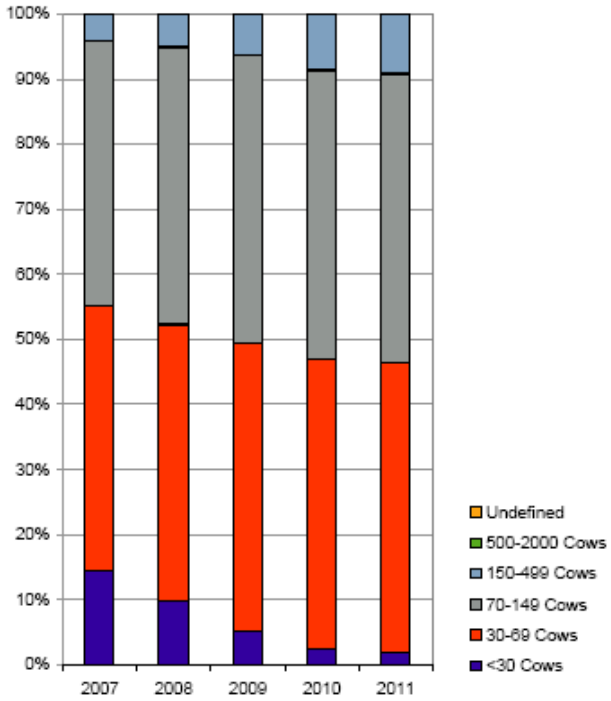

Figure 4. The distribution of cows in different herd sizes in The Netherlands (DeLaval, 2008).

3.1.2 Norway

The dairy farms in Norway is in general small, an average herd size of fewer than 30 milking cow is the most dominating farm structure (figure 5) (DeLaval, 2008). The most common milking system used in Norway is pipeline milking. The number of dairy cows were under the year of 2007 just about 259 000 heads and under the same year around 1 520 000 tons of milk were produced.

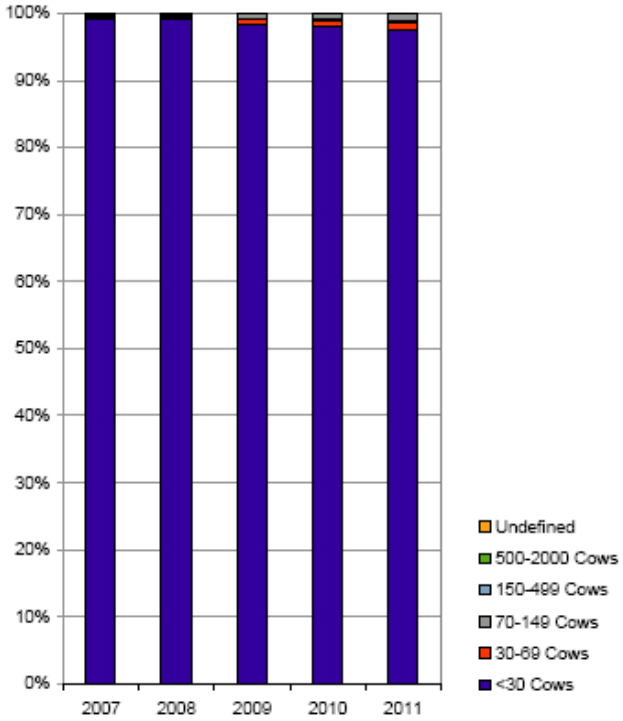

Figure 5. The distribution of cows in different herd sizes in Norway (DeLaval, 2008).

3.1.3 Latvia

The total milk production in Latvia was 846 000 tons in 2007 (DeLaval, 2008). This milk is produced by just about 180 000 dairy cows. Latvia is a country of diversity concerning the dairy farm structure. The dominating farm structure in Latvia is farms with fewer than 30 cows (figure 6). There is however a large number of farms with considerably larger herd size. Fore instance, there is over 400 farms with a herd size of 70-149 cows, 80 farms with a herd size of 150-499 cows and about 25 farms with a herd size of 500-2000 cows. Worth mentioning is that neither Norway nor The Netherlands has any farm that have a herd size that exceeds 500 cows.

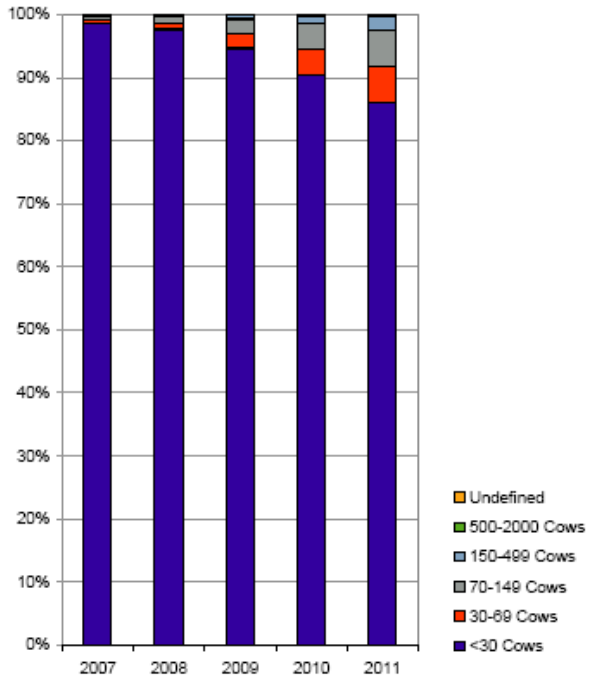

Figure 6. The distribution of cows in different herd sizes in Latvia (DeLaval, 2008).

3.2 Farm visits

3.2.1 The Netherlands

The Netherlands were visited during February the 9th-11th. Three different farmers were visited and interviewed during the stay. A private dealer who sells DeLaval products was also interviewed at his office in Leeuwarden on the 10th of February. The three visited farms were located in the northern parts of the Netherlands, rather close to the town Leeuwarden. Andre De Leeuw who was the sales manager of calf feeders in the Netherlands guided us throughout the journey to the different farmers. Andre was also interviewed.

The mechanization level in the dairy farming was steadily growing in the Netherlands (De Leeuw, 2009). The most common farm structure in the Netherlands was a family farm with roughly 80 dairy cows (Andre De Leeuw, 2009). When the mechanization and automatization level on the farm increases, the dairy cow number also increases, for example if a VMS was installed. A higher degree of automatization often means that an automatic milk feeder was installed; around 10-15 % of all the farmers in the Netherlands had an automatic milk feeder. The biggest advantages with installing a milk feeder were, according to Andre, that the workload was lowered, that the milk supply got a more even quality and that the milk rations were distributed during the whole day. He recommended the calves to be about 7-10 days when they were introduced to a group depending on the group size. The optimal group size was around 10 individuals. The average mortality in the Netherlands among calves under the milk feeding period was approximately 7-8 %.

Andre felt that the supply of colostrum was not satisfying on most farms. The farmers were well aware of the fact that the colostrum should be supplied as quickly as possible after birth but the

amount given was most often not enough (often just about 1 litre). Not many of the Dutch farmers used a Colostrometer to measure the quality of the colostrum. Andre's experience was that the treatment of sick calves was not working in a satisfying way on most farms. Sick calves were seldom isolated from the group; instead they were treated with for example antibiotics while they were staying in the group. The farmers that installed a milk feeder were most often very satisfied with the investment. The price for a milk feeder in the Netherlands was approximately 6-7000 euro and the most common models that were used were CF200+ and CF500.

Farm 1

The first farm that was visited had 170 dairy cows. Approximately 70 (heifer) calves was fed in the calf feeder each year and the peak number of calves fed by the milk feeder simultaneously was about 22-24 calves. The dairy cows calved the whole year around. After a calf was born, 4 litres of colostrum was supplied to the calves within 1-2 hours. If the calf was born in the night the colostrum was distributed as quickly as possible the next morning. The farmer used forced feeding to distribute the colostrum to the calf.

The milk feeder (CF200+) was installed in the year of 2004 and served two teats in two different pens. The calves were fed only with milk replacer and the daily ration was 6 kg (in total the calves received 28 kg of milk replacer powder in 60 days). The concentration of the milk replacer was about 83 grams of milk powder per kg. The milk feeder was cleaned once a week but the milk powder sensor that determines the powder amount in each ration had to be cleaned daily in order to work correctly. The teats were never cleaned but was replaced around every forth week.

The calves were moved to a single pen directly after birth. They were then kept there for 10 days and fed with whole milk mainly from antibiotic treated cows. The bull calves were kept in single pens for about 2-3 weeks and thereafter sold. When the heifer calves were moved to the group pen the farmer seldom experienced any kind of problems and he thought that the calves easily learned how to use the milk feeder. Concentrate and chopped maize ensilage was supplied to the calves as a mix in a tray. The farmer accommodated up to 17 individuals in the same group under peak circumstances. But the optimal group size according to this farmer was 12 individuals. The age range in the same group could be up to 2 months on this specific farm, but the optimal age range was pursuant to the farmer a maximum of 4 weeks.

The group pens were located in an uninsulated stable next to the cow stable. The group pens were provided with deep straw bedding. The bedding in the front part of the pen (where the calf feeder was located) was changed every fifth week and the bedding in the rear part of the pen was changed twice per year. Every third day the farmer provided the pen with new straw. If the farmer had the opportunity to change something of the interior design of the pen he would make the pen a little bit shorter and instead do it wider. The main health disorders on this particular farm were diarrhoea and respiratory diseases. This year and the year before all the calves were treated with a single dose of antibiotics a few weeks after birth as a preventative action against lung problems. The cases of diarrhoea most often occurred within the first 2 week after the calf was born. Electrolyte treatment was used as a first alternative and if this has no effect antibiotics was used. When the electrolyte treatment was initiated the milk was withdrawn for 1 day. The electrolyte solution was given in the amount of 2 litres twice a day. The average mortality among the calves was about 4%. This number was however much higher this year since 15 calves had to be slaughtered in January 2009 because they were carriers of BVD (Bovine virus diarrhoea). As

an attempt to eliminate BVD on the farm, now all calves were vaccinated and a blood sample was taken when the calves were 6 weeks to determine if they were BVD-carriers.

When a sick calf was detected, it was not removed from the group pen. The farmer argued that the calves recovered better if they were not removed from their group. Before the installation of the milk feeder smaller groups of calves were held (4 calves per group) and they were fed with milk in a tray twice a day. The labour time had been greatly reduced after the milk feeder was installed since now the farmer worked with the calves for about 30 minutes compared to 1-1.5 hour before the installation of the milk feeder. The main reason for the farmer to install the milk feeder was to reduce the labour time for the calves. He experienced that he had saved time and that this time could be put on other things. He also thought that he more easily could supervise how much milk the calves actually drank per day compared to before.

Farm 2

The second farm that was visited in the Netherlands had about 200 dairy cows and fed approximately 80 calves (peek of calves was 35 individuals) in the milk feeder per year. The milk feeder, a CF 200+, was installed in 2002. The cows mainly calved in the fall from August to January. The calves were supplied with 2 kg of colostrum 3 times per day for 2 days. The first colostrum ration was given within 1 hour after birth. If the calf was born during the night forced feeding of the first colostrum ration was applied. A colostrometer was used to determine the quality of the colostrum. The calves were fed with 6 kg milk replacer per day. The concentration of the milk replacer was approximately 135 g powder / kg. The milk feeder was cleaned once a week with detergent. The teat was never cleaned and was replaced when it was broken, which was about every forth week.

The calves were placed in a single pen directly after birth and kept there for about 14 days. The calves in single pens were given milk replacer which was prepared by hand and administrated in buckets without teats. After 14 days in the single pens the calves were moved to a group pen. A maximum of 10 individuals were held in an introduction group. After 2 weeks in this group the calves were moved into a larger group pen in which the farmer kept up to 25 calves. The group pens had deep straw bedding and a scraped manure alley closest to the feeding table. The straw bedding was changed twice a year and the manure alley was scraped every day. The calves were given hay in a rade and concentrate was provided in both a concentrate feeder and ad libitum in cribs. The reason why the farmer supplied the calves with concentrate in both a concentrate feeder and ad libitum was unknown. The calves were weaned when they were 61 days and this is done gradually. The farmer thought that an optimal group size was around 25 individuals. The age range in the large group was between 3.5-4 month. Consequently the calves often stayed in the group even after weaning. When they were moved from the group pen depended on the crowding level of the young stock. The farmer didn't experience any problems with having calves in different ages in the same group but argued that the calves learned from each other for example to eat forage.

About 20 % of the calves got diarrhoea and most of the diarrhoea cases occurred during the first 2 weeks after birth. A calf with diarrhoea was treated with electrolytes and the milk was withdrawn for 3 days. The mortality before weaning among the calves was 19% and the majority of all deaths occurred in the second week after birth. A sick calf was seldom isolated from the group. Only if the calf was very sick it was removed from the group and put in a single box.

The farmer spend about 30 minutes on the calves per day and this was a reduction by half compared to how much time he spent on the calves before the installation of the milk feeder. The calves were previously kept in single pens. The main reason for installing a milk feeder was to save labour time. The farmer thought that the milk feeder had saved him time and that he had more time left for other farm duties now. He also thought that this feeding system was easy to use and that it gave him more flexibility and provided the calves with milk rations of a higher quality than before. With quality he meant that the milk rations were now more even in powder concentration, that the milk rations could be provided during the whole day and that temperature was more even than before when the rations were mixed by hand.

Farm 3

The last farm that was visited in the Netherlands had 60 dairy cows and reared approximately 30 calves in the milk feeder yearly. The milk feeder (CF 500) was installed in January of 2009. 1.5 litres of colostrum was supplied to the calves 3 times per day for 2-3 days after birth. The first ration of colostrum was given within 1-2 hours after birth.

Directly after birth the calves were placed in single pens and kept there for about 3-4 days. After that they were moved to a small group pen (introduction group) and stayed there for 14 days. Thereafter they were moved to a larger group pen. The farmer only uses milk replacer in the milk feeder and the calves receive 4-6 kg per day. The concentration of the milk replacer was 125 g powder/kg. The milk feeder was cleaned twice per day but the teats were never cleaned. Since the milk feeder was installed as late as in January of 2009, the teat had not yet been replaced.

The calves were weaned gradually after 70 days. The calves had access to hay on a feeding table and concentrate was fed in a crib. The group size was for the moment 10 individuals and the farmer had not yet an idea of an optimal group size since he had not been using the milk feeder for a long period. The age range in the large group pen was about 2.5 month. The pen had a straw bedding which was replaced every month.

The most pronounced health issue on the farm was diarrhoea and about 30 % of all the calves were treated with antibiotics for this every year. When a calf with diarrhoea was detected the milk was withdrawn for 3 days and the calf was given electrolyte solution for the same period. If the diarrhoea was mild, electrolytes sometimes were added to the milk instead of giving it as a separate solution. The mortality of the calves was around 10 %. When a sick calf was detected in the group pen it was placed in a single box and treated separately.

The farmer spent approximately 30 minutes on the calves every day. This was much less than before the milk feeder was installed. Before the milk feeder was installed calf hutches were used and the milk was provided in buckets by hand. The farmer had not been using the milk feeder for a long time but despite this still experienced that this feeding system was easy to use, that it saved time and he hoped that it would lower the incidence of diarrhoea among the calves. He also thought that it was positive that the milk rations were distributed throughout the whole day. The most important things concerning calf management was according to the farmer healthy calves and optimal growth.

3.2.2 Norway

Norway was visited the 16th to the 17th of February. The sales manager for DeLaval calf feeders in Norway, Kristian Hauge were interviewed on the 16th of February and on the 17th a dealer who sells DeLaval products in Felleskøpet were visited.

In Norway there was a maximum quota of milk that a dairy farm was allowed to produce (Kristian Hauge, 2009). This quota was around 370 ton per farm. The number of cows per farm was therefore limited. The average number of cows per farm was around 19 individuals and about 70 % of all dairy farms had tied up cows. If a dairy farm in Norway invested in a new milking system it was most often a VMS system. According to Kristian most Norwegian farmers had a good knowledge concerning calf management. Many farmers were however quite sceptical towards automatic milk feeders. They thought that the milk feeder and group housing resulted in a higher disease frequency and that the portions of milk were too small. However, nowadays the portion size is easy to adjust in the milk feeder software program (Hauge, 2009).

The major reason for Norwegian farmers to invest in a milk feeder was to get rid of the time consuming labour that bucket feeding involved. After they had installed a milk feeder a majority of the farmers experienced that they had more control over the calves' milk consumption. The CF150 was the most common milk feeder in Norway. Kristian recommended his customers to clean the milk feeder every day. He also recommended that the calves should be about 2 weeks old before they were introduced into a group and that the optimal group size was around 10-12 individuals. Most farmers in Norway didn't use a Colostrometer to measure the quality of the colostrum. The main advantages with a milk feeder was according to Kristian that the farmer got a good control over the milk amount that each calf ingest and that the quality of each meal was more even compared to manual feeding. The fact that calves could be gradually weaned off was also a great benefit. The disadvantage was however that the spreading of diseases increased when calves were kept in groups and therefore it was of great importance that the cleaning of the milk feeder and the group pen was done in a satisfying way.

Farm 1

The first farm that was visited was situated north of Oslo in the southern part of Norway. When the farm was visited it had 27 dairy cows but was planning to increase this number up to 60 individuals. The cows calved the whole year around but mainly from August to September. The farmer fed about 32-34 calves in the milk feeder per year. The peak number of calves was around 16 individuals. Colostrum was fed to the calves within 4 hours after birth, 2 litres 3 times per day. The farm had one milk feeder (CF150). The farmer fed the calves with both whole milk and milk replacer depending on the access of whole milk. The whole milk was treated with formic acid in order to preserve it by lowering the pH level. The calves were fed 4.8-7.2 litres of milk per day which was distributed in a maximum of 4 portions. The milk feeder, the teat and the whole milk container were cleaned at least once a week. The teat was changed every month.

After birth the calves were directly placed in a single pen. They stayed in this pen for about a week and were fed with whole milk in teat bottles. After a week the calves were moved to the group pen. In the group pen they had free access of hay and concentrate was supplied in a concentrate feeder. The farmer didn't think that the calves had any problems to learn how to use the milk feeder. The calves were weaned gradually after 8-10 weeks. The time for weaning depended on their intake of concentrate. When the daily intake was 1 kg concentrate the weaning

was initiated. The calves were about 3 month when they were moved from the group pen, sometimes even older. The group size was around 8-12 individuals and the farmer thought that the number of calves in one group should not exceed 12 individuals. The age range in the group pen was 2.5-3 month. The farmer thought that when the age range was large the competition level among the calves increases and small calves can then easily be displaced from the milk feeder by older calves.

The group pen had two lying areas in each end of the pen, which was provided with saw dust. In the middle of the pen it was a concrete floor which was scraped daily. The lying areas were provided with new saw dust twice a day. If the farmer had the opportunity to change something of the design of the pen he would make a slatted floor where the milk feeder is placed. The incidence of diseases among the calves was low; the farmer only treated about 2 calves per year with electrolytes for diarrhoea. When a calf with diarrhoea was detected, the farmer withdraw the milk for a day and then gradually increased the amount of milk for 3 days until the former daily ration was reached. If this had no effect on the diarrhoea, electrolyte solution was provided to the calf and the calf was placed in a single pen. Only one calf had been treated with antibiotics last year and this was against a respiratory disease. The mortality among the calves were very low, only two calves had died since the milk feeder was installed in the year of 2005.

The farmer spend about 15-20 minutes per day on the calves and this was a reduction compared to before when the calves were held in single pens and were fed in buckets. The labour time for the calves had been reduced with about 1/3 since the installation of the calf feeder. The farmer installed a milk feeder because he had too small single pens which became banned and he was therefore forced to change his calf housing. The farmer was very pleased with the milk feeder and thought that he had done a good investment for both himself and for the calves. However, the farmer would like to install a back gate on the milk feeder which would make the calves stay in the milk feeder and wait for the milk ration to be distributed. The farmer argued that sometimes the calves didn't have the patience to wait for the milk ration and that they then backed out of the feeder before it had been distributed. A back gate would probably prohibit this phenomenon.

Farm 2

The second farm that was visited in Norway was situated in the southern part of Norway near Oslo and had 30 dairy cows. However, the farmer planned to increase the dairy cow number to 40 individuals. The farm had a milk feeder, a CF150, which was installed in 2002. The farmer fed about 40 calves per year in the milk feeder. The peak number of calves on the farm was 13 calves. The dairy cows calved the whole year around. When a calf was born colostrum was supplied in a teat bottle, 1.5-2 litre was given 4 times a day for about 2-3 days. The farmer used both whole milk and milk replacer in the milk feeder. The whole milk was acidified with formic acid. The calves were fed with 5 litres per day which was divided in rations of ½-2 litres. The milk feeder was cleaned twice a week and the teat was cleaned daily. The teat was replaced for a new one every 1-2 month.

The farmer had not experienced any type of problems with the milk feeder since the installation in 2002. The calves stayed with the dam for about one day after birth and then they were moved into a single pen in which they stayed for about 5-7 days. Hereafter they were moved into a group pen. The farmer didn't think it was hard to get the calves to understand how to use the milk feeder. However, he experienced that it took more time for the bull calves to learn compared to

the heifer calves. The calves were weaned gradually. When they were consuming ¾ kg of concentrate the weaning was initiated automatically. The concentrate was provided in a concentrate feeder. The weaning most often took place when the calves were around 2 month. The calves had access to silage in the group pen. After weaning the calves were moved directly from the group pen and therefore the age range in the group was about 2 month. The farmer had a maximum of 13-14 calves in one group and thought that the optimal group size was 11-12 individuals. If the age range was big and if the number of calves was more than 11-12 calves the young calves easily got displaced from the milk feeder by older calves.

The group pen had a lying area with a rubber mat which was scraped and provided with saw dust on a daily basis. The rest of the group pen had slatted floor. The farmer had problems with coccidiosis in some calves and affected calves got bloody diarrhoea. This problem aroused when the number of calves in the group pen was large. The number of calves which were treated with antibiotics per year was about 5%. When a calf got diarrhoea it was treated with electrolytes and the milk ration wasn't withdrawn. When a calf got sick in the group pen it was placed in a single pen. The farm hasn't lost any calves since the milk feeder was installed in 2002 so the average mortality among the calves is 0%. The farmer didn't thought that cross sucking was a big problem among the calves but he experienced a connection between large groups and an increased frequency of cross sucking.

The farmer spent about ½ hour on the calves per day. This was a reduction of labour time compared to before when the calves were housed in single pens and fed with milk in buckets without teats. It was hard to say how big the reduction of labour time was but the farmer concluded that he spent much more time on cleaning pens before compared to today. The farmer also thought that the time saved by the milk feeder should be spent on supervision of the calves. This resulted in, according to the farmer, more calm and affectionate animals which would pay off in the future when they become dairy cows. The farmer invested in a milk feeder because he wanted to get rid of all the hard work that bucket feeding results in. He felt that the milk feeder was easy to use and that the milk rations was more even in quality than before.

3.2.3 Latvia

Latvia was visited during the 23rd-25th of February. In Latvia the sales manager of DeLaval calf feeders, Daiga Bisniece was interviewed. There were about 172000 dairy cows in total in Latvia (Bisniece, 2009). The average dairy cow number per farm was about 3 individuals. For a couple of years many dairy farmers had been investing in new technique. However, the last year was a bad year for Latvian dairy farmers, consequently all the investing had stopped. The average farm in Latvia was a small family farm without employees. There were approximately 30 DeLaval milk feeders in the whole country, about 15 of the model CF150 and 15 of the models CF200 and CF500.

According to Daiga the knowledge concerning calf management in average was rather low. Farming had not been considered to be a job of high status, only those who couldn't get jobs elsewhere ended up farming. This had over the years been changing and nowadays more people choose to work with farming instead of other jobs but still the knowledge level was rather low. The average milk yield per cow was approximately 6500 kg ECM, which was rather low, compared to for example Sweden. The main advantages of a milk feeder was, according to Daiga, that group housing was less space demanding than single housing and that the calves got

access more to space. Another advantage with a milk feeder was that the calves get milk more often compared to bucket feeding which was most often administered twice a day. A milk feeder was also connected with some drawbacks. These were for example that the farmer got less individual overview of the calves in a group housing system compared to a single housing system. A milk feeder also increased the spreading of diseases. Daiga therefore emphasized the importance of a good hygiene of both the milk feeder it self but also in the group pen. There should for example be adequate amount of bedding material in the group pen and the pen should be properly cleaned at a regularly basis. She recommended her customers to clean the milk feeder each day.

Daiga didn't feel that it was some particular problem that arises after a milk feeder had been installed but some farmers didn't mix the milk replacer in warm water and this resulted in that the calves got diarrhoea. The milk replacer had to be mixed in warm water otherwise the powder and the water would not mix properly. Daiga recommend the calves to be about 7-10 days before they are introduced into a group. The most common practice on the farms was that the calves stay in a single pen for the period when the dam's milk can not be sold to the dairy plant. The optimal group size for small calves was around 12 individuals and for older ones around 25 individuals (Bisniece, 2009). This was however much depending on the farmer and the presumptions on the farm. A Colostrometer was usually not used on the dairy farms in Latvia. The awareness of the importance of colostrum was steadily increasing in the country but still many farmers know too little about colostrum management. The disease control on farms in average was not well known but Daiga thought that bigger farms had more frequently visits of a veterinarian and might therefore had better disease control. Cross sucking was a problem among group held calves in Latvia.

Two sales persons were asked for their best sale argument for the milk feeder. They said that the fact that the farmer got more control over the quality of the milk that the calves are ingesting and that he knew when and how much the calves were eating was a great advantage. They also thought that a milk feeder excludes the human factor so the milk rations got more even in quality and that they were distributed irrespective of the person who was working in the stable. The last thing that they highlighted was that with a milk feeder the farmer didn't have to do all the heavy labour with milk buckets etc.

Farm 1

The first farm that was visited in Latvia had 56 dairy cows. The cows calved the whole year around. The farm had a CF150 milk feeder that was situated outside the barn. The milk feeder was installed in 2006 and was previously used when the farmer bought it. Because the milk feeder was situated outside it could only be used under the warmer period of the year - spring to early fall. During this period the calves were kept outside. The milk feeder was placed under a roof. During the winter period all the calves were kept inside the cow barn in single pens. The calves were given colostrum as soon as possible after birth. The colostrum was distributed in buckets without teats 3-4 times per day for 3 days. The bull calves were sold when they were 2-4 weeks.

Irrespective of feeding system the calves were given both whole milk and milk replacer. The calves were given at least 8-10 litres of whole milk or milk replacer per day, sometimes even larger amounts of milk were distributed, depending on the calf's size. During the winter time

when the calves were kept inside they were receiving milk twice a day. When the milk feeder wasn't used the calves were fed in buckets without teats. During the time when the milk feeder was in use it was cleaned every day with the same detergent that was used for the milk pipelines. After birth the calves were directly placed in a single pen and kept there until they were 2 weeks. Then they were moved outside to the milk feeder if this was in use, otherwise they would stay in the single pens until they were weaned. The farmer didn't think that it was hard to learn the calves how to use the milk feeder. Most often it was enough to show the calves how to use it two times and then they understood the concept.

The calves were weaned gradually when they were about 3 months or sometimes even older. When the farmer used the milk feeder the calves were weaned when they were consuming about 1 kg of concentrate feed. All the calves had access to hay and concentrate in cribs and when the milk feeder was in use they received concentrate in an additional concentrate feeder next to the milk feeder. During the time the calves were kept in single pens they didn't have free access to water. Water was only offered twice a day. When they were kept outside and used the milk feeder they had free access to water in a tray. When calves were kept in groups the age range among them were about 1 month. The farmer thought that not more than 20 calves can be kept in the milk feeder at the same time. This was due to the fact that the milk feeder was placed outside the barn and the ground got to muddy if more calves than 20 individuals were kept there at the same time. The farmer had experienced that if you have calves in various ages in the milk feeder the older ones often displaced younger calves from the feeder. This problem was minimized if the age range among the calves was kept small.

Approximately 1 calf per year died. When a calf got diarrhoea the milk was not withdrawn and the calf was given electrolyte solution and a glucose injection. The veterinarian came once a year to the farm and the rest of the year the farmer herself treated sick animals. If a calf got ill when it was in the group it was placed in a single pen inside the barn. When the calves were outside and the milk feeder was in use the farmer spent about 1 hour on the calves per day. When they were inside and kept in single pens the farmer only spent about half this time on the calves. According to the farmer the increased labour time in the group system was due to the time that it took to clean the milk feeder. The farmer argued that the milk tank was very hard to clean and empty for one person and that it took a lot of time. The farmer had preferred if the milk mixer in the tank would have had a larger diameter in order to mix all the powder milk properly. The farmer was not satisfied how this worked today.

Farm 2

The second farm that was visited in Latvia had 100 dairy cows. The cows calved the whole year around. The farm reared about 50 (heifer) calves in the milk feeder per year. All the bull calves were sold at an early age and were never placed in the milk feeder group. The calves were supplied with colostrum as soon as possible after birth. The calves received the colostrum in buckets without teats for 3 to 7 days. The farm installed the milk feeder in 2005 and it was a CF150 with an additional concentrate feeder. The farmer used only milk replacer in the milk feeder. The calves were fed with approximately 6 litres of milk replacer per day. The milk feeder was cleaned every day. After birth the calves were directly placed in a single pen where they were fed from buckets without teats for about 1-2 weeks. They were then moved to the group pen and fed by the milk feeder. The group pen was situated in another barn so the calves were moved between different barns when they were placed in the group pen.

The farmer said that the calves easily learned how to use the milk feeder. It was often enough to show the calves a couple of times. The calves were weaned after 2-3 month, sometimes even later in age depending on the condition of the calf. All the calves were weaned abruptly. The farmer didn't thought this was a problem. The calves were often very confused and stressed directly after the milk had been withdrawn but settled down after a couple of days. All the calves were given hay. Concentrate was supplied in a concentrate feeder situated next to the milk feeder. The calves were moved from the group pen when they were 3-4 months. This resulted in a rather large age range in the group, approximately 3.5 months. The farmer had experienced that older calves often displaced younger individuals from both the milk feeder and the concentrate feeder when the age range among the calves was large. According to the farmer the optimal group size was about 10 individuals. When the number of calves was less the farmer didn't use the milk feeder, instead the calves were fed in buckets. The farmer argued that the time he spent on cleaning the milk feeder didn't pay off if the number of calves was less than 10 individuals.

The group pen was situated in an old tied up cow barn. In the middle of the group pen there was a feeding table were hay was fed. The calves were kept loose on both sides of the feeding table. They were kept on barren concrete floor without any straw or other comparable bedding material. This meant that the calves had no access to a dry and comfortable lying area. Consequently the calves in the group pen were rather wet and dirty. The farm had problems with diarrhoea and other infections diseases among the calves. When the calves got diarrhoea the milk ration was lowered. The calves were not given electrolytes of any kind, instead the farmer himself did a home made blend of various herbs, eggs etc. The mortality among the calves during the time they stayed in the milk feeder group was roughly 6-8 %. A calf was only taken out of the group when it was seriously ill.

The farmer spent about 3 hours on the calves per day and this had not changed after installation of the milk feeder. Before all the calves were held in single pens and were fed in buckets without teats. The farmer invested in a milk feeder because he wanted to reduce the labour time that he spent on the calves. However he felt that the milk feeder had not reduced the labour time as much as he had expected. The labour time was very much depending on how many calves that the milk feeder served. When the group size was large the milk feeder paid off in a labour time aspect. However, the farmer felt that the cleaning of the milk feeder was a very time consuming labour. The milk tank was heavy to handle when it was full of milk or water and many parts of the milk feeder was hard to reach when they should be cleaned. The farmer thought that the milk tank should be provided with a water tap in the bottom of the tank in order to facilitate the draining of cleaning water or milk.

3.3 Conclusions from the study visits

3.3.1 The Netherlands

- All the visited farms sold their bull calves early and they fed only the heifer calves in the milk feeder.
- 99% of all Dutch farmers used milk replacer in their DeLaval milk feeders.
- All the visited farmers did apply gradual weaning of the calves and this was based on the calf's age and not the intake of solid feed.
- The feeding plans for the calves in the milk feeder were most often done by the feed advisers from the milk replacer manufactures and not by the farmer himself.
- None of the visited farmer knew how much the calves grow per day or what they weighed when they were weaned off.
- All the visited farmers experienced a reduction of labour time after the installation of a milk feeder.

3.3.2 Norway

- The average farm in Norway was small (average dairy cow number is 19 individuals) and thereby the number of calves per farm was quite small.
- The majority of all Norwegian farmers with a DeLaval milk feeder had a CF150 with an additional concentrate feeder.
- All the visited farmers had a CF150 milk feeder with an additional concentrate feeder.
- All the visited farms applied gradual weaning which was initiated when the calves had reached a specific daily consumption of concentrate feed.
- All the farmers thought that the milk feeder had reduced the labour time that the farmer spent on the calves.

3.3.3 Latvia

- The average cow number per farm in Latvia was very low, only 3 cows per farm.
- The mechanization level in the country was in average low; there were only 30 DeLaval milk feeders in total in the country.
- The knowledge level about calf management was in average rather low.
- All the visited farmer had a CF150 milk feeder
- All the visited farmers experienced that the cleaning of the milk feeder was a very time consuming work. They also thought that it was a very heavy work that would usually require more than one person.
- The visited farmers would like to have a water tap in the bottom of the milk tank so that the drainage of water and milk could be done easier.
- The farmers did not experience that the milk feeder had reduced the labour time.

4. Discussion

The opportunity to perform a social behaviour is affected by many factors. The housing system in which calves are kept is one thing that affects the ability to perform different types of social behaviours. The traditional way of housing calves, in single pens or hutches prevents the calf's social behaviour in many ways. EU legislation establish that calves over 8 weeks of age must be held in groups and calves younger than 8 weeks should at least be allowed to have social contact (visual and head to head contact) with other calves (Council directive 97/2/EEC).

The design of the group pen in the farms that were visited varied a lot. All the Dutch farms had straw bedding for the calves which were in one of the farms combined with a manure alley closest to the feeding table. All the visited Norwegian farmers had saw dust as bedding material and thought this worked well. In Latvia one of the farms didn't use bedding material at all. Another kept their calves outside with no bedding material when the milk feeder was in use. Straw bedding is to prefer if the calves are kept in an uninsulated stable because of its isolating ability. If the building is isolated the choice of bedding material is less important. The most important thing is however that the group pen is kept clean and that bedding material is provided to the calves so that they have access to a dry and comfortable lying area.

Optimal group size with respect to:

Behavioural needs

Optimal group size with respect to behavioural needs of calves and risk for competition is something that has been discussed in many studies (Webster, 1984, Viesser *et al*., 1994, Jensen *et al*., 1997 etc.). Jensen (2004) showed that the competition level was significantly higher in a large group of 24 individuals compared to a smaller group with 12 individuals. The study also showed that the duration of rewarded and unrewarded visits in the milk feeder was shorter in the large groups. Displacements from the milk feeder were more frequent in the large groups compared to the smaller. The fact that a larger group results in a higher level of competition compared to a smaller group is something that the visited farmers also experienced. The majority of the farmers claimed that a large group results in more displacements from the milk feeder. They also saw a correlation between a large age range among the calves and more displacements of young individuals from the milk feeder. One farmer in the Netherlands did however argue that a large age range could even have a positive impact on the calves since he thought that the younger calves learned from the older ones to eat forage for example. Many of the interviewed farmers stated that the number of calves in a group had a great impact on the young calves' possibility to get access to the milk feeder or the concentrate feeder.

Cattle have a high developed social behaviour (Esteves *et al*., 2007, Holm *et al*., 2002). Calves has been shown to work harder in order to get access to full social contact with another calf compared to just head to head contact. This indicates that social contact with other individuals is very important for calves and cattle in general and is therefore considered to be a basic need for them (Holm *et al*., 2002). Group housing does give the calves opportunity to have social interactions with other individuals and therefore promotes the development of a social behaviour. The group housing also makes it possible for the calves to perform play behaviour in a much greater extent compared to single housing. The locomotion play for example, which often

includes a group of calves and involves jumping, kicking and running, can by obvious reasons not be performed in a single pen. It is hard to determine to what extent the number of calves in a group affects the social behaviour of the calves besides the fact that a larger group results in a more competitive environment.

Weight gain, health and risk of diseases

Sufficient colostrum supply is the single most important factor which determines the health status and survival chance of a new born calf (Godden, 2007). Calves that are given colostrum in adequate amount as soon as possible after birth will get improved pre-weaning health and survival, improved growth rate and feed efficiency, reduced age at onset of puberty, reduced age at first calving and improved first and second lactation. The quality and quantity of the colostrum that the calf is given have a great impact on the calf's future health status (Davis and Drackley, 1998). In order to know how much colostrum that a calf needs you must have an idea of the colostrum quality. A colostrometer estimates the amount of Ig in the colostrum from its density and thereby provides a measure of colostrum quality. Only one of all the visited farmers used a colostrometer to determine the colostrum quality. The sales managers in each country also indicated that a colostrometer is seldom used among farmers. The majority of all farmers did claim that they supplied the calves with colostrum within a couple of hours after birth. However, if the calves were born during the night the colostrum supply was in most cases delayed to the following morning. All the visited farmers did supply the calves with colostrum in either buckets with or without teats or in teat bottles. The use of buckets without teats for feeding of milk is not a good alterative due to the fact that the ingestion of milk is with this feeding method performed very quickly and in a less natural way (compared to feeding with teat buckets) which can have a negative effect on the oesophageal groove reflex (Blowey, 2005). If this reflex isn't working properly the milk will end up in the rumen and deteriorate which might result in diarrhoea and other disorders.

There are a number of factors that have an impact on the health status of the calves in a group. Proper cleaning of the milk feeder is one very important factor in order to keep the calves healthy. How often the milk feeder must be cleaned depends on a number of things, for example: if whole milk or milk replacer is used, if the milk or milk replacer is acidified, season etc. The interviewed farmers had very diverse cleaning routines. The majority of all the farmers cleaned the feeder once a week. Only one farmer cleaned the teat every day, the other farmers never cleaned the teat but replaced it for a new one approximately once a month. The farmers in Latvia stated that the cleaning of the milk feeder was a very time consuming and hard work. They felt that the milk tank was extremely hard to get clean and that it was difficult to manage to clean the milk feeder for just one person. All the Latvian farmers had a CF150 feeder. Also in Norway all the visited farmer had a CF150 feeder in which no automatic cleaning exists. However, the Norwegian farmers didn't feel that the cleaning of the milk feeder was hard at all. So, why were the opinions surrounding cleaning of the milk feeder so diverse between these two countries? One explanation could be that the facilities concerning water supply and practical issues were better in Norway. In Latvia one of the farmers had to carry water out to the milk feeder which was situated outside when it should be cleaned. This was of course not optimal and took much time. The other Latvian farmer had placed the milk feeder in an old tied up stall in which the facilities for cleaning was not optimal.

All the visited farmers kept their calves in single pens before they introduced them in a group pen. The time that the calves were kept in single pens varied between 4-14 days. None of the visited farmers applied routines to create stable groups. All the farmers in the Netherlands placed their calves in an introduction group were they kept up to 10 individuals. After approximately 2 weeks in the introduction group the calves were moved into another group in which they were kept until they were weaned. In the second group a larger number of calves were often kept. Jensen (2006) concluded that calves of the age of 6 days had less ability to compete in large groups in a system where computer controlled milk feeders are used compared to calves of the age of 14 days. This might indicate that if you keep large groups in the milk feeding system you should introduce the calves at the age of 14 days. Generally you should try to keep stable groups to as large extent as possible since stable groups have beneficial consequences such as higher live weight gain and lower disease frequency among group kept calves (Engelbrecht Pedersen *et al*., 2008). The majority of all the visited farmers didn't isolate a sick calf from the group. Some of the farmers claimed that they isolated calves from the group if they were seriously ill. However, if a sick calf is detected in the group pen it should preferable be placed in a single pen an be isolated from the rest of the group as soon as possible (Heinrichs & Radostits, 1994). This will decrease the risk of the disease spreading to other individuals and the individual housing will also facilitate the supervision and care of the sick calf.

Svensson and Liberg, 2006 showed that larger groups (12-18 individuals) had approximately 40 g less daily weight gain compared to calves in smaller groups (4-6 individuals). In the same study they concluded that there was an increased risk of respiratory diseases and increased respiratory sounds in the large groups. They could however not see any difference in the risk of diarrhoea between large and small groups. The study indicates that it is preferable to have less than 12 individuals in a group with respect to both health issues and live weight gain.

Labour demands

The optimal group size according to the farmers was very different. Five of the visited farmers claimed that an optimal group size was 10-12 individuals. However, two farmers thought 20-25 calves was optimal to have in one group. The labour time the visited farmers spent on their calves varied between 20 minutes – 3 hours per day. All the farms except the two farms in Latvia thought that the milk feeder had reduced their labour time. The Norwegian and the Dutch farmers experienced a reduction in labour time with up to 50%. Kung *et al*. (1997) showed that a great reduction of labour time can be achieved when an automatic milk feeding system is used compared to hutches. The time reduction could be up to 90%. How large the labour reduction becomes after a milk feeder has been installed is very hard to say. As shown in the interviews this can vary a lot. In order to achieve a reduction in labour time it is important that the planning of the calf housing is done in a proper way. As was seen in Latvia the installation of a milk feeder is not in every case connected with a reduction in labour. One farmer had placed his calves in an old tied up barn and he didn't experience a reduction of labour time. This could possibly be explained by the fact that the building wasn't planned or build for calf housing from the beginning and the facilities weren't optimal. This particular farmer had the dairy cows and calves in different buildings which resulted in logistical problems which could also affect the labour time. Overall, the majority of the visited farmers were satisfied with their milk feeder and felt that it was a good investment. It is important to emphasize that at least part of the labour that is saved by using a group housing system with a computer controlled milk feeder should preferable be spent of supervision on the calves to achieve a successful calf rearing (Kung *et al*., 1997).

Capacity of the milk feeder
The manufactures of the two milk feeders that was seen at the farm visits, the CF150 and the CF200+ claims that the machines can handle up to 25 calves in each group (DeLaval, 2008). The CF150 can only serve one teat whereas the CF200+ can serve two teats. The manufactures therefore claim that one CF200+ milk feeder can serve up to 50 calves at the same time. 25 individuals in the same group might be what the milk feeder can handle but this is not in accordance to what the studies concerning optimal group size indicates.

Optimal group size varies depending on the actual conditions on the farm (and/or in the country) as seen in the interviews mentioned above. All the farmers in the interview reared home bred calves. The result from the interview might be quite different if calves were bought from many other farms and brought to the farm.

Advantages and disadvantages with automatic milk feeding according to farmers

+ Lowering of work load.
+ Better control over the milk intake for each calf.
+ The milk feeder result in a more flexibility concerning the time the farmer spends on the calves.
+ Automatic gradual weaning.

- The cleaning of the milk feeder (CF150) is very time consuming
- The mixer in the milk tank (CF150) should have a larger diameter in order to mix the milk replacer in a proper way

Advantages and disadvantages with automatic milk feeding according to sales managers

+ Lowering of work load
+ More even quality of the milk distribution (the human factor is eliminated).
+ Milk is available during the whole day
+ Automatic gradual weaning.

- A higher risk of disease spreading.
- Less individual supervision of the calves compared to single housing.

5. Conclusions

- Group housing gives the calves opportunity to develop a social behaviour with other individuals, which have a positive impact on the ability to function in a group even later in life.

- Sufficient supply with colostrum is the single most important factor in order to minimize disease outbreaks among calves.

- A colostrometer estimates the quality of the colostrum and should be used in order to achieve a satisfactory colostrum feeding.

- Calves should be supplied with palatable forage of good quality and concentrate feed in order to make the weaning as smooth as possible.

- Calves should preferable be gradually weaned.

- An automatic milk feeder will in most cases lead to a reduction in labour time.

- The optimal group size for calves is very much depending on the management and the presumptions on the actual farm.

- The incidence of disease outbreaks can be lowered and the daily weight gain can be increased if small and stable groups are kept.

- Calves should preferably be kept in small groups (max 12 individuals) and the age range among them should be as small as possible in order to achieve optimal conditions for the calves.

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Uppsala, April 2009

Ida Eriksson

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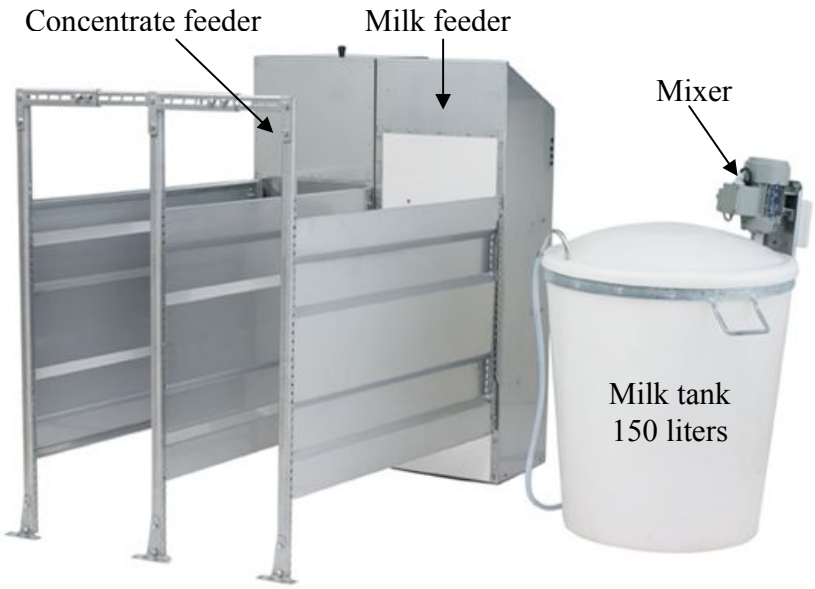
Appendix 1

DeLaval CF150

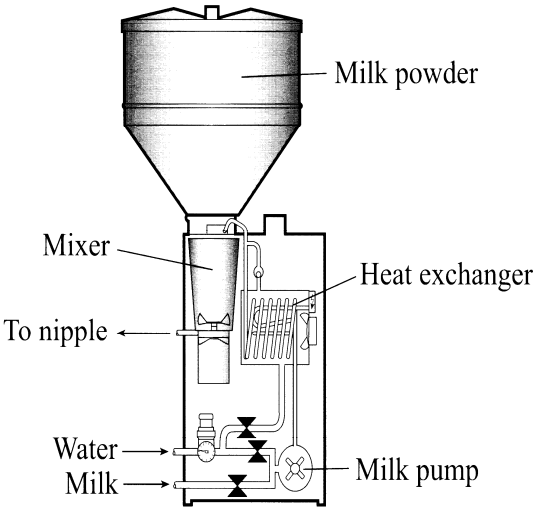


Data

- Milk replacer, whole milk or sour milk can be used
- The milk tank must be prepared with whole milk or milk replacer by hand, the cleaning of the milk feeder is also done by hand
- The feeder has a built in milk heater
- Automatic weaning function is available
- One milk feeder can serve one teat
- The capacity is up to 25 calves per milk feeder

Source: DeLaval, 2009.

DeLaval CF200+



(A milk tank is not shown in these pictures)

Data

- Milk replacer, whole milk and sour milk can be used
- Powder milk rations are prepared automatically in the mixer
- Automatic weaning function is available
- One milk feeder can serve two teats
- The capacity of the milk feeder is up to 60 calves (2*30 calves)

Source: DeLaval, 2009.

Appendix 2

INTERVIEW – SALES MANAGER

Name:
Address:
E-mail:

Give a short description of the average farm structure in your country (*herd size, mechanisation level, do the average farmer have employees, etc.*)

_____
_____
_____
_____
_____
_____
_____
_____
_____

1. What's the average labour cost for a farm worker in your country?

   _____
   _____
   _____

2. What's the average cost for milk replacer and whole milk?

   _____
   _____
   _____

3. Describe the knowledge level among the caretakers of the calves in your country. (*Education etc. surrounding calf management*)

   _____
   _____
   _____

4. What's according to you the main advantage with installing a computer controlled milk feeder?

   _____
   _____
   _____

5. Why do farms choose to install a milk feeder, what's the main reason?

   _____
   _____
   _____

6. How often do you recommend your costumers to clean the milk container and the computer controlled milk feeder?

_____
_____
_____

7. How often do you recommend to clean and/or change the teat on the milk feeder?

_____
_____
_____

8. What is the most common problem that arises after a milk feeder is installed?

_____
_____
_____

9. How old do you recommend the calves to be before introduction to the group pen and the computer controlled milk feeder? (*What is the average age when introducing the calf to the group?*)

_____
_____
_____

10. What is the optimal group size according to you? (*What is the* a*verage number of calves that farmer have in one group?*)

_____
_____
_____

11. How often do you recommend the farmers to clean the pen? (*Empty periods etc?)*

_____
_____
_____

12. How high is the average mortality among calves in computer controlled milk feeding systems? (*Compare with other systems (single pen system) + is there any difference before and after installing a milk feeder?*)

_____
_____
_____

13. How high is the average daily weight gain among calves? (*Before and after installing a milk feeder + compared to other feeding systems?*)

_____
_____
_____

14. Is the supply of colostrum to the calves satisfying on most farms? (*If no, what are the main problem/problems?*)

    _____
    _____
    _____

15. Do the treatment and care (isolation, antibiotics, electrolytes etc.) of sick calves work on most farms? (*If no, what are the main problems?)*

    _____
    _____
    _____

16. Do you feel that cross sucking is a problem in systems were computer controlled milk feeding is used? (*If yes, how can the farmer solve this problem?*)

    _____
    _____
    _____

17. Which do you think are the biggest advantages with a computer controlled milk feeder?

    _____
    _____
    _____

18. Which are the biggest disadvantages?

    _____
    _____
    _____

19. Do most farmers feel that the milk feeder lives up to their expectations? (*If no, which are the most common problems?*)

    _____
    _____
    _____

21. Which do you feel are the most important parameters surrounding calf management in order to achieve a successful calf breeding? (*low disease frequency, low veterinary costs, low mortality, high daily weight gain etc?*)

    _____
    _____
    _____

22. In a sale situation, which are the most important arguments you use to convince a buyer to invest in a calf feeder? (*Rank your 5 best sale-arguments*)
    1.
    2.

3.
4.
5.

23. Do you have any economical calculations which support any of these arguments? (*If so, are these calculations available?*)

_____
_____
_____

24. What parameters do you use in your economical calculations?

_____
_____
_____

22. Other thoughts or opinions?

_____
_____
_____
_____
_____
_____

Appendix 3

INTERVIEW - FARMER

Name:
Address:
E-mail:

1. When did you install computer controlled milk feeding?

   _____(month) _____(year)

2. How many dairy cows do you have? _____
   How many calves do you approximately feed per year? _____
   How many calves do you have at the most on the farm? _____

3. The cows calve
   ( ) the hole year around
   ( ) mainly in the fall or spring from _____ (month) to_____ (month)
   ( ) other distribution:
   _____
   _____
   _____

4. Do you supply the calves with colostrum?
   ( ) Yes in a bottle
   ( ) Yes in a bucket or teat bucket
   ( ) No, the calf suckles the cow
   ( ) The calf is helped to suckle the cow

5. If colostrum is fed, how much do you feed the calves?
   _____
   _____
   _____

6. When is the colostrum fed? (*Within how long after birth*)
   _____
   _____
   _____

7. Do you use a Colostrometer or any other tool to make sure that the colostrum is of good quality?
   _____
   _____
   _____

8. How many computer controlled milk feeders do you have _____and how many teats do they serve?_____

9. Of what model are the milk feeder/feeders? _____

10. What do you serve your calves?
    ( ) only whole milk
    ( ) both whole milk and milk powder
    ( ) only milk powder

11. How big rations do you feed the calves?
    _____
    _____
    _____

12. Do you have the milk feeder/feeders in a
    ( ) separate room or
    ( ) in the same room as the calves

13. How often do you clean the milk container?
    _____
    _____
    _____

14. How often do you clean the milk tube between the milk container and the teat?
    _____
    _____
    _____

15. How often do you clean the teat and how often do you replace it for a new one?
    _____
    _____
    _____

16. Have you experienced some types of problems with the milk feeder?
    ( ) No
    ( ) Yes
    If yes, what kind of problems?
    _____
    _____
    _____

17. For how long after birth do the calves stay with the dam?

_____
_____
_____

18. Where do you place the calf after birth?
    ( ) in a single pen
    ( ) directly in to a group
    ( ) other

    _____
    _____

19. Do you have dynamic groups or do you use stable groups (all in all out system)?

    _____
    _____
    _____

20. If you use single pens or hutches for the calves before introduction to a group pen, for how long do you keep them in single pens/hutches?

    _____
    _____
    _____

21. How old are the calves when they are introduced to the group?

    _____
    _____
    _____

22. Do you have any problems getting the calves to understand how to drink from the milk feeder?
    ( ) No, never
    ( ) No, hardly ever
    ( ) Yes, sometimes
    ( ) Yes, often

23. Have you experienced any other problems when the calves are introduced to the group?

    _____
    _____
    _____

24. Do the calves move when they are introduced to the group?
    ( ) Yes, between different farms
    ( ) Yes, between different buildings
    ( ) No

25. At which age do you wean the calves?

_____
_____
_____

26. Do you wean the calves abruptly or gradually?

_____
_____
_____

27. Do the calves have access to concentrate and/or roughage in the group pen?

_____
_____
_____

28. How do you feed the concentrate
( ) in a crib
( ) in a concentrate feed station

29. How old are the calves when they are moved from the group pen?

_____
_____
_____

30. How many calves do you have in each group?

_____
_____
_____

31. What group size do you think is the optimal and why?

_____
_____
_____

32. How large is the age range in a group, specify the youngest and the oldest individual in a group.

_____
_____
_____

33. Do you feel that it's a problem to have calves in different ages (sizes) in the same group?

_____
_____
_____

34. Formation of the pen:

A. Calf feeder
B. Water supply
C. Concentrate feed
D. Roughage

35. The group pen is _____ m * _____ m

36. What type of floor do you have in the group pen?
( ) Straw bedding
( ) Straw bedding and slatted floor
( ) Straw bedding and a scraped alley
( ) other
_____
_____

37. How often do you clean the group pen? (*Empty periods etc?*)
_____
_____
_____

38. Are you satisfied of the formation of the group pen?
( ) Yes

( ) No
If no, why not?

_____
_____
_____

39. Do you have problems with any diseases among the calves?

_____
_____
_____

40. How many of your calves do you treat with antibiotics (%) and what do you treat them for?

_____
_____
_____

41. Do you use electrolytes as a treatment for diarrhoea, if yes in what extent?

_____
_____
_____

42. How high is the mortality among the calves? (*Before and after installation of the milk feeder – is it any difference?*)

_____
_____
_____

43. What is the average daily weight gain of the calves? (*Difference before and after installation of the milk feeder?*)

_____
_____
_____

44. What do you do when you find a sick calf in a group pen? (*Treatment, isolation, etc*.)

_____
_____
_____

45. Do you have a problem with cross sucking?

_____
_____
_____

46. Do the calves suck on the interior of the box?

_____
_____
_____

47. Do you feel that some calves are displaced from the milk feeder by other calves? (*Which individuals are being displaced and by who?)*

_____
_____
_____

48. How much time do you spent on the calves per day? (*Before and after installation of the milk feeder – how has it changed?*)

_____
_____
_____

49. How is the time that you spend on the calves divided between the different chores? (*For example cleaning the pen, cleaning the milk feeder, supervision of the calves, treatment of sick calves etc? Has this distribution changed after the installation of the milk feeder?)*

_____
_____
_____

50. Do you feel that you have more time left for other chores after the installation of the milk feeder?

_____
_____
_____

51. What was the main reason for installing a milk feeder?

_____
_____
_____

52. Do you feel that the milk feeder has met your expectations?

_____
_____
_____

53. Which do you feel are the most important parameters surrounding calf management in order to achieve a successful calf breeding? (*Low disease frequency, low veterinary costs, low mortality, high daily weight gain etc?*)

_____
_____
_____

54. Other thoughts and opinions?

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