MSc thesis

Suckling as rearing method on dairy farms

The effect on farm system aspects of two dairy farms in the Netherlands

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Summary

Maternal behaviour, interactions and contact between cow and calf is limited or absent in modern dairy production due to the widely use of artificial calf rearing. Introduction of suckling on a dairy farm has effects on many aspects such as calf growth, animal health, milk production, rearing costs, behaviour, welfare and naturalness etc. Depending on the purpose and duration of the suckling period, three methods can be distinguished.

- Single suckling without additional milking, calves suckle with their own mother during the colostrum period. The suckling period varies from 24 hours to 3 days.
- Single suckling with additional milking, the cow is suckled by a calf and is also milked by the farmer. Calves suckle during the period of nutritional need for milk, the first 6 to 12 weeks.
- Multiple suckling without additional milking. Two or more calves suckle with a nurse cow, the period varies from 6 to 12 weeks.

In a pilot study on two farms the effect of suckling systems on calf growth and milk production of dairy cows was assessed. Furthermore, the development of naturalness on the case study farms was described, as well as the motivation, for the use of suckling as rearing method, of seven farmers.

There was a big difference between the two case farms used for this study. Farm I is a biodynamic dairy farm with double purpose cows in a deep litter stable. Low replacement and low calf mortality characterised this farm with a moderate production per cow. Farm II is an organic dairy farm with a specialized milk breed (HF) in a cubicle stable, with high replacement, high calf mortality and high production per cow. Both farmers aimed at the improvement of durability of their cows. The first farmer aimed to improve udder health and social behaviour. The second farmer had expectations on lower calf mortality as result of suckling.

Live weights of calves at the two farms were measured weekly for a period of five months. At the first farm 12 suckling calves were weighed pre- and post-weaning. At the second farm 10 bucket-fed calves and seven suckling calves were weighed pre- and post-weaning. Suckling had a positive effect on calf growth. At Farm II the suckling calves had a higher weight gain as the bucket-fed calves. Suckling calves reached earlier a life weight of 100 kg and could be weaned sooner than bucket-fed calves. Weaning at a younger age saves milk consumption costs. High weight gain is indicated to result in higher milk production for heifers that had been allowed to suckle as calves.

Data on milk production were collected monthly and covered a period of five months for farm I and four months for Farm II. The milk production of non suckled cows was higher than of suckled cows at Farm I. At farm II only a small difference was found between suckler and non suckler cows. The reason for this small difference was the incidence of suckling calves ‘borrowing’ milk from non-suckled cows in the herd.

The milk consumption at both farms was estimated at 10 kg per day, in the first 14 days after birth in with a single suckling method with additional milking. After 14 days the milk consumption per day was 15 kg using a single suckling method with additional milking. With the use of a multiple suckling method, was the milk consumption 10 kg per day.

Total milk consumption by suckling, in a pre weaning period of 84 days, was estimated at 840 kg per calf at Farm I. At farm II, the total milk consumption by suckling, in a pre weaning period of 65 days, was estimated at 880 kg per calf.

Total milk consumption, by suckling, increased with 300 kg per calf, with a value of 120 euro at Farm I. Total milk consumption by suckling, increased with 160 kg per calf at Farm II, representing a value of 64 euro per calf. The milk production of one cow on yearly basis was

sufficient to compensate extra milk consumption by 15 calves at Farm I and 25 calves at Farm II. The combination of suckling methods used and duration of the suckling period decreased consumption cost to acceptable levels for the farmers. Farm I used a single suckling period with additional milking for only 14 days, after that, multiple suckling without additional milking until 84 days. Farm II used a single suckling period with additional milking for 60 days and after that, multiple suckling without additional milking for five to seven days. Both farms used multiple suckling systems in order to limit the milk intake and to stimulate the intake of roughage. Milk consumption costs on short term could be compensated by increased milk production benefits on long term.

An important argument to use a suckling system, mentioned at both pilot farms, was increased naturalness of the farming system. Naturalness refers to the avoidance of inorganic, chemical inputs, to the application of organic, agro-ecological principles and to the respect for the 'integrity of life'. During the weekly meetings were opinions, experiences and vision on calf rearing exchanged with the two pilot farmers. The farmers' opinion on naturalness changed with the introduction of the suckling system. The farmers used suckling methods according to their own perception of naturalness.

The motivation of farmers to use suckling as calf-rearing method was analysed. In semi-structured interviews with open questions experiences and expectations of seven farmers and four experts on suckling systems were collected and analysed with an objective tree. Problems resulting from the bucket feeding system were indicated as reasons to experiment with suckling system. Compulsory feeding of cow milk to calves, diarrhoea problems, high somatic cell count and mastitis, public opinion and development of social behaviour were reasons to use suckling systems as well. These expectations of positive effects on the long term were high. Expectations on improved udder health, development of social behaviour and improved health of calves and cows are supported by several studies. The strong points of the system, according to farmers, were less labour, pleasure and enjoyment, and increased activity of cows. Weak points were fear for inter-suckling and decreased milk ejection. Next to economical benefits, were social and welfare benefits arguments mentioned for the use of suckling.

The suckling systems at the farms under study were not static. Many positive effects of suckling are found in literature and in practice farmers experienced and expected many positive effects too. Farmers with suckling systems utilized these positive effects. Farmers attempted to reduce or prevent the side effects of suckling, by the use of different methods, duration and number of calves. With this combination of methods farmers developed their own 'tailor made'suckling system. .

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Introduction

Ideally animals should be kept in husbandry systems, which allow them to express natural behaviour. However, in almost all production systems animals have to adapt themselves to the husbandry system. According to the Dutch policy note on welfare of 2002 do animal production systems have to develop towards the needs of animals. In order to improve the welfare of their diary cattle a number of organic farms introduced suckling systems, in which the calf is reared suckling its mother, ranging from 3 days up to 3 months of age. Compared to artificial calf rearing, suckling systems are more beneficial to the welfare of calves. The calf will be nursed by its mother, suckle milk, learn to eat roughage at a younger age, have social contact with other calves and cows and have space enough to exercise and play. Most of these factors are absent in artificial calf rearing systems (Krohn, 2001).
The Louis Bolk Institute works on a range of research topics at organic dairy farms. Some farmers requested their cooperation in exploring suckling systems. This report is the result of a pilot study aimed at pointing out the practical aspects of introducing a suckling system at a dairy farm. The study focused on:

The effects of a suckling system on calf growth
- Do suckling calves perform better in terms of daily weight gain in both pre- and post-weaning period?
- What is the difference in daily weight gain between bucket-fed calves and suckling calves in the first 2 months after birth?
- Is there a difference in the age and live weight of weaning of bucket-fed calves vs. suckling calves?

The effects of suckling systems on milk production
- What is the difference in milk production (kg/day) between suckling and non suckling cows pre- and post-weaning?
- What is the difference in milk production (kg/day) of suckled cows in pre- and post-weaning period?
- What is the difference in somatic cell count during the pre- and post-weaning period comparing non suckled cows and suckled cows?

The development of naturalness of the case study farms
- Does the opinion of the farmer change regarding to naturalness, with the introduction of suckling?

The motivation of farmers to make use of suckling systems
- What are problems related to the bucket feeding system?
- What are the arguments of farmers to use a suckling system?
- What do experts expect of suckling systems?

In chapter 1 the effect of alternative calf rearing systems on different aspects of the farming system are described. Altered calf rearing practices affect the farming system at three levels: animal, farm and sector level. The way these levels are affected is presented in a problem tree. Chapter 2 describes materials and methods. The farm characteristics of the two case study farms and their calf rearing methods are outlined. The results are presented in chapter 3. The effect of suckling on calf growth, milk consumption and naturalness is presented. The motivation of farmers to use suckling as calf rearing method are described. In chapter 4 the results are discussed and conclusions are presented. Finally recommendations for further research are given.

1 Literature review

In this chapter the effects of alternative calf rearing systems on different aspects of the farming system are described. This starts with a description of common and widely used calf rearing systems. Second a description is given of the natural situation based on behavioural studies of feral cattle herds. The effects of suckling on animal, farm and sector level are presented in an overview of the farming system. (Udo et al, 2002) In this study, a system refers to an integrated whole within a defined boundary, with specific characteristics resulting from the relations between its components and it's specific context.

1.1 Common and widely used calf rearing systems

In dairy farming, where the main purpose is to produce milk for sale, the calf will be separated from the dam at birth or a few days later and reared artificially. Economic, health and compassionate reasons are cited for early separation of cow and calf (Flower and Weary, 2001). By removing calves immediately, milk consumption by the calf can be controlled, leaving more milk for the producer to sell. Artificial rearing does also allow closer supervision by farmers of colostrum, milk and solid feed intake.
Milk or artificial milk replacer can be offered in an open bucket, automatic feeder or teat-bucket (Krohn, 2001). Milk replacer is cheaper than milk. Whereas the costs of organic milk replacer are higher than for conventional milk replacer. Costs of conventional artificial milk replacer are 1.30 euro per kg powder, which is 0.14 euro per litre milk replacer using a dilution 1:9. Organic milk replacer costs are 2.61 euro per kg, which is 0.29 euro per litre milk replacer using a dilution 1:9. Price of conventional milk is on average 0.34 euro per kg and of organic milk 0.40 per kg (Werf, 2002). Using the Bucket method 35 kg of artificial milk powder or 250-300 litre of milk is needed per calf
Housing in single pens is recommended for the first 14 days and group housing from 14 days until 3 months. After 3 months calves can be housed in a cubicle stable. (Anonymous, 1993)
Fifty percent of the Dutch dairy farmers feed fresh milk, however this is often 'waste' milk that cannot be sold (Lavrijssen, 2001). The other half of the farmers feed milk replacers, which are cheaper than milk. Nevertheless calf mortality in the Netherlands is 12% (Anonymous, 2002). In general calves can be weaned when their body weight has reached 65-75 kg and or the calves are 8- 10 weeks old (Anonymous, 1993).

Bucket feeding
The bucket method, concentrates method, aims to develop the rumen of the calf as quickly as possible. With this method it is important to minimise the intake of milk to stimulate the uptake of water, fodder and concentrates. Milk replacer as well as cow milk can be used. Cow milk gives more digestion related problems due to the higher and varying fat content. Milk contains 4% fat vs. 2,5-3% for milk replacer. However fat content of cow milk varies during the seasons. In contras with the fat content of milk replacer, which does not vary when prepared exact according the instructions of the producer.

Automatic feeding
The automatic feeder is available in different types. Usually milk replacer is offered in small portions of 0.5 litre. Some types offer the possibility to feed cow milk in combination with milk replacer. The main advantages of the automatic feeder are the possibilities to feed calves individually different rations in small portions over the day. The investment costs of this system are high (Subnel et al,1994).

Teat bucket
In the teat bucket method the calf receives milk replacer after the colostrum period. The teat bucket is connected to a barrel with conserved milk replacer. The uptake of water, fodder and concentrates is lower than with the bucket method, because the uptake of milk is ad libitum (Anonymous, 1993).

Suckling
Suckling systems are common in extensive beef production. Beef cows can however be very selective. There are differences in acceptation and rejection of foster calves between breeds. When cows without previous maternal experience have no contact with any calves during the first 24 h after calving, they will not accept being suckled by a calf. In contrast to ewes, cows with previous maternal experience do accept calves even when their first contact with them is not until the day after birth (Bouissou et al, 2001). In dairy farming, where the main purpose is to produce milk for sale, suckling systems are rarely seen. During recent years, a number of organic farms have introduced suckling systems in order to improve the welfare of the dairy herd (Krohn, 2001). Three different categories depending on the purpose and duration of the suckling period can be distinguished.

- Short term suckling, covering only the colostrum period, duration varies from 24 hours to 3 days.
- Long term suckling with additional milking the first 6 to 12 weeks. Cows are milked during pre- and post-weaning period.
- Long term suckling without additional milking, covering the period of nutritional need for milk of the calf, the first 6 to 12 weeks. The cows are not milked during the pre weaning period but only post-weaning. In a single suckling system does a cow suckle her own calf, however in a multiple system does a nurse cows suckle 2 upto 4 calves.

1.2 The natural situation

Only a few descriptions of feral cattle are available. The behaviour of feral cattle of the Chillingham (UK) and Maremma (Kenya) herds is studied. In these herds cows isolate themselves from the herd to give birth. The calf remains hidden for 2 to3 days before joining the herd with its mother. The calf suckles the dam from the first day until 8 to12 months. The weaning goes gradually (Krohn, 2001). During the postnatal period cows display protective behaviour and may attack dogs, foxes or humans coming close to their calves. During the first few days after birth cows stay close to their calves. After this postnatal period, cows begin to spend more time away from their calves and integrate progressively with the herd. The postnatal period is essential for the establishment of the bond between the calf and its dam (Bouissou et al, 2001). In general the calf suckles within the first hour. Licking is an important activity of the cow towards her calf. The cow licks her young until it is dry. According to Lidfors, (1996) maternal licking of the new-born calf has different functions:

- stimulation of activity, breathing and circulation
- stimulation of urination and defecation
- removal of the foetal membranes
- drying of the coat leading to a reduction of heat loss
- improvement of general hygiene leading to reduced risk of infection and predation
- strengthening of the maternal bond.

The number of lickings of the mother towards the young remains high for more than 10 months after birth. Half of the lickings are associated with suckling. When calves are not with their mother, they stay alone concealed in the vegetation, usually lying down for long periods. They can be considered as ‘hiders’. In their early days calves have little interactions with other calves even though they spent most time with them. Especially between the 11th and 40th day of life ‘crèche’ behaviour can be observed. Some have observed dams remaining near to the calves, these dams are called ‘Cow guards’.
The number of interactions of the young with other members of the herd increases slowly with age and become similar to the interactions between adults. Before the age of 2 months behaviours are rarely non-agonistic. Activities resembling fights occur as soon as 2 weeks of age, however they are displayed in a different social context as real fights. Mock fights are associated with running games and playful mountings. Other types of play include jumping, bucking, kicking, prancing, butting, vocalising, head shaking, sporting, goring and pawing. Schloeth (1961) describes a play call and a play-specific tail position of calves. When cows do not have a new calf in the following year, their calves will continue to suckle three times a day at 10 months of age and 1.5 times a day at about 400 days. After the birth of a new calf, the young of the previous year still have preferential contact with their dams (Bouissou et al, 2001).

1.3 The farming system

In the following paragraph the effects of suckling will be described on the different levels of the farming system. Suckling as calf rearing method has effects on animal, farm and sector level. The farming system is presented in Figure 1.

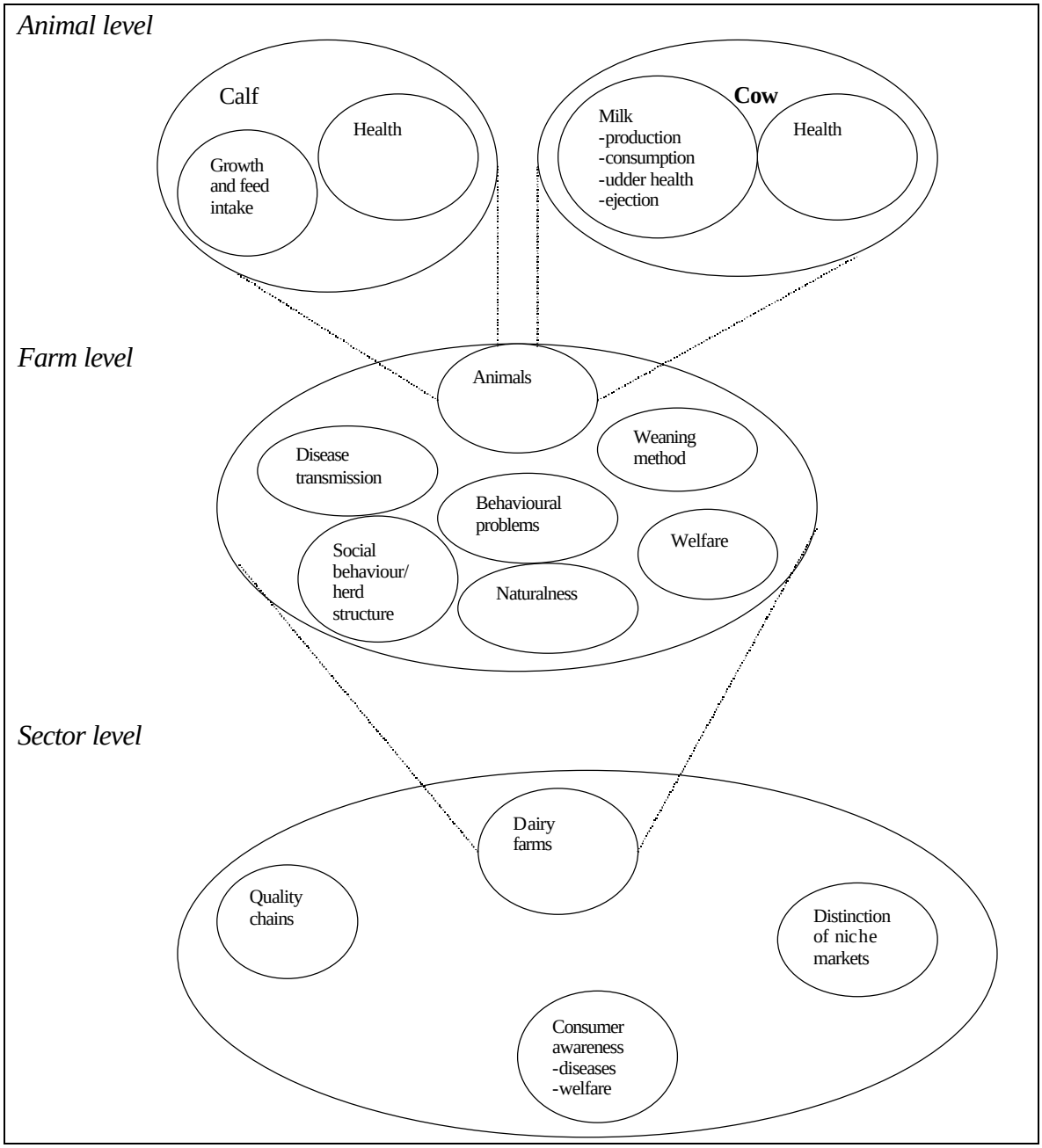

Figure 1 Aspects of the farming system affected at animal, farm and sector level by suckling.

1.4 Animal level

1.4.1 Growth of calves and feed intake

Weight gain
Several studies observed a high weight gain for suckling calves compared with bucket feeding. Bar-peled (1997) studied the production parameters and weight gain of HF heifers that were allowed to suckle from birth to six weeks of age. The weight gain from birth to conception was higher for suckling calves compared to bucket-fed calves. Twenty calves, in pairs of two, were allowed to suckle three times daily for 6 weeks. One pair of calves suckled one dam. This group was compared with 20 control calves, which were fed milk replacer in open buckets. During the first 6 weeks the suckling calves had significantly higher average weight gains as the control calves.

Body size at maturity.
Body size seems to be positively affected by suckling. High weight gain during the pre weaning period has been described to have a positive correlation with higher bodyweight at conception and higher milk production (Bar-Peled, 1997). Besides energy, protein and minerals, does milk from the dam contain growth factors, such as IGF-I, IGF-II and IGF-binding proteins mammary-derived growth inhibitor. Age at conception was significantly lower and the bodyweight at conception and conception rate tended to be higher for calves that were allowed to suckle The milk production during first lactation tended to be higher for heifers that had been allowed to suckle as calves. This result was expected because nutrition during an early age can affect body size at maturity. Intensive feeding (calves can consume up to 30 kg milk per day) accelerates the onset of sexual maturity and the development of the uterus and the udder. Heifers that had been allowed to suckle, also had a greater height at the withers at calving than heifers that had been fed milk replacer.
It seems that milk quality (referring to growth factors) other than the additional 14 % energy intake by the suckling calves was the factor during the first 42 days of life that contributed to the improved performance of the suckling calves. This improved performance was recorded even when suckling totally suppressed intake of solid feed and caused greater weaning trauma (Bar-Peled, 1997).

Roughage intake
Late-separation suckling calves were frequently observed ruminating by two weeks of age and were been eating more solid feed than non suckling calves normally consume at this age (Flower and Weary, 2001). Late-separation (separation at two weeks) calves gained weight more rapidly and maintained this weight advantage over the early-separation calves until at least 4 weeks of age. Rapid weight gain likely resulted from ad libitum suckling, although other aspects of maternal contact may have also influenced weight gain, like roughage intake. In the study of Bar-peled (1997), described above, did suckling calves not consume concentrates or hay, during the first 6 weeks, although this was available. The calves were weaned at 6 weeks. Body weight decreased sharply during week 7 for the suckling group, suggesting a greater stress as the result of weaning and adjusting to solid feed. The bucket-fed calves also showed a decreased growth, however, the decrease was less compared to the suckling calves (Bar-Peled, 1997).
Krohn (2001) states on this matter: A high daily gain obtained through a high milk intake is not necessarily beneficial, because it results in a decreased intake of roughage, and hence delayed rumen development, and increases the difficulties associated with weaning separation.

In a Danish study about cow-calf relations, the behaviour, production and health of suckler calves was studied (Jonasen and Krohn, 1991). The suckling calves in this study consumed more milk and had a higher weight gain, both from day to day as through the whole observation period than bucket-fed calves. Calves that were allowed to suckle twice a day, ate very little concentrates after weaning compared to the calves removed immediately after birth. They had also difficulties in changing from large quantities of milk to only concentrates and hay, which impaired the growth for the first 3 weeks after weaning. However measured over the whole period after weaning (42 until 101 days) there was no difference in feed intake.

Results of the studies are conflicting. The milk consumption is ad libitum with suckling calves, their energy intake from milk will meet their daily energy requirement. Bucket-fed calves are restricted in their milk consumption and probably need to supplement their daily energy intake with concentrates and hay. Restricting the milk intake of suckling calves could stimulate them to supplement their diet with roughage. This was the case in the last study, however the calves showed impaired growth for 3 weeks, there was no difference in feed intake between the two groups post weaning.

Other causes of increased weight gain besides milk consumption

Other factors besides high milk intake and growth factors may contribute to higher weight gain of suckling calves vs. bucket-fed calves. Social interaction is indicated as an important factor. In an experiment 57 calves were divided into three treatment groups:

- Calves were removed from the dams immediately after birth and placed in single pens and fed from a teat-bucket.
- Calves were left with their dams in the calving pen for the first 4 days. The dams' udders were covered with udder nets, and the calves were fed from a teat-bucket.
- Calves left with their dams for the first 4 days for free suckling.

On the same intake of milk the presence of the mother increased the daily gain of the calves significantly from 266 to 533 g/day. Free suckling (the last treatment) did not have any further significant effect on the daily gain (549g/day). It was concluded that social interaction between cow and calf in the colostrum period had stimulated the growth of the calf (Krohn, 2001).

Growth of foster calves in a multiple suckling system

In multiple suckling systems the variation in weight gain of calves is higher. Compared to bucket feeding multiple suckling leads to greater individual variation in weight gain, especially if the birth weights of the calves differ. To avoid malnutrition or even death, the farmer has to ensure that all calves are allowed to suckle daily (Krohn, 2001).
In a comparison between bucket feeding and suckling with a nurse cow, foster calves gained more weight, had less diarrhoea and were more economical to raise than bucket-fed calves. In another study the weight gain of foster calves was dependant on the relationship with the nurse cow. Calves were considered as adopted when they could suckle in a parallel position and were licked by the cow. In this case the foster calf had the same weight gain as the cow's own calf. If the relationship between nurse cow and calf was poorer, the difference in weight gain between the two calves increased (Loberg and Lidfors, 2001).

Conclusion on growth of calves and feed intake

Concluding, suckling calves had a higher weight gain during the suckling period compared to bucket-fed calves. This weight gain was due to a higher feed intake in quantity as in quality of milk. Milk from the dam also includes growth factors, such as IGF-I, IGF-II and IGF-binding proteins mammary-derived growth inhibitor. The social interaction between cow and calf has

a positive effect on the daily weight gain of the calf as well. After the suckling period the calves showed a decreased growth suggesting a greater stress as the result of weaning and difficulties adjusting to solid feed.

1.4.2 Health of calves

In an experiment comparing bucket-fed calves with suckling calves, calf health was studied (Bar-Peled et al, 1997). No difference in disease incidence was found except for diarrhoea. Only suckling calves exhibited diarrhoea during the first 14 days, however no pathogenic effects were found. Colostrum is an important factor in developing immunity. Lidfors (1996) found lower mortality rates for calves that received their colostrum by suckling their mothers compared to calves that received colostrum from an open bucket.

Prevention of diseases by prevention of contamination
Bacteria and viruses causing diarrhoea or diseases are present in the farm environment. Separating mother and calf in the light of disease prevention is often mentioned. In this study the focus will be on Johne's disease, and used as a case, to show the effect of diseases on different levels of the farming system.
Preventive measures against this disease, which is caused by bacteria, are recommended by the Dutch health service for animals, (GD, Gezondheids Dienst voor dieren). These measures include: no calf-cow contact, feeding of disinfected (radiation treated) colostrum, no feeding of cow milk, no animal contact between different age groups (Lavrijssen, 2001). The use of suckling is in conflict with these measures because there is cow calf contact, untreated milk consumption and contact of animals of different age groups.

Prevention of diseases by developing immunity
Prevention of contamination with bacteria is not the only way to prevent diseases. Developing a strong immune system contributes to calf health too. The uptake of colostrum is an important factor in building immunity. The reticular groove reflex is necessary to allow the colostrum to pass directly to the abomasum so that immunoglobulins can be transferred to the duodenum for absorption to establish the passive immunity necessary to combat pathogenic enteric organisms. This reflex is activated by milk and the act of suckling, when milk is drunk from a bucket the activation is often not properly (Bell, 1981). The right temperature of the milk or milk replacer, 40 degrees C, is also an important factor for the functioning of the reticular groove reflex (Anonymous, 1993).
In an extensive study on calf health and immunity, differences in health between suckling and bucker-fed calves were found (Earley and Fallon, 1999). These differences were caused by the insufficient quality and quantity of colostrum intake by bucket-fed calves. Conclusions of the study were:

- Suckled calves had significantly higher serum Immunoglobulin concentrations than non suckling calves. Immunoglobulins are proteins that bind to and help eliminate foreign agents in the body such as bacteria and viruses. Each form of immunoglobulin protects the calf against a specific disease or infection.
- The marked differences in immunoglobulin levels between suckling calves and non suckling calves suggest that non suckling calves received either insufficient quality or quantity of colostral immunoglobulins. It is well recognised that immunoglobulins are absorbed from the intestine for only a short period after birth and that efficiency of absorption is dependent on ensuring that the calf receives adequate colostrum in the immediate postpartum period.

- Factors affecting calf serum Ig concentrations are: Ig concentration in colostrum, colostrum intake, Ig mass, calf age at first feeding, nutrition of the dam, method of ingestion, presence of the dam, age of the dam and the calf.
- It is well recognised that immunoglobulins are absorbed from the intestine for only a short period post birth and that efficiency of absorption is dependent on ensuring that the calf receives adequate colostrum in the immediate post-partum period.

Prevention of disease by behavioural strategies
Behavioural strategies for health offer the potential for providing sustainable health care for animals (Engel, 2002). There is no need to imagine that animals do this consciously or intentionally; the strategies needed to be adaptive in the past to become part of the behavioural repertoire. When young animals grow up with their mother and animals of their own age (peer groups) they get the opportunity to learn from them. Mammals have an opportunity to learn the taste and smell of safe foods while in the uterus, and later from their mother's milk, as well as by sampling what she is eating. Growing up in a diverse environment also gives young animals the opportunity to "familiarize" with the pathogens with which they have to deal in later life. An advantage of growing up in a diverse ecosystem is that youngsters are exposed early to local pathogens and acquire immunity to them. Problems occur when animals come in contact with 'new' pathogens.
While some people focus solely on the destruction of pathogens, animals fight infectious disease via a holistic approach that involves avoidance, prevention and treatment of disease. Our optimism about eliminating infectious diseases with pathogen-targeted antibiotics has proved to be misplaced. Many of the diseases initially controlled by antibiotics have returned with more resistance and greater virulence (Engel, 2002).

Conclusion on calf health
Methods of disease prevention differ and can be conflicting. Prevention of contamination by separating calf and cow is in conflict with behavioural strategies that require a learning opportunity to taste and smell safe feeds from their mother's milk, as well as by sampling what she is eating. The introduction of suckling systems seems to contribute to calf health positively by efficient uptake of colostrum, however it is in conflict with preventive measures against Johne's disease.

1.4.3 Milk production

Milk consumption by the calf
Suckling calves will take the milk of the cows directly, leaving less milk for the producer to sell. In a system where calves are kept within the dairy herd, calves can drink milk ad libitum. During extreme intensive feeding, to accelerate the onset of sexual maturity, calves could consume up to 30 kg milk per day (Bar-Peled et al, 1997). Under 'normal' circumstances such extreme milk consumption is not observed.
Hovi (1998) has described a single suckling system with additional milking (calf at foot system) for a dairy farm in Finland. Eighty Ayrshire cows were housed in a cubicle stable producing on average 8900 litres in 305 days. The consumption of the calf was estimated at approximately 10 litres per day during the first 14 days, in the third week up to 15 litres. The mother's milk production was observed to increase with approximately 15 litres per day after the calf was removed at 3-4 weeks of age. The farmer with this system points out, that there is not a big price difference for organic farmers using nurse cows or bucket feeding and calf-at-foot systems, as whole milk is used to feed the calves in both systems. It is obliged to feed calves whole milk in organic agriculture (Hovi, 1998).

In a Danish study the milk consumption of suckling calves varies from 10 litres in week 1 after birth up to 13.5 litres in week 8 (Jonasen and Krohn, 1991).

Milk ejection

In a study on long term suckling with additional milking, a poor milk let-down by the dairy cow during machine milking was found during the suckling period. Suckling was better stimulation for milk ejection than a machine milking for a suckled cow. The release of the hormone oxytocin was measured under different treatments (Tancin et al, 2001). Release of oxytocin from the pituitary is caused by milking but also by sensory stimuli from other areas in the body. Milk ejection is activated by teat stimulation in response to oxytocin released. Suckling includes three different phases, pre-stimulation, milk intake and post stimulation. Machine milking does not include all these phases, suckling causes therefore a greater oxytocin release compared to machine milking (Unväs-Moberg et al, 2001).

Suckled cows had a higher oxytocin release during suckling compared with machine milking (Tancin et al, 2001). However oxytocin release of suckled cows during suckling did not differ from oxytocin release during milking of non suckled cows. The amount of milk in the udder could also be an important factor for oxytocin release during machine milking. The amount of milk in the udder is not important for oxytocin release during suckling. It was concluded that poor milk let down can be caused by suckling.

Poor milk let down can also be caused by emotional stress. Milking of dairy cows under emotional stress from novelty normally evokes a central inhibition of the oxytocin release. Machine milking can be considered as a novelty for heifers and can cause poor milk let down, as can other stressful events.

Milk production and udder health of the suckled cow

The consequences of different suckling systems on milk production have been studied for long-term suckling with or without additional milking Krohn (2001). Short-term suckling was also studied during the colostrum period. Long-term suckling without additional milking in early lactation could in some situations stimulate the subsequent milk production to a greater extent than milking alone. No clear significant differences could be found between restricted and free suckling systems. Krohn (2001) states that free suckling can stimulate the subsequent milk production, probably with an increase of up to 20%. This higher milk production affected by suckling could be a result of better evacuation of the udder, better udder health and maybe by a higher release of lactogenic hormones, i.e. prolactin and growth hormone both during and after the suckling period. Suckling also seems to affect the incidence of mastitis. Most experiments show that suckling decreases the risk of mastitis in the suckling period and in some cases even for some time after the suckling has been terminated.

Hovi (1998) described a decline in mastitis incidence and cell counts in long term singe suckling system with additional milking. However simultaneously with the introduction of the calf-at-foot system the farm described went from two to three times milking a day and this could have contributed to the decline as well.

The effect of suckling as a calf on later milk production

Many aspects influence later milk production, including type of calf rearing system. Lactating heifers who were allowed to suckle as calves turned out to be excellent mothers and milkers (Hovi, 1998).

A positive effect on milk production in the first lactation was found comparing suckling calves with non-suckling calves. The milk production tended to be higher while fat and protein yields were similar for both groups. 9171 kg/300days for heifers who were not

allowed to suckle as calves vs. 9624 kg/300 days for heifers that were suckling calves, p=0.08 (Bar-Peled et al,1997).

Conclusion on milk production
Estimates on the milk consumption by the calf vary from 8-10 litres in the first month until 15 litres in the age of 4-8 weeks. Problems with milk ejection are observed. They are caused by inefficient stimulation of the oxytocin release during machine milking. The higher milk production by suckling could be a result of better evacuation of the udder, better udder health an maybe a higher release of prolactin and growth hormone both during and after the suckling period. The effect on later milk production of the suckling calf seems to be positive as well. The increased milk consumption for a suckling period of 8 weeks with the above estimated milk consumption is 500 litres. An increased milk production for heifers, which were allowed to suckle as calves of 453 kg/300 days was found.
Consumption costs on short term are compensated by production benefits on long term. There are indications for increased total milk production on long term.

1.4.4 Health of the cows

Effects on cow health can be expected in the form of decreased retention of fetal membranes after partus and increased fertility. Stress in the cow just after partus has been linked with the retention of fetal membranes. In a study on 200 cows, 2-3% had problems with retention of fetal membranes. In another group of approximately 20.000 cows prevalence of retention of fetal membranes was only 0,025%. In the latter group suckling was allowed. This difference is significant. The stressors in this study were removal of the calf from the cow with no suckling allowed by the calf (Albright and Arave, 1997).
In an experiment on productivity aspects of keeping cow and calf together for 10 days post-partum an effect on the calving-conception interval was found. The calving-conception interval was significantly shorter comparing suckler cows with non suckler cows, 66 vs. 97 days, $p < 0.05$ (Metz, 1986). There are indications suckling increases the length of post-partum anoestrus interval.
Krohn (2001) concludes, if restrictive suckling has a small effect on the number of days to first an-oestrus, it does not seem to lengthen the calving interval much, because of a relatively higher fertility of the cows when the calves are removed.

1.5 Farm Level

1.5.1 Weaning

Whereas separation in nature often results from gradual weakening of bonds, separation of animals on farms is typically abrupt and permanent. Weaning involves:

- abrupt severance of the mother-young bond,
- abrupt change in diet,
- depriving the offspring of the opportunity to perform suckling behaviour at an age when they are highly motivated to perform this comforting behaviour (Newberry and Swanson, 2001).

It is assumed that early separation is less distressing for both cow and calf, because a longer period of contact between dam and offspring is thought to increase bonding. As little as 5 minutes of contact immediately after birth may be sufficient for the formation of a strong maternal bond. Early weaning is very common in dairy husbandry. It is not only the change of

diet, which stresses the young animals (Flower and Weary, 2001). It is also the change of environment and deprivation of social contact with the mother. Weaning of the young can also stress the mother. The response to separation by both cows and calves increased when calves were separated at 2 weeks rather than 1 day of age. However the calves separated at the later age gained more weight and delayed separation appeared to influence the development of calf social behaviour.
With advantages to the calf for staying with its mother, it can be questioned if the removal of the calf after the mother has attached to it, through several hours of close association, causes stress in the dam which has been left behind (Hopster, 1994). In this experiment the heart rate of dams increased significantly during the first minute after separation, however in the first 10 minutes the change on average heart rate was only 4 beats per minute. The number of vocalizations varied a lot, from 1 to 29 times in the 20 minutes after separation of the calf. The conclusion was that separation of the calf from the cow after bonding only evokes a weak stress response in the dairy cow. Hopster discusses his results as follows: Until 2-3 days after birth the mother and calf stay close together in a natural situation. After this period the mother spends most of the time with the other cows in the herd. The calf spends most of the time in the calf-crèche with other calves. Cow and calf do not spend all the time together; short-term separation is part of their natural behaviour. Separation of the calf does not initiate a strong stress response in case it is measured over a short term.

Reduction of the negative effects of weaning
Separating cow and calf partially by allowing them to make contact across a fence seems to be less traumatic than isolating them completely (Price et al, 2002). A study on 100 beef calves showed decreased negative effects of separation on behaviour and growth rate. Calves, which were allowed to have contact with their dam through a fence, had significant higher weight gain post-weaning, compared to total separated calves. Calves assigned to the total separation treatment had no contact with their dams. Fence line calves and cows spent respectively 60% and 40% of their time, within 3 metres of the fence during the first two days post-weaning. For the first two days, fence line calves vocalized less and spent more time eating and lying down and less time walking (pacing) than calves in the three totally separated treatments. Two weeks after weaning fence line calves had 95% more weight gain than the totally separated calves. At 10 weeks post-weaning did fence line calves have still 31% more weight gain.

1.5.2 Social Behaviour

Different housing systems have an effect on the development of social behaviour. Social hierarchy can be established at a young age, depending on the animals' experience and the social context. Suckling calves establish dominance relationships at an earlier age than artificially reared ones, on average 4-5 months vs. 9 months, and they learn at an earlier age the meaning of social interactions such as threat (Bouissou et al, 2001).

1.5.3 Disease transmission

Bacteria, viruses, fungi and parasites can cause infections. Transmission of micro-organisms, depending on the species, can take place by direct contact between animals or via air, water feed, housing, manure etc. Preventing contact between animals by separating cow and calf and single housing is used to prevent the transmission of some infectious diseases (Holzhaur,1992).
One T-spoon of contaminated dung is enough to contaminate the calf with Johne's disease (Lavrijssen, 2001). Bacteria of Johne's disease are mainly excreted in manure, however,

clinically diseased animals excrete the bacteria in milk to. Prevention measures are cleaning and sanitation of the calving stable before each use. A piece of plastic behind the cow in labour is an easy way to avoid the calf from ending up in a pile of its mother's dung. To be able to feed the valuable colostrum to the calf, only colostrum with a radiation treatment must be used. A treatment of colostrum will kill bacteria like Para-TBC. The radiation treatment is expensive, 7 Euro per litre. In Denmark an artificial colostrum alternative is available on the market. The next step is feeding milk replacer instead of cow milk.
The sensitivity for a Para-TBC infection is highest at the time of birth of the calf. Around 150 days of age the sensitivity percentage is halved from 100 to 50%. Thus after the weaning period the calves are still at risk. Bacteria are able to survive in the low pH of silage. It is therefore important to feed 'clean' silage. Grass silage of parcels fertilised with artificial fertiliser are 'clean'. The machinery used for making silage can cause a transmission when contaminated with manure. Besides the introduction of preventive measures the adjustment of the management practices and self-discipline is the only way to stop new contamination (Lavrijssen, 2001). The impact of these preventive measures are extreme high on farm level.

1.5.4 Behavioural problems with inter and cross suckling

Problems with cross-suckling by calves and inter-suckling by older animals are observed in meat and milk production systems (Passillé, 2001). Cross-suckling is the suckling of ears, tails, prepuce and other body parts. Inter-suckling is milk-suckling and udder-suckling between older animals. Behavioural deprivation of suckling is observed in most modern farms. Since the survival of the young mammals depends on suckling success, it is assumed that suckling motivation must be strong. Deprivation of suckling could result in frustration and has negative impact on welfare. Calves reared separately from their mother are often bucket-fed and can only suck at objects in the pen or at pen mates to satisfy their suckling motivation. When calves can suckle their dam, they rarely suck on other calves. However cross-suckling and inter-suckling can occur after weaning.

1.5.5 Naturalness

In organic agriculture naturalness is an important issue. Naturalness refers to the avoidance of chemical inputs, application of agro-ecological principles and respect for the integrity of life. Verhoog et al (2002) developed a naturalness diagram. This framework, of approaches and values, can be used to assess naturalness of different activities and methods in organic agriculture. Three different approaches of naturalness in organic agriculture were distinguished.

- No chemistry aspect, organic agriculture can be seen as natural because it does not make use of artificial (chemical/ synthetic) additives. It is, however, accepted to make use of additives of a natural source.
- Agro-ecology aspect, organic agriculture can be seen as natural because natural (ecological) processes are used to enhance the self regulation of the system.
- Integrity aspect, organic agriculture can be seen as natural because the species-specific nature of plants, animals, humans and products are respected (Verhoog et al, 2002).

An ethical assessment is characterised by a rational component, a value component and a normative component. In a naturalness diagram these components are called value-dimensions and enlightened below:

- Cognitive dimension. Opinions and theories, which influence appreciation of nature by people.

- Emotional dimension. The attitude towards nature, distinguished are controller, stewardship, partner and participant
- Normative dimension. What man can do with nature and what is not accepted

Suckling systems cover all three aspects of naturalness. Fresh cow milk is used instead of milk replacer, this contributes to the no chemistry aspect of the farming system A suckling system enhances the self regulation of the system, for example development of immunity by an efficient quantity and quality of colostrum. Cows have the opportunity to display maternal care, calves receive maternal care and have more social contact, the species-specific nature is hereby more respected.

1.5.6 Welfare

Suckling systems are different in terms of calf welfare. The Brambell commission (1965) formulated five freedoms for animals. This list is useful to evaluate (affected) animal welfare. The five freedoms are:

- free of thirst, hunger and malnutrition,
- free of physical and physiological discomfort,
- free of pain, wounds and disease,
- free of fear and chronicle stress,
- free to express natural (species specific) behaviour.

Maternal behaviour, interactions and contact between mother and calf is limited or absent in modern dairy production systems (Bestman, 1999). The calf is removed from its mother immediately or within 24 hours after birth. Calves are generally bucket-fed and housed in single pens or in groups with animals of the same age (peer groups). This is common practice in conventional and organic dairy farming.
The issue of behavioural deprivation is central to welfare (Passillé, 2001). Since in most modern farms, the animals cannot perform many of the behaviours regularly seen in less restrictive environments. According to Krohn (2001) are suckling systems more beneficial to the welfare of calves than the more common artificial rearing systems. The calf will be nursed by the mother, suckle the mik, learn to eat roughage earlier, have social contact with other calves and cows and have space to play.

1.6 Sector level

1.6.1 Distinction of niche markets in the diary sector at national level

At the moment organic dairy produce has a market share of 1.5 %. In order to keep this share and to increase it steadily, the produce and production methods should be distinctive and be able to maintain the premium prices of organic produce. To distinguish organic from conventional agriculture on basis of naturalness it is important to integrate all three aspects in the production methods: the avoidance of chemical inputs, the application of agro-ecological principles and respect for the ‘integrity of life’ (Verhoog et al, 2002).
Naturalness and animal welfare are distinctive features of organic agriculture. One of the principles in organic farming is to keep production animals in suck a way that they can express species specific behaviour as much as possible. The housing and management of the animals is adapted to the needs of the animal (Jonge and Goewie, 2000).

1.6.2 Quality chains for export in the international market

The Netherlands is an exporting country. To maintain a competitive position in the international market the Dutch dairy sector should be distinctive (Booij, 2001). The Netherlands has a quality certificate, KKM (Keten Kwaliteit Melk), a quality certificate for the meat chain (IKB) and a unique I&R (Identification and Registration) system. Quality certificates are important on the national and international market. A disease free status is an important distinctive feature for a country.
The opinions on future development of the Dutch dairy sector are in conflict. Some stakeholders would like to increase export. Preconditions are guaranteed constant quality and continuity. An industrial attitude is needed to organize the sector, according to a stakeholder in the Beef sector (Booij, 2001). A socialistic politician argues: If animal production systems are shaped by economical laws the system becomes very vulnerable. An animal is more than an economical production unit. Sustainable and animal friendly agriculture is in conflict with a free market. To produce feed in a sustainable way production should be limited, the market protected and prices guaranteed (Koopman, 2001).

1.6.3 Consumer awareness

Animal welfare
Criticism at the current modern intensive animal productions systems is increasing. The public has been confronted with the side effects of animal production with the outbreak of pest and diseases. In 1997 there was an outbreak of the classical swine fever, the mad-cow disease, dioxin scandal in Belgium and The Netherlands, foot and mouth disease in Great Britain in 2001 and recently the outbreak of avian influenza with chickens in The Netherlands. Society wants animal husbandry systems, which are economically viable, ecologically healthy, and animal friendly. However at the same time prices of agricultural products are determined by the market. Investments in animal welfare friendly systems are expensive. The financial returns low or even negative due to price competition for agricultural products at the market.
Suckling systems offer an extra in terms of calf welfare. Besides the importance of welfare for the animals itself, animal welfare and freedom to express natural behaviour are distinctive features of organic agriculture. Animals in animal husbandry systems should live in an environment in which they can express their natural behaviour. In several productions systems animals have to adapt themselves to the husbandry system (Jonge and Goewie, 2000). Also according to the Dutch policy note on welfare, the housing and management in animal production systems should change towards the needs of animals.

Disease transmission to humans
With the recent outbreaks of diseases in animal husbandry systems, the concerns on disease transmission from animals to humans rise. There is no evidence on Johne's disease being a risk for human health. However the disease is said to be related with Crohn's disease, which is a disease in the intestines of humans. The quality certificate (KKM) in the Dutch dairy sector asked farmers to be active in combating Johne's disease (Lavrijssen, 2001). A member of the NZO, (Nederlandse Zuivelorganisatie, the Dutch dairy organisation) states, we want a safe product on the market, produced by healthy cows. Obliged Para TBC prevention is a sensible step forward (Lavrijssen, 2001).

1.7 Discussion on literature review

Many aspects of the farming system are influenced by the introduction of a suckling system. Suckling has many positive effects, such as increased calf growth, better calf health, better cow health, better development of social behaviour, increased naturalness and improved animal welfare. There are indications for increased total milk production on the long term. By increased milk production of heifers that were allowed to suckle as calves and by better udder health of suckled cows.
Some aspects can be influenced positively and negatively for example prevention of disease. There can be a conflict with on one hand animal welfare and on the other concerns about human health. It can be questioned how effective the preventive measures, described in the paragraph 1.5.3 disease transmission, are in practice. Eliminating infectious diseases by preventing contact with the bacteria can be misplaced (Engel, 2002). Desinfection of the environment of calves, radiation treatment of colostrum, use of milk replacer, use of artificial fertilizer, single housing of calves and no contact with animals of other age groups are preventive measures with a high impact on animal welfare and farm management. These measures may also prevent the development of a strong immune system. It could be questioned if the suggested measures make the animals stronger, or make them weaker and therefore susceptible to diseases.
Some effects of suckling are unknown or unclear because of conflicting results in different studies. More research is necessary to clarify these conflicts, for example on uptake of roughage and on building resistance and development of immunity against diseases.

2 Materials and Methods

Case study farms

Two farms, which introduced suckling as calf rearing method, were studied during 5 months. The farms were selected on their will to co-operate and exchange information on different aspects of their farm. The general characteristics of the case study farms are presented in Table 1. The effects on calf growth on milk production of dairy cows were assessed in an on-farm trial. The costs of the milk consumption of the calves were calculated for both farms.

Table 1 The general farm characteristics of the two case study farms.
The characteristics were calculated over the period august 2001 until august 2002 and are representative for this period.

Farm characteristics	Farm I	Farm II
Certification	Bio Dynamic since 1990	Organic since 2000
Number of cows	63	70
Number of heifers	14	25
Number of calves (<1 year)	15	25
Replacement %	<25%	>35%
Calf mortality	< 5%	>12 %
Average age at calving	4 year and 6 months	3 year and 8 months
Horned cows	Yes	No
Number of days between two calvings (calving interval)	379 days	405 days
Breed	18 % Black and white, 79 % Red and white. Crossbreeds of MRIJ, FH, Montbéliarde and Lakenvelder	>95% Black and white Holstein (HF)
Presence of a bull	Regularly	No
Stable type	Unique system of a deep litter stable with a floor with gradient, a litter hill	Cubicle stable
Number of concentrate automates	0	3
Housing of non lactation cows	Outside the herd	Last month within the herd
Housing of old heifers	Outside the herd	Last months within the herd
Milk production	320.000 kg/year	450.000 kg/year
Area	50 ha.	53 ha.
BSK (index number, see measurements of milk production)	24.7 kg milk/day/cow	37.9 kg milk /day/cow
Milk production per ha.	6400 kg/ ha.	8500 kg/ ha.
Milk production per cow	5373 kg milk/ 305 days 5250 kg per lactation, average lactation duration is 298 days.	6936 kg milk/ 305 days 7800 kg per lactation, average lactation duration is 343 days.

Weight gain of calves

Treatments and housing

At Farm I all calves (n=12) received the same treatment that is suckling their mother in the pre weaning period until three months of age. Calves were born before and during the experimental period. Calves had free access to suckle their mother during the pre weaning period. Suckling calves were houses together with the dairy herd during pre weaning. The calves had also access to a straw pen, which was not accessible for cows. During the first month of the experiment went cows and calves outdoor grazing during the day. After the first month cows and calves were kept indoors in a deep litter stable, 24 hours a day. Post weaning calves were housed in a straw and fed with grass silage ad libitum and two kg of concentrates per calf per day.

At Farm II, 17 calves were assigned to two treatments. Calves born before the experimental period received a control treatment (bucket feeding system). The calves born during the experimental period received a suckling treatment. The treatments were conducted during pre weaning that is until calves received a body weight of 100 kg. Post weaning all calves received the same treatment.
Bucket-fed calves (n=10) were fed fresh cow milk in open buckets, six kg per day. Bucket-fed calves were housed in single pens for 14 days and thereafter in groups of two until four calves in straw pens.
Suckling calves had free access to suckle their mother ad libitum. Suckling calves had free access to the cubicle stable of the dairy herd. The calves had also access to a straw pen, which was not accessible for cows. Calves and cows were kept indoors 24 hours a day because the treatments were conducted during the winter season.
During the post-weaning period calves were housed in a cubicle stable in groups of four to six calves. Calves were fed grass silage ad libitum and one kg concentrates per day.

Measurements
Weight gain in the pre- and post-weaning period of calves was measured weekly during the experimental period of five months. Duration of the pre weaning period varied per farm and per treatment group.

Milk production
Treatments and housing
At farm I, 12 cows were assigned to the treatment of suckling their calves. 36 cows were used as control. During the first month of the experiment did cows have access to outdoor grazing during the day. After the first month cows were kept indoors in a deep litter stable, 24 hours a day. In the stable all cows had free access to grass silage and were fed concentrates corresponding with their lactation stage. All cows were milked two times a day in a milking parlour.
At farm II, seven cows were assigned to the treatment of suckling their calves. 56 Cows were used as control. The cows were kept indoors in a cubicle stable 24 hours a day. In the stable all cows had free access to grass silage and were fed concentrates corresponding with their lactation stage. All cows were milked two times a day in a milking parlour.
At both farm, selected the farmers the cows for the treatments. Only cows that gave birth to a female calf for replacement were assigned to the treatment of suckling. Cows that gave a bull calf or female calf unsuitable for replacement were assigned as non suckler cows.

Measurements
The milk yield of all the cows was sampled every four weeks during the experimental period. Milk quantity was measured in kg/day. The somatic cell count of the milk samples was determined as well. Measurements and calculations of index numbers were carried out by cooperative cattle organisation (CR Delta). The cooperative cattle organisation makes use of correction-factors to calculate ISK values (Anonymous, 2003). ISK can be used to compare milk yield (in kg/day) of individual animals. To calculate ISK, measured milk production of a cow is corrected for production level, age, season and lactation stage. The correction factors are dependant on the production class a cow is assigned to. In total 28080 production classes can be distinguished based on :
20 farm production levels
18 age classes
6 seasons
13 lactations stages
Cows between day 5 and 250 of their lactation can be assigned to one of these classes.
Y= Cf * P
Y = ISK
Cf = Correctionfactor
P = measured milk yield on day of sampling
The milk yield is corrected as being the yield of an adult cow (69-92 months), calved in February/March and on lactation day 50. BSK is the average of ISK values of the sampled cows on the farm.
BSK can be used to get insight in the mean production level of a herd and variation in production during the year due to variation in feed quality, weather or health. BSK can also be used to compare average production levels of different farms (Anonymous, 2003).

Statistics
The data, of weight gain and milk production, were analysed statistically using SPSS 11.0. Data were checked for normality with the Skewness test. If normality was found a T-test (independent samples) was used. Equality of variances was tested with Levene's test. When normality was not found non-parametical (independent samples) tests were used. Depending on the n of the treatment, the Mann-Whitney test was used for treatments $n>5$ and the Kolmogorov-Smirnov test for $n<5$.

To reduce the effect of repeated measurements, the average weight gain per day was used within one test period (month). Average weight gain per day was calculated dividing the weight gain in the test period by the number of days in the period.

ISK values of suckler cows were compared with ISK of all lactating non suckler cows. For suckler cows the post-weaning period started at the time of weaning of their own calf. The post-weaning period for non suckler cows was defined as: the period starting from the average weaning age of suckler calves at that farm.

Somatic cell counts of suckler were compared with non sucker. To prevent a bias for somatic cell count only cows with bull calves were compared with suckler cows.
Tests on differences were only made within the case study farms, not between farms.
Cows in both treatment groups were maximal five months in lactation for the somatic cell count analysis.

The milk consumption at both farms
The average difference in milk production of suckler cows between pre and post weaning together with the difference between suckler and non suckler cows pre weaning is used to estimate the milk consumption of the suckling calves. An organic milk price of 0.40 euro is used per kg difference in milk production.
The total amount of milk consumed per calf in a suckling system is dependent on:

- suckling method (single or multiple suckling)
- duration of suckling period (number of days per suckling method)

The total amount of milk consumed at a farm is dependant on the number of calves kept for replacement.
Y= P * R ((DSS * CSS) + (DM *CM))

Y = Costs per year
DSS = Number of single suckling days per calf
DM = Number of multiple suckling days per calf
CSS = Consumption per day during single suckling per calf
CM = Consumption per day during multiple suckling per calf
R = Number of calves for replacement
P = Milk price

The naturalness of calf rearing systems at two case study farms
During weekly contact for five months opinions, insight and experiences on calf-rearing systems were exchanged with the two pilot farmers. The bucket feeding and suckling method were discussed in unstructured interviews. The farmers had 20 years experience with bucket feeding. The first farmer used suckling six months before the experimental period of this study. Farmer II started simultaneously with the experimental period. The data were analysed with a naturalness diagram (Verhoog et al.,2002).

Motivation of farmers to make use of suckling systems
Problem analysis of bucket feeding
In a problem analysis the cause effect relations were established of the bucket feeding method. These relations were presented in a problem tree. In a problem tree, causes were put at the top of the diagram and the effects at the bottom. In between the problem that connects causes and effects. The problem tree was descriptive and based on the literature study of chapter one.

Objective analysis for the use of suckling
Seven farmers and four experts were selected and asked for their experiences and expectations with suckling. The farmers gave their arguments for and against suckling systems. In appendix I an overview is given of the farmers and experts. The information was collected by means of semi-structured interviews with open questions. The data were analysed and presented in an objective tree. In an objective tree the arguments of the farmers to experiment with suckling systems were put at the top of the tree and experienced or expected effects were put at the bottom of the tree. Experiences were categorized in positive and negative effects of suckling systems:

- economical costs or benefits
- social and cultural arguments
- effects on welfare and naturalness

Arguments mentioned more as three times were considered as strengths or weaknesses of suckling.

3 Results

In this chapter the calf rearing systems used at the two case study farms are described. The results on daily weight gain of the calves and milk production of the cows on the case study farms are presented as well. The naturalness of the calf rearing system on the farms is described. In a problem tree the cause effect relations of the bucket feeding method are established. The experiences and expectations of farmers and experts are set out in an objective tree.

3.1 Description of the calf rearing systems of the two case study farms

Bucket feeding system
In the bucket method at farm I, calves were housed individually in straw pens 14 days and thereafter in groups. In four feedings a day, six litres of cow milk was offered per calf. The calves were weaned at three months. The milk consumption in this system was 540 litres per calf. The calf mortality was low, < 5 %.

In the bucket method at farm II, calves were housed individually in straw pens for 14 days and thereafter in groups of 2 up to 4 calves. Calves were given six litre of cow milk in four feedings per day. The calves were weaned at a body weight of 100 kg, on average at four months. The milk consumption in this system was 720 litres per calf. The calf mortality was high, > 12 %.

Suckling system
Farm I
Motivation for the use of suckling were fighting incidences by bored cows, problems with udder health and questions of consumers, why calves did not suckle with their mother. The farmer had high expectations good social behaviour on improved udder health, and improved durability of cows. See for objective tree appendix II.
Shortly before giving birth, cows were housed separate from the herd. The first two to three days after birth, the cow was kept with her calf in a straw pen as calving stable. In case of high milk production cows were milked twice a day during the colostrum period. After three days the cow and calf integrated with the dairy herd. The herd was housed in a deep litter stable. In the start of the experimental period, the calves stayed with their mother for three months and consumption of milk was ad libitum. After the experimental period the farmer introduced multiple suckling. This to limit the milk consumption of the calves and to avoid problems with milk ejection, the duration of the suckling period with its own mother was only 14 –30 days. Thereafter a multiple suckling without additional milking was used. A nurse cow, preferably an ‘output cow’ with high somatic cell count, or a suckling cow with poor milk ejection (in the milking parlour) was used. In the calf crèche the calves had ad libitum access to grass silage and concentrates. The duration of the suckling period was on average 90 days. In multiple suckling, two to three calves were suckling one nurse cow. The milk consumption of the calves was therefore not ad libitum but dependant on the number of calves suckling. After separation of cow and calf, fence-line contact was still possible. The weaning method was therefore gradual by decreasing the milk consumption with the use of nurse cows and by allowing tactile, visual and audio contact with the mother after weaning.

Farm II
Motivation for the use of suckling was high calf mortality and high replacement of dairy cows. The farmer had high expectations of increased durability of calves and cows, resulting in lower calf mortality and decreased replacement. For the objective tree of the second farmer see appendix III
Shortly before giving birth, cows were housed separate from the herd. The first two to three days after birth the cow stayed with her calf in a stray pen as calving stable. Thereafter cow and calf joined the herd in the cubicle stable. The cows were milked twice a day pre weaning. The calves had continuous access to the calf crèche, a straw pen which was not accessible for the herd. The calves were locked in the calf crèche during milking two times daily, for two hours. In the calf crèche the calves had access to water and grass silage ad libitum. The calves had also access to the grass silage of the cows and made regular use of this possibility. No concentrates were fed to the calves pre weaning. The pre weaning period lasted on average 65 days. In the last week of the suckling period the calves were kept with a nurse cow in groups of two to three calves. The weaning method was gradual, by decreasing the milk consumption by multiple suckling and allowing contact with the cow after separation.

3.2 Calf growth

3.2.1 Weight development of calves on Farm I

Weight gain
The weight gain of the suckling calves on the first farm is shown in Table 2. Weight gains (in kg/ day) of suckling calves pre and post weaning are presented for farm I. The recommended weight gain for bucket feeding is given in the last column (Anonymous, 1993). This standard weight is an average of 0.55 kg in the first 2.5 months and an average of 0.85 kg from three to eight months. As an average over a long period it does not show the impaired growth post weaning.
During the pre weaning period a high daily weight gain was accomplished. However after weaning a decline in weight gain can be observed. This impaired weight gain immediately after weaning is common in different feeding methods. The weight development of suckling calves is shown in Figure 2.

Table 2 Daily weight gain, weight and age at weaning of suckling calves pre and post weaning during of fist 6 months at farm I

	Suckling calves pre weaning	Suckling calves post weaning	Std. Deviation	Recommended growth
Age at weaning (in days)	84	nd	18	56-70
Weight at weaning (in kg)	146	nd	16	65-75
0-14 days (kg/day)	0.30	nd	0.61	
Month 1 (kg/day)	1.04	nd	0.23	0.55
Month 2 (kg/day)	1.09	nd	0.41	
Month 3 (kg/day)	1.07	nd	0.30	
Month 4 (kg/day)	nd	0.54	0.36	0.85
Month 5 (kg/day)	nd	0.76	0.27	
Month 6 (kg/day)	nd	1.23	0.85	

nd= not determined

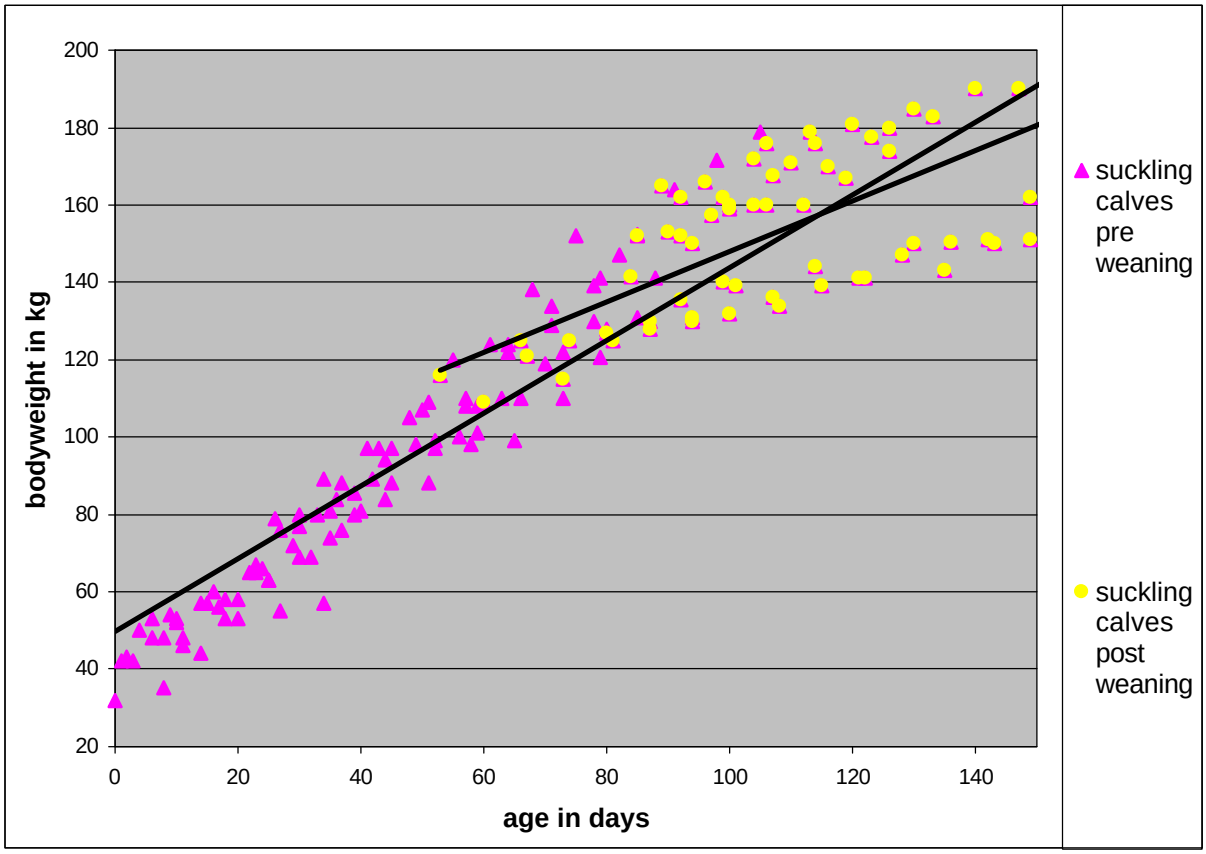

Figure 2 Development of body weight of suckling calves at farm I

The triangles are the weight development pre weaning. The round dots are presenting the post-weaning period.
The linear regression lines: Y= A+B*X
Suckling calves pre weaning: Body weight = 33.53 + 1.3 * age, R^2=93.4, RSD=8.37, N=82
Suckling calves post weaning: Body weight = 81.77 + 0.66 * age, R^2=58.2, RSD=16.9, N=68

3.2.2 Weight development of calves on Farm II

Weight development during pre weaning period
An overview of the weight development of suckling and bucket-fed calves is given in Figure 4. All measurements of all animals of Farm II were used. The daily weight gain, age at weaning and weight at weaning are presented in Table 4. Growth of bucket-fed calves was not measured for the first 14 days.

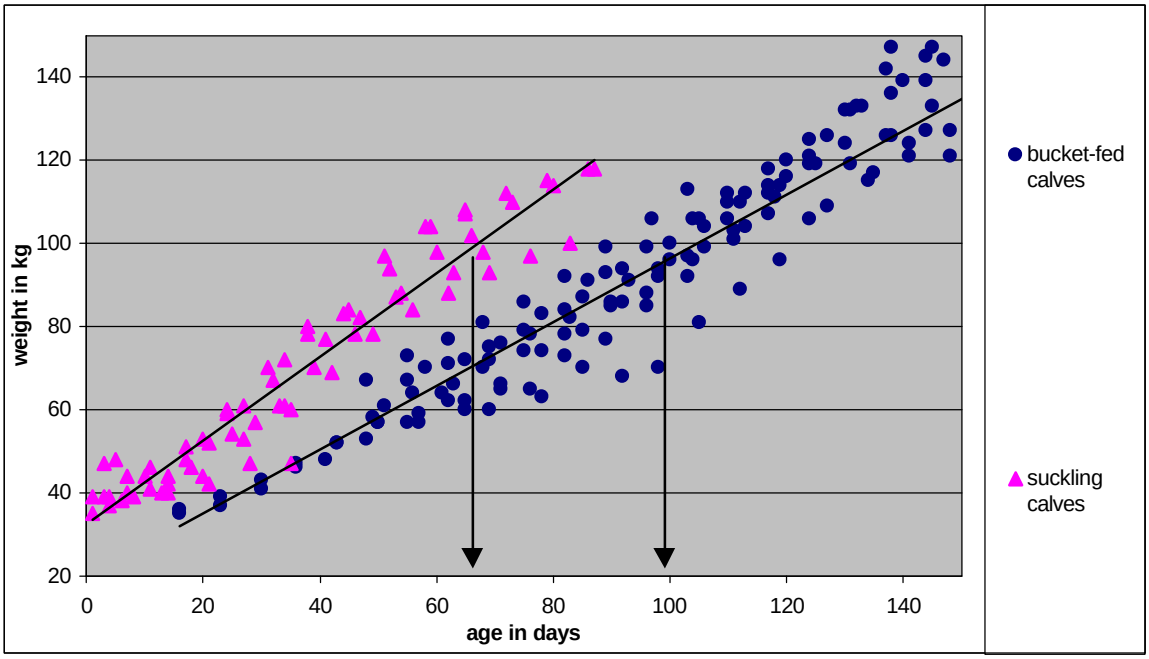

Figure 4 Weight development of the calves at Farm II.
The triangles are suckling calves in pre and post weaning. The round dots are bucket-fed pre and post weaning.
The arrows indicate the average age at weaning.
The linear regression lines: Y= A+B*X
Suckling calves pre and post weaning: Body weight = 30.41 + 1.05 * age, R^2=99.2, RSD=6.9, N=63
Bucket-fed calves pre and post weaning: Body weight =18.96 + 0.77 * age, R^2=93.8, RSD=8.58, N=149

The age at weaning differed between the calves; some suckler calves were weaned at two and some at three months. The bucket-fed calves were weaned at three and some at four months. The trend line indicates linear growth development. Right after weaning an impaired growth for several weeks is described in literature. This impaired growth could also be observed in Table 3 in average daily weight gain of bucket-fed calves in month five.
The bucket-fed calves show significantly less growth in the first month pre weaning than of suckling calves. The mean growth of suckling calves is 0.97 vs. 0.59 for bucket-fed calves. The difference is 0.38 kg per day kg per day, P< 0.1.For the second month pre weaning a significant difference is also found. The mean growth of suckling calves is 0.50 kg higher than growth of bucket-fed calves P< 0.001

Body weight and age at weaning
Table 3 shows that the body weight at weaning of bucket-fed calves was significantly higher than of suckling calves, 111 kg vs. 101 kg, P< 0.05. The weight at weaning seems to be higher compared to the recommended weight of 65-75 kg at weaning.
There was a large difference in age at weaning caused by the high weight gain by suckling. The age of bucket-fed calves was significantly higher as of suckling calves, 118 days vs. 65 days P<0.001.

The age of 65 days at weaning was not too young, compared to the recommended growth, see Table 3. Weaning at 118 days was late. Unless the introduction of a suckling system the farmer still aimed at a bodyweight of 100 kg at weaning. Suckling calves reached a body weight of 100 kg in less days and were therefore weaned earlier. By shortening the pre weaning period the milk consumption of calves is restricted and therefore milk consumption costs were within acceptable limits for this farmer.

Table 3 Statistic results on daily weight gain, weight and age at weaning of bucket-fed and suckling calves pre and post weaning of the fist 6 months at farm II
nd = not determined, recommended growth after Anonymous (1993)

	Bucket-fed calves pre weaning	Bucket-fed post weaning	Std. Deviation Bucket-fed calves	Suckling calves pre weaning	Std. Deviation Suckling calves	P	Std. Error differ-ence	Recommen-ded growth
Age at weaning (in days)	118	nd	9.7	65	2.2	<0.01	4.5	56-70
Weight at weaning(in kg)	111	nd	7.4	101	8.1	<0.05	4.2	65-75
0-14 (kg/day)	nd	nd	0.35	0.37	0.3	nd	nd	
Month 1(kg/day)	0.59	nd	0.03	0.97	0.3	< 0.1	0.2	0.55
Month 2(kg/day)	0.50	nd	0.34	1.00	0.2	<0.01	0.2	0.55
Month 3(kg/day)	0.77	nd	0.30	nd	nd	nd	nd	0.85
Month 4(kg/day)	1.07	nd	0.17	nd	nd	nd	nd	0.85
Month 5(kg/day)	nd	0.71	0.22	nd	nd	nd	nd	0.85
Month 6(kg/day)	nd	0.85	0.22	nd	nd	nd	nd	0.85

3.3 Milk production

3.3.1 Milk production on Farm I

The production as ISK of non-suckler and suckled cows of Farm I pre and post weaning are presented in Figure 5. In Figure 6 the milk production in kg of milk of 8 individual suckler cows is given. An increase of measured milk production of 10- 15 litres can be observed for two cows after weaning. Figure 7 shows the milk production of non-suckler cows in BSK and of suckler cows in ISK.

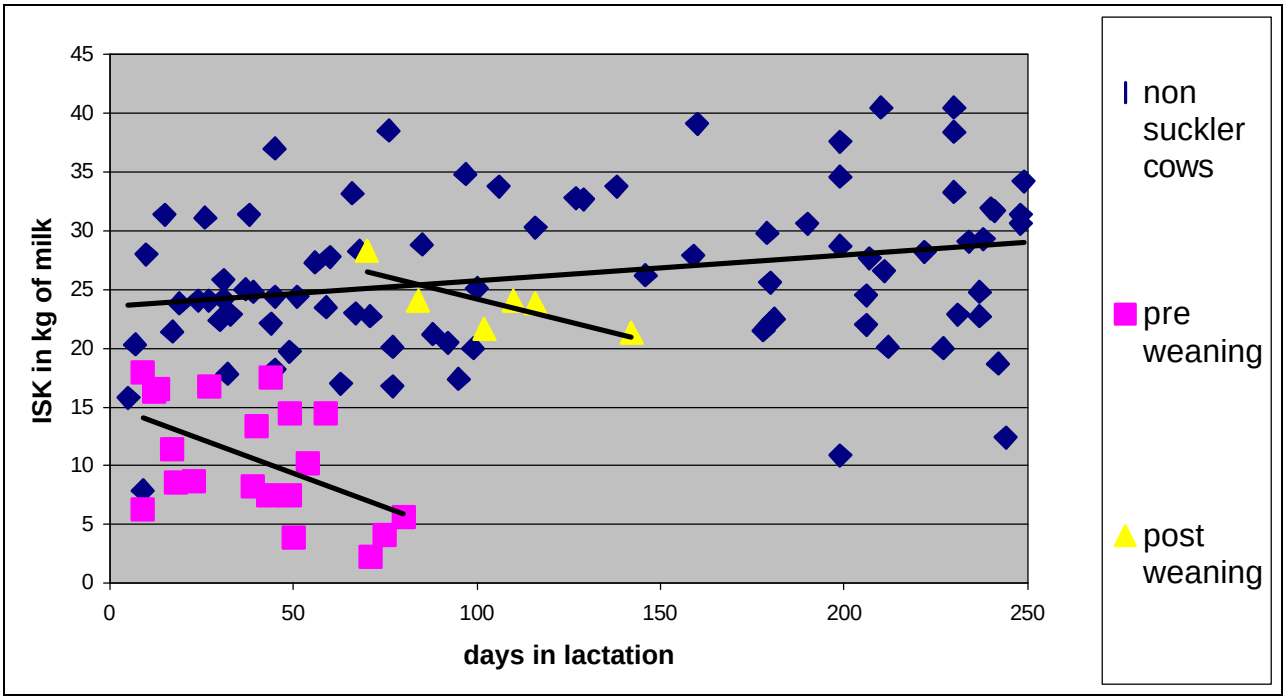

Figure 5 Milk production as ISK in kg per day at Farm I
The linear regression lines: Y= A+B*X
Non-suckled cows: Milk production = 23.52 + 0.02 * days, R^2=6.3, RSD=6.56, N=81
Suckled cows pre weaning: Milk production = 15.07 + -0.11 * days, R^2=22.1, RSD=4.43, N= 19
Suckled cows post weaning: Milk production = 31.9 + -0.08 * days, R^2=51.2, RSD=1.73, N=5

In Figure 7 the ISK of individual suckler cows and BSK of the farm is presented.
The values from the suckler cows were measured in the pre and post weaning period. The BSK values were measured at 5 times during the period of 5 months.

The non-suckler cows show a large variation. This is also indicated by a low R^2 of the regression line in Figure 5. However the average of all ISK values of non-suckler cows levelled out these large differences and no significant difference with the ISK values of suckler cows post weaning. Suckler cow show significantly less measured milk production during the pre weaning period. This difference varies from 13.3 kg within the suckler cow group to 15.7 kg between suckler and non suckler cows. Statistic results are presented in Table 4 and 5.

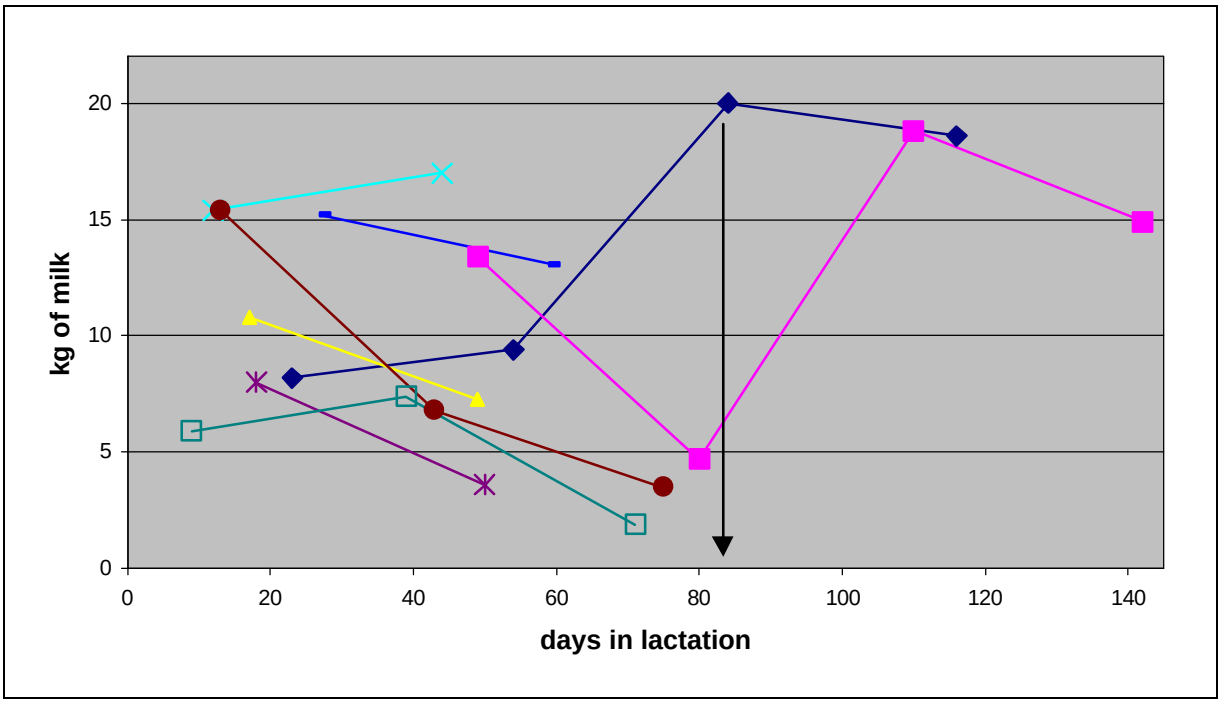

Figure 6 Milk production in kg of milk of 8 individual suckler cows.
The different lines represent the individual suckler cows. The arrow indicates the time of weaning.

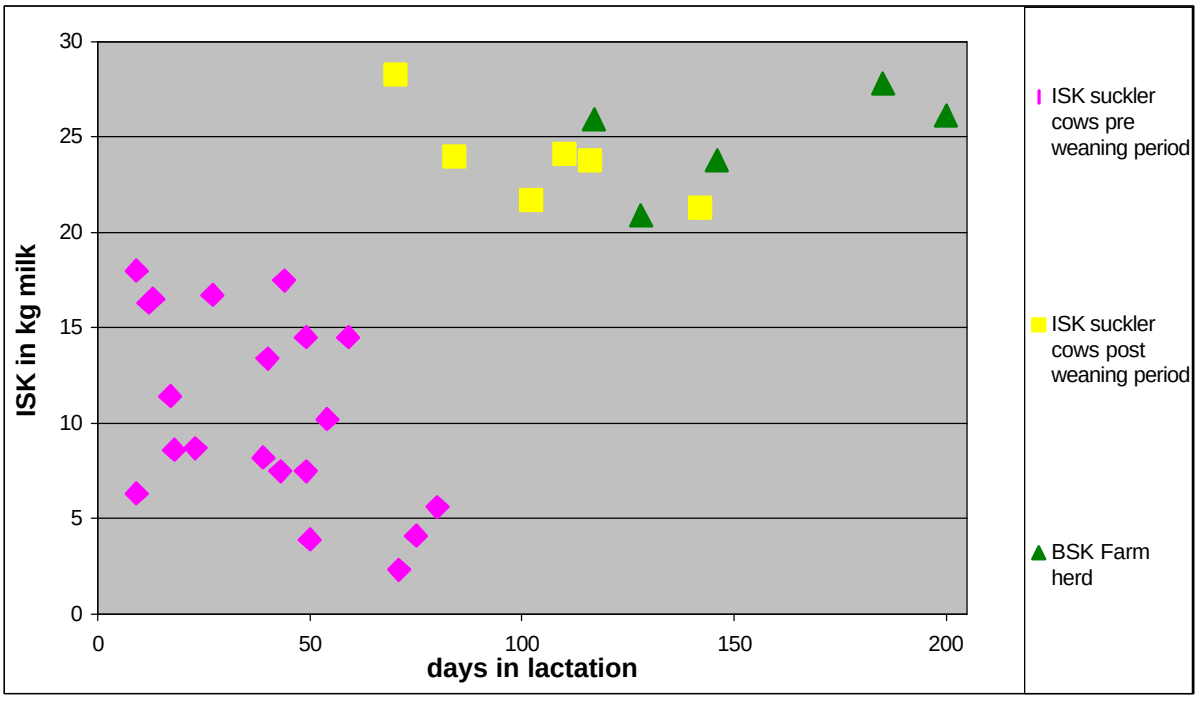

Figure 7 BSK of the herd and ISK of suckler cows at farm I.

Table 4 Milk production of suckler and non suckler cows.

Milk production per period in kg /day	Suckler cows	Non suckler cows	SE	P
Pre weaning	10.6	26.3	1.6	0.000
n	20	82		
Post weaning	23.9	26.3	2.8	ns
n	6	82		

Results are based on ISK values in kg milk/day. Production of non suckler cows is of all lactation stages
SE: Standard Error, ns: Not significant

Table 5 Milk production suckler cows pre and post weaning

Milk production in kg/ day	Suckler cows pre weaning	Suckler cows post weaning	SE	P
Milk production	10.6	23.9	2.1	0.000
n	20	6		

Results are based on ISK values in kg milk/day. Production of non suckler cows is of all lactation stages.
SE: Standard Error, ns: Not significant

Somatic cell count

To compare the two groups on somatic cell count in the pre and post weaning period, the post weaning period for non suckling cows was defined as the period after 84 lactation days at farm I. Statistic results on somatic cellcount are presented in Table 6.

No significant effect on cell count is found between suckler and non suckler cows.
The somatic cell count during the pre and post weaning did not increase or decrease significantly.

Table 6 Somatic cell count pre and post weaning

Period	Suckler cows	Non suckler cows	SE	P
Pre weaning(<84days)	311	239	nd	ns
n	21	34		
Post weaning(>84days)	296	600	nd	ns
n	4	9		

Somatic cell count in cells * 1000,
SE: Standard Error, nd: not determined, ns: Not significant

3.3.2 Milk production on farm II

The post-weaning period, for non-suckled cows, was defined as the period after 65 lactation days at farm II. The production in kg of milk of non-suckled and suckled cows of farm II pre and post weaning are presented in Figure 8. Little difference between suckler and non-suckler cows can be observed. In Figure 9 the milk production of 2 selected individual suckler cows is given. Only in figure 9 an increase of 10 to 15 kg can be observed for suckler cows after weaning.

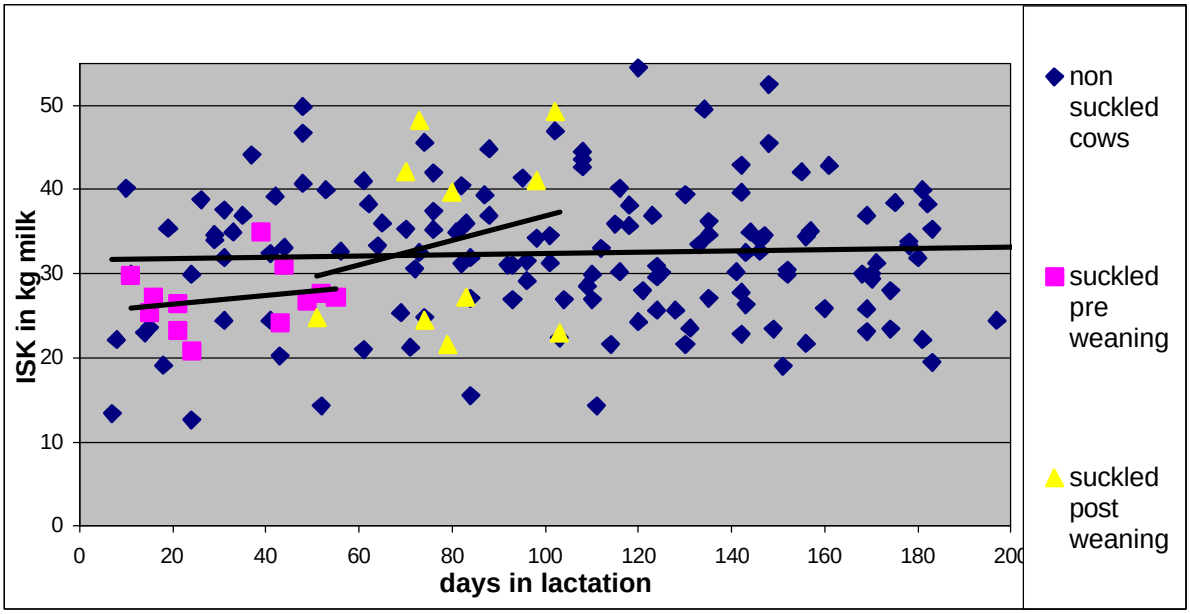

Figure 8 The milk production in kg per day at farm II.
The linear regression lines: Y= A+B*X
Non-suckled cows: Milk production = 31.64 * 0.01 days, R^2=0.3, RSD=8.39, N=155
Suckled cows pre weaning: Milk production = 25.38 + 0.05 * days, R^2=4.9, RSD=3.78, N=11
Suckled cows post weaning: Milk production = 10.5 + 0.29 * days, R^2=21.8, RSD 11.1, N=10

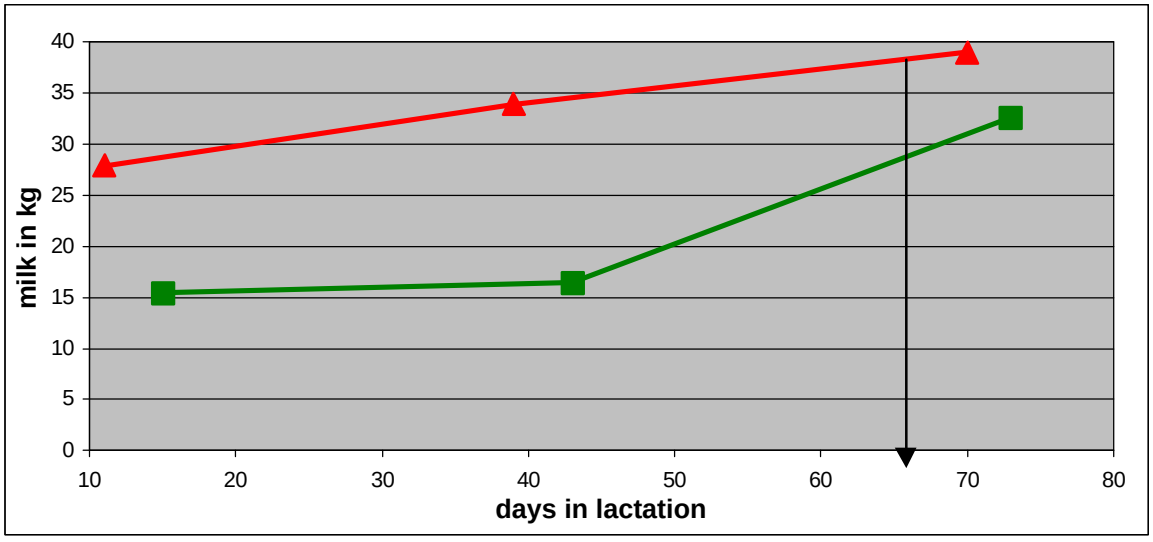

Figure 9 Measured milk production of two individual suckler cows during three months
The arrow indicated time of weaning. The values right of the arrow are milk productions after weaning.

Milk quantity

The statistic results on milk quantity are presented in Table 7 and 8. Statistic results on soamatic cell count are presented in Table 9. Suckler cow show on average 3.7 kg less measured milk production during the pre weaning period than non-suckled cows.

Table 7 Milk production of suckler and non suckler cows.

Milk production per period in kg /day	Suckler cows	Non suckler cows	SE	P
Pre weaning	28.8	32.5	2.2	0.094
n	16	156		
Post weaning	30.8	32.5	nd	ns
n	7	156		

Results are based on ISK values in kg milk/day. Production of non suckler cows is of all lactation stages
SE: Standard Error, nd: not determined, ns: Not significant

Table 8 Milk production suckler cows pre and post weaning

Milk production in kg/ day	Suckler cows Pre weaning	Suckler cows Post weaning	SE	P
Milk production	28.8	30.8	nd	ns
n	16	7		

Results are based on ISK values in kg milk/day. Production of non suckler cows is of all lactation stages. SE: Standard Error, nd: not determined, ns: Not significant

Somatic cell count

No significant effect on somatic cell count is found between suckler and non suckler cows. The somatic cell count during the pre and post weaning did not increase or decrease significantly.

Table 9 Somatic cell count pre and post weaning

Period	Suckler cows	Non suckler cows	SE	P
Pre weaning (< 65 days)	130	199	nd	ns
n	18	21		
Post weaning(> 65 days)	657	87	nd	ns
n	7	14		

Somatic cell count in cells * 1000,SE: Standard Error, nd: not determined, ns: Not significant

3.4 Estimation of milk consumption of the calves at Farm I and II

At both case study farms a relatively high daily weight gain was observed. The milk intake of the calves during the pre weaning period was ad libitum. At Farm I a significant difference in mean milk production in ISK from 13.3 to 15.7 kg was found. At farm II a significant difference in mean milk production of 3.7 was found. Figure 8 shows the large variation within the non-suckled cows group. By observations of the farmer it was known that suckling calves at Farm II drank also with other cows as their mother. Different cows allowed suckling by calves other as their own. Non suckler cows were observed to allow suckling of the suckling calves too. According to the farmer it seemed that non suckler cows in this pilot, which had previous experience suckling a calf, for example short term suckling with a bull calf, were often observed to allow suckling to suckling calves. At Farm II this “borrowing” of milk was observed daily while on Farm I this behaviour was rarely observed.
Figure 9 shows the measured milk production of two individual suckler cows who were rarely observed to allow suckling by other calves as their own. With these cows a clear difference between pre and post weaning measured milk production can be observed. At both farms a high weight gain of suckling calves is found. It is therefore assumed that calves at both farms drank milk ad libitum and milk consumption at both farms is comparable.

The milk consumption of the calves at Farm II is estimated with use of the data available of Farm I. Farm I used at the start of the experiment a multiple suckling system with additional milking for on average 84 days per calf. A milk consumption of 10 kg a day in the first two weeks and 15 kg per day from day 14 to 84, makes a total milk consumption of 1190 kg per calf, on average 14.2 kg a day.
At the end of the experimental period farmers decided to make use of multiple suckling without additional milking for a part of the pre weaning period. Nurse cows were selected by the farmers and had a daily milk yield of 20 kg.
The milk consumption of bucket feeding and suckling systems of the farms is presented in Table 10. The use of suckling increases milk consumption costs at Farm I with 120 euro per calf and at Farm II with 64 euro, based on an organic milk price of 40 euro cent. On average produce cows at Farm I and II respectively 5373 and 6936 kg milk in 305 days. The production of one extra cow on yearly basis will compensate the extra milk consumption of 15 and 25 suckling calves at respectively Farm I and II.

At Farm I the milk consumption by the calves was limited by decreasing the duration of the single suckling period and made use of multiple suckling with a nurse cow, this change of method reduced the milk consumption from 15 to 10 kg a day. At Farm II suckling calves reached a bodyweight of 100 kg at a younger age and therefore weaned earlier. The total duration of all suckling methods was shorter, this reduced the milk consumption at Farm II.

Table 10 Consumption of bucket feeding, single and multiple suckling systems of two case study farms.

The farms have made use of a bucket feeding system in the past. During the experiment the farms made use of a combination of single and multiple suckling as calf rearing method. The number of replacement calves differs between the farms. Farm I used 15 replacement calves per year, Farm II 25 replacement calves per year.

Milk consumption	Farm I	Farm II
Bucket feeding system		
Milk consumption 4 * 1.5 kg	6 kg/ calf/ day	6 kg/ calf/ day
Duration	3 months	4 months
Total consumption by bucket feeding per calf	540 kg/ calf	720 kg/ calf
Total consumption per year by all calves	8100 kg/ year	18000 kg/year
Single suckling		
Milk consumption 10 kg a day	14 days	14 days
Milk consumption 15 kg a day	Not in use	46 days
Multiple suckling		
Milk consumption 10 kg a day	70 days	5 days
Total suckling consumption per calf	840 kg/ calf	880 kg/ calf
Total suckling consumption, per year by all calves	12600 kg/ year	22000 kg/ year
Extra consumption by suckling		
Extra consumption per calf, bucket feeding vs. suckling	300 kg milk per calf	160 kg milk per calf
Extra consumption per year by all calves, bucket feeding vs. suckling	4500 kg milk per year	4000 kg milk per year

3.5 The naturalness diagram

As mentioned in chapter one is naturalness an important aspect of suckling systems. The improvement of naturalness was an important argument for farmer I and II for the use of suckling. See paragraph 1.5.5 for explanation of the naturalness diagram. In two diagrams, an overview is given of the attitude and opinion of the farmers, on bucket feeding and suckling. It is indicated, in the diagram, if the opinion or attitude is valid for the bucket feeding method (1), the suckling method (2) or for both methods (1 & 2).
Table 11 shows the diagram of Farmer I and Table 12 for Farmer II.

Opinions valid for bucket feeding only, were mostly found in the category no chemistry. The 'no chemistry' and 'agro-ecology' aspects were mentioned often for both methods. While 'integrity' aspects were mentioned almost exclusively for the suckling system.
It could be concluded that some of the 'no chemistry' aspects decrease with the introduction of a suckling system. In both diagrams more agro ecological aspects and integrity aspects were mentioned for suckling systems.

Box 1 Nature of the animal
According to one of the farmers, it is not like we discovered something new. The maternal behaviour was always there. However we did not leave room for this behaviour in the system, it was regarded as inconvenient. I had to switch a button. And now I am surprised how easy and beautiful it is. It is no trouble; it is already in the nature of the animal.

Effect on the development of a suckling system
With the introduction of a suckling system it seemed that the farmers made better use of resources within the system. The cows (the mothers) were considered to be the 'natural recourses' which strengthen the system. By the utilization of mother qualities of the cows, their care and milk, to produce healthy and strong calves who will be the cows for the future.

For the first farmer, is suckling very important for the calf. The calf is considered to be the cow of the future. Single suckling with the mother was allowed for replacement calves for 14 days. Thereafter multiple suckling system with a nurse cow was used to develop social behaviour and prevent problems with frustrated animals. For the second farmer suckling is very important for cows and calves. This farmer makes use of single suckling systems for all calves and allowed suckling by bull calves for 10 days. In this way all cows were allowed to suckle their calves.

Table 11 Naturalness diagram for Farmer I

Value dimensions Naturalness approaches	Cognitive Vision at	Emotional Attitude towards	Normative What to do and what not	Practical examples
No-Chemistry	• Calf rearing is needed for replacement of the herd (1) • Good nutrition is cow milk (1 & 2)) • Disease prevention by singe housing (preventing contamination) (1)	• Farmer is controller • Control on milk intake (1 & 2) • Control on cross contamination between animals (1)	• Feeding cow milk (1 & 2) • Feeding Colostrum (1 & 2) • No feeding of 'waste'milk with antibiotics (1 & 2) • Individual housing (1) • Feeding of milk with a high cell count (1 & 2)	• Use of output cow, with a high cell count as foster parent.
Agro-Ecology aspect	• Calf rearing is the rearing of future cows (1 & 2) • Calf rearing is the rearing of animals for a regional and soil bound system. "development of a farm specific cow" (1 & 2) • Disease prevention by the use of healthy food (1 & 2) • Disease prevention by the use of homeopathy "To enhance the immune system from within" (1 & 2)	• Farmer is controller(1 & 2) • Humans have the right to keep animals for own use and profit within economical and practical limits (1 & 2)	• Calves for replacement are suckling (2) • Bull calves are sometimes suckling (when practical) (2) • Economic use of 'output' cows as foster parent. "Efficient use of cows which are not suitable for the production (2)	• Developments of the suckling system (2) • Experiment with few bull calves with the mother(2) • Suckling for all replacement calves(2) • Suckling for some bull calves(2) • Experimenting with a multiple suckling system(2) • Experimenting with one calf in a suckling system for beef production (2)
Integrity acpect	• Calf rearing is raising animals according to their behavioural needs. "I want a good development of the social behaviour so I will not have problems with frustrated cows"(2).	• Farmer is participant(1 & 2) • Respect for the behavioural needs of the animal (2) • Be open-minded towards emotional needs of the animal. "when I separate calf and cow I use Ignatia against restlessness and loss"(2).	• Calves for replacement are allowed to suckle (2) • Almost all cows can suckle their calf for 14 days (2)	• Enjoying the presence of maternal behaviour (2) • Experimenting with a system to give all calves the opportunity to suckle, also a suckling system with bull calves for beef production (2)

Table 12 Naturalness diagram for farmer II

Value dimensions Naturalness approaches	Cognitive Vision at	Emotional Attitude towards	Normative What to do and what not	Practical examples
No-Chemistry	• Calf rearing is needed for replacement of the herd (1) • Good nutrition is cow milk (1 & 2) • Disease prevention by singe housing (preventing contamination) (1)	• Farmer is controller(1) • Control on milk intake and cross contamination between animals (1)	• Feeding cow milk (1 & 2) • Feeding Colostrum (1 & 2) • No feeding of 'waste'milk with antibiotics (1 & 2) • No feeding of high cell count milk (1 & 2) • Individual housing (1)	• Farmer invested one year ago in single housing (Igloo's) (1)
Agro-Ecology aspect	• Calf rearing is the rearing of future cows (1 & 2) • Good nutrition is mother milk (2) • Disease prevention by good nutrition, mother care and alertness of the farmer (2) • Mother care is better as care of the farmer (2) • Maternal behaviour activates cow and calf (2)	• Farmer is participant(1 & 2) • Humans have the right to keep animals for own use and profit within economical and practical limits (1 & 2) • Farmer is part of the system. "There are more differences between farmers as between cows" "The cattle are like a mirror of the farmer"(2).	• All calves suckle their mother for activation of cow and calf (2) • Trust calf to the mother (2)	• Developments of the suckling system (2) • Experiment with one bull calf with the mother "The calf would be sold anyway, so the economic risk was small"(2). • Give a cow a chance to activate her inactive and apathetic calf. An experiment with a very positive result, the calf suckled the mother within seconds after reunion within (2) • Suckling for all replacement calves (2) • Suckling for all calves born (2)
Integrity acpect	• Calf rearing is aimed at the development of strong and sustainable cows (1 & 2) • Calf rearing gives room to maternal behaviour and species specific behaviour (suckling motivation) (2) • Maternal behaviour is also a piece of the lifecycle and therefore a sort of fulfilment and meaning for the animal (2)	• Farmer is participant • Respect for the behavioural needs of the animal (2) • Be open-minded towards emotional needs of the animal (2)	• All cows can suckle their own or other calves (2)	• Enjoying the presence of maternal behaviour (2) • Observing 'dancing' calves running in the stable (2) • Give a cow with a dead calf the opportunity to find comfort in the care for another calf (2) • Borrowing of milk is not allowed and not considered as a problem (2)

3.6 Effects of the bucket feeding system

In the problem tree in Figure 10 the causes and effects of bucket feeding are presented. Not every farmer or expert experiences the current system as problematic. They can consider the effects as not relevant or not problematic. The problem tree is theoretic and based on the literature study of chapter 1. However some farmers and experts see the current situation as problematic and are experimenting, practising and promoting suckler systems. Some of the problems presented in the problem tree are arguments of farmers to experiment with suckling systems.

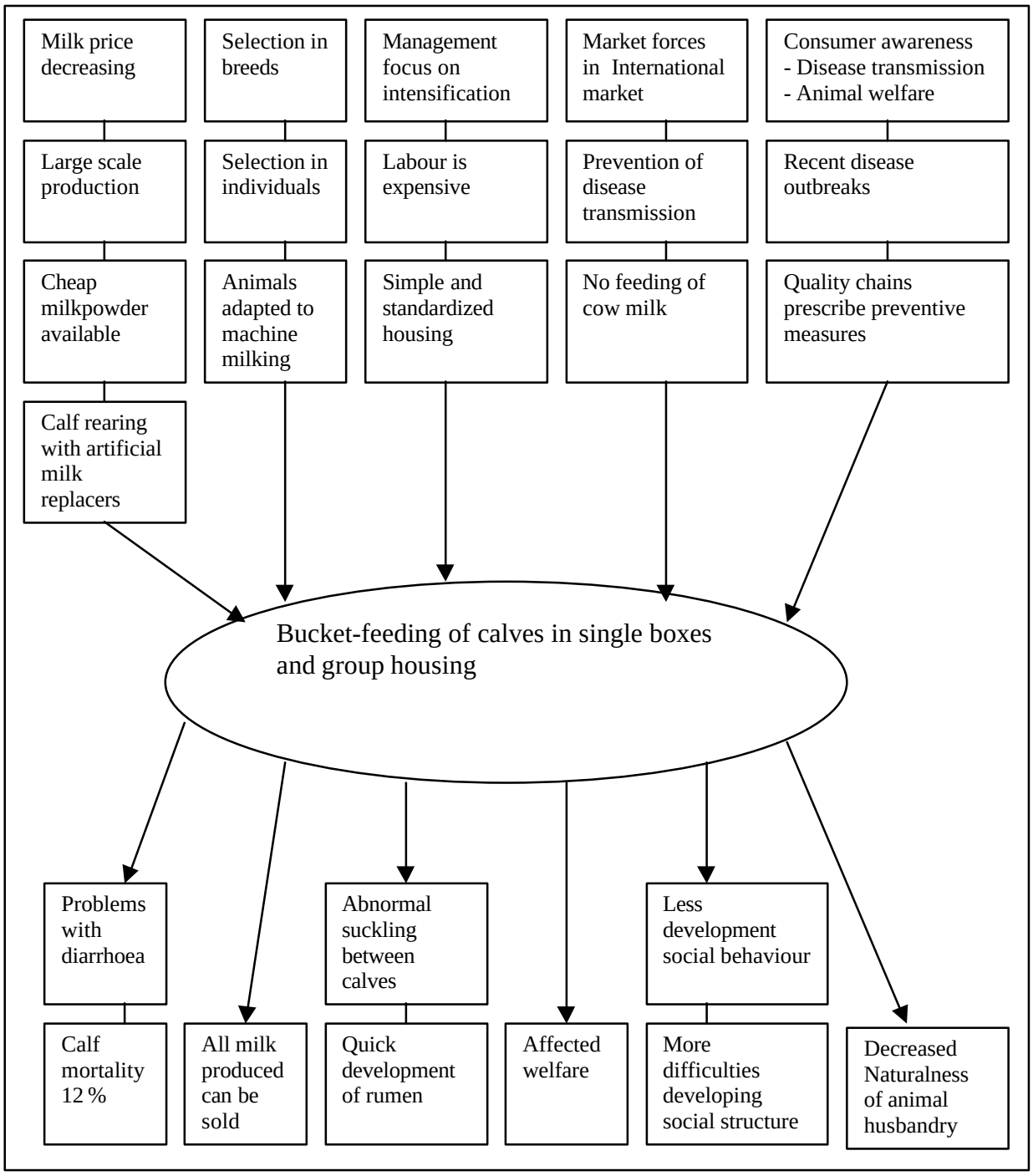

Figure 10 Problem tree with the causes and effects of the bucket feeding system

3.7 Motivation of farmers to make use of suckling

Arguments for and against suckling systems are based on the experience and expectations farmers have of suckling systems. Beside the problems of the bucket feeding system are other arguments mentioned. Especially these unexpected arguments are mentioned so often that they were considered as strengths of suckling. The reasons of farmers to change their calf rearing system and opinions of experts on suckling systems are summarized in an objective tree in Figure 11.
The arguments are based on personal experiences and expectations and are therefore subjective. Nevertheless the objective tree gives a clear overview of the goals and objectives of suckling systems, of the desired future situation of these farmers and the ideas of the experts on future animal husbandry systems.

For explanation of the arguments and quotes see appendix IV.

Box 2 Social behaviour
According to Francien de Jonge, from the department animal and Society of the University of Utrecht: "When the calf gets separated from it mother, I expect it to be in its development more sensitive for stressors and social problems between animals. The function of play between animals and the interaction between the elder and younger are thought to be to learn social skill to function well in a social structure as a herd. I expect that animals separated from their mothers and kept in peer groups have social problems. Problems because of missing skills we don't even know because we never see 'normal' herds. I expect butting problems in horned herds to decrease when animals grow up within the herd."

Box 3 Disrupted suckling period
Liesbeth Ellinger de Sonnavile is a veterinarian and works with homeopathy for companion- and farm animals. " A few years ago I heard of a homeopathic product, a potency of mother milk, used for human breast problems,- infections and- tumours. This product is used when the suckling period is disrupted, when the mother died, early weaning or early-bottle-feeding. The results with this potency of mother milk were positive. In own experiments with early weaned kittens with problems at later age were positive as well. We see in dairy faming substantial problems with udder health and immediate separation of calf from their mothers is common practice. You could conclude that to improve udder health you should at least not disturb the suckling period by removing the calf immediately after birth. The positive effect could be as well on the calf as on its mother. A few dairy farms experiment at the moment with the use of the potention of mother milk in case of udder problems. Homeopathic potency works at an energetic level. When a calf drinks with its mother it is not only milk with a feed-value, which is transferred. There is an energy transfer on another level between the mother and the calf. In a homeopathic potency you try to catch this energy."

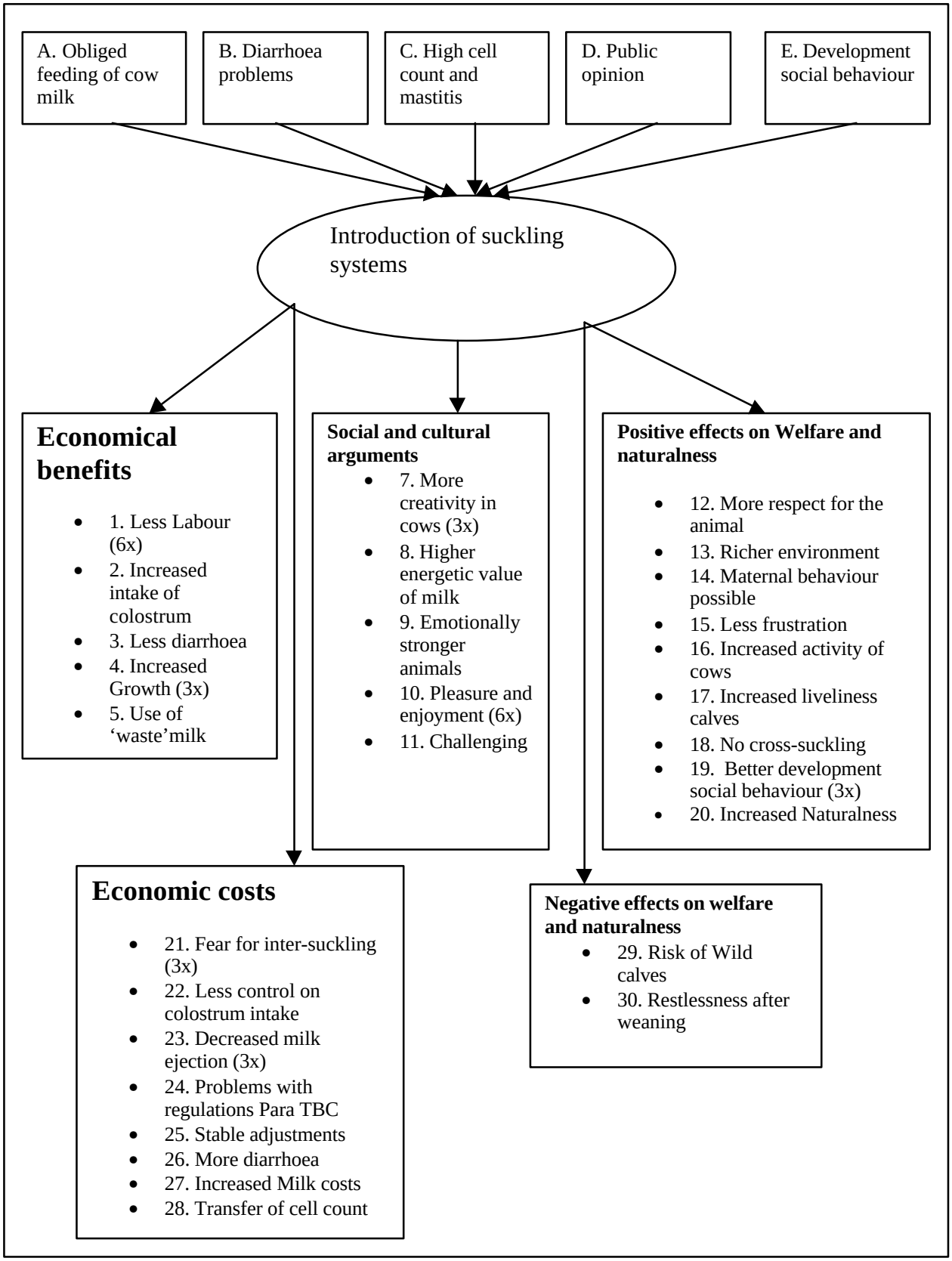

Figure 11 The Objective tree, The causes of the introduction of suckling systems, the positive and negative effects of suckling systems as experienced and expected by farmer and experts.
For explanation of arguments see appendix IV

Box 4 Ignatia
According to Liesbeth Ellinger de Sonnaville: "Ignatia is a homeopathic product which is know for its effect due to grief or distress over separation or death. Very strong grief. A lot of people are enthousiastic over this product. Calling by animals, cows and calves, is often seen after seperation and several people see a decline in distress within an hour after use of Ignatia. It seems the animals can cope with the situation .

Shared arguments of three farmers and more

Strengths of a suckling system
The decreased amount of labour needed was mentioned six times. This argument us usually mentioned at first. The labour involved, was according to the farmer little and easy.
Three farmers indicated that the calves show increased growth, less diarrhoea, increased liveliness and are emotionally stronger. The pleasure farmers have to watch the calves and the enjoyment they experience practicing a suckling system was mentioned by six farmers and for some of them the most important feature. The increased activity of the cows, especially short after partum was regarded as positive.

Weaknesses of a suckling system
The fear for intersuckling was mentioned three times and reason for two farmers to let bull calves suckle only. This argument was not funded on negative experience of these farmers, however it should not be neglected. Three farmers mentioned the risk of poor milk ejection. Two of them mentioned this as negative side effect, however they did not consider it as a problem. The third did experience the poor milk ejection as a problem.

Conflicting arguments
The experiences with diarrhoea incidence are different. For some farmers the high incidence of diarrhoea with bucket feeding was reason to experiment with suckling systems to improve their situation. Some farmer experienced no problems with diarrhoea with suckling (anymore). One farmer did experience problems with diarrhoea especially in the first 10 days. Little control on the intake of colostrum was also mentioned as weakness while others regarded the uptake of colostrum as strength. In this case it is not the uptake, which is the problem but the fact the farmer cannot control or estimate the uptake and is unable to judge if the uptake is sufficient. Alertness of the farmer is required and other skills to judge the sufficient uptake of the calf. On this subject the farmers stressed the importance of a well-established bond between mother and calf. The use of a calf pen was regarded important, to keep cow and calf separate from the herd for a couple of days and to assure good bonding and control of sufficient milk intake.

Negative effects of the introduction of a suckling system were decreased by the farmers by using only a short suckling period, letting only bull calves or only calves for replacement suckle.

4 Discussion

The calf growth at both case study farms

The conditions of calf rearing were under control of the farmer and were dependent on farm conditions and management practices of the farmer. The treatments could therefore not be standardized and controlled in this experiment. The outcome of the experiments is only applicable on the case study farms and their typical farming system. The results can therefore only give an indication and overview of the weight development of bucket-fed and suckling calves and their milk consumption on the two farms. Because the growth of calves is not exactly linear, it is not possible to compare calves weaned at different ages. More data of more calves are needed.

The benefit of increased growth of suckling calves, previously described by Bar-peled (1997), is increased height at the withers, which is indicated to increase milk production. However Krohn, (2001) states: a high daily gain obtained through a high milk intake is not necessarily beneficial, because it results in a decreased intake of roughage and increases the difficulties associated with weaning. It was not possible to assess if the above-mentioned impaired growth was present farm II, because bucket-fed calves were weaned at later age than suckling calves. To prevent an impaired growth the farmers of both farms limited the milk consumption at the end of the pre weaning period to increase the intake of roughage. It is well possible, that the management of the farmers decreases the negative side effects of a high daily weight gain.

At farm II the variation in ISK, in the pre weaning period within the treatment groups, non suckler and suckler, was very large. The explanation for this very large difference between animals and little difference between treatment groups at farm II was unexpected. The farmer observed calves ‘borrow’ milk from other dams as their mother.

Cause effect relationships are not clear from the naturalness diagram. However there seemed to be a relation between choices farmers made and their opinion on naturalness. It is possible that introduction of the suckling system influences the opinion of the farmer on agro-ecology and integrity aspects of his system. At the same time agro-ecological and integrity aspects can initiate farmers to introduce a suckling system. The development of an increasing number of agro-ecological and integrity aspects was also observed when farmers convert from conventional farming to organic farming (Bor, 2002).

The case study farmers as well as the other interviewed farmers had high expectations of the suckling system. The experiences were sometimes conflicting for example on diarrhoea incidence. One farmer had a high incidence of diarrhoea while other farmers had no problems with diarrhoea at all. Sometimes an aspect was considered as a problem by one farmer while the same aspect in not considered as a problem by another farmer. This is the case with poor milk ejection. This illustrates how personal and subjective the expectations were. However there are similarities between the arguments of the farmers. Many of their individual expectations were supported by studies on calf growth by Bar Peled (1997), on calf health by Earley and Fallon (1999) and Engel (2002), milk consumption, cow health and welfare by Krohn (2001), weaning method by Newberry and Swanson (2001), social behaviour by Bouissou et al (2001) and naturalness by Verhoog (2002). What the farmers did have in common is that not only economical benefits were considered as important. It seemed that social, welfare and naturalness arguments were important positive effects of suckling.

5 Conclusion

The use of a suckling system can contribute positively to economic, social/cultural, welfare and naturalness aspects of the farming system. However it can also have negative effects.
The weight gain of suckling calves at Farm I and II was high during the pre weaning period. High weight gain as a result of suckling has been described to have a positive correlation higher milk production as heifer compared to bucket-fed calves.
Suckling calves at Farm II, reached at a younger age the aimed body weight for weaning and were therefore weaned earlier as bucket-fed calves. The milk consumption at both farms was estimated at 10 kg per day in the first 14 days, with a single suckling method with additional milking. After 14 days the consumption was 15 kg per day, with a single suckling method without additional milking.
The total milk consumption of calves in the pre-weaning period of 84 days at Farm I was 300 kg per calf more with suckling than with bucket feeding. At Farm II the difference compared to bucket feeding was only 160 kg milk per calf. The increased consumption costs for Farm I and II are respectively 120 and 64 euro per calf. By the use of a multiple suckling system did Farm I limit the milk consumption to the above mentioned level. Farm II weaned the calves at an earlier age, this reduced the milk consumption in this suckling system. The farms made also use of multiple suckling systems to limit the ad libitum intake of milk and to increase the uptake of roughage.
The case study farmers, chose to use different suckling methods and different duration of suckling to reduce milk consumption to an acceptable level.
The choices farmers make are also dependant on their experience of naturalness on their farms. For the first farmer, is suckling very important for the calf. Single suckling with the mother is allowed for replacement calves for 14 days and thereafter, multiple suckling systems with a nurse cow. For the second farmer suckling is very important for cows and calves. This farmer makes use of single suckling systems and allowed suckling by bull calves for 10 days too. In this way all cows were allowed to suckle their calves. The farmers developed a suckling system corresponding with their opinion of naturalness. It can be concluded that the system and the opinion on naturalness are not static.
Increased calf growth is not the only argument of the farmers to make use of suckling. Other reasons are compulsory feeding of cow milk, diarrhoea problems with bucket feeding, high somatic cell count, mastitis, the public opinion and development of social behaviour. The expectations on positive effects of suckling are high on economic, social, welfare and naturalness aspects.
Strong points were less labour, pleasure and enjoyment and increased activity of cows. Weak points were fear for inter-suckling and decreased milk ejection. The experiences were various and not always related with the original reasons to experiment with suckling systems. The eventual success of the system will be dependent on the objectives a farmer has in mind.

It can be concluded the used systems are not static, unanimous neither are the opinions. The farmers made and enjoyed the positive effects and strengths of suckling. The negative expectations and experiences were decreased or prevented by their management. The suckling systems on the studied farm were made to measure. The effects of suckling on a farming system are therefore dependant on the type and duration of methods used.
The positive effects and high expectations of farmers and experts, together with the possible variation in methods, make the use of suckling interesting for dairy farms. The preconditions, for use of suckling as alternative calf rearing method on a larger scale, still need to be determined.

6 Recommendations

Some aspects described by this pilot need further study to analyse the pre conditions for broader use of suckling. Several suckling methods of different duration are used to incorporate the positive effects of suckling and decrease the negative effects. The effectiveness of the preventive measures of the farmers to decrease side effects, such as decreased roughage intake need to be determined.
Aspects which need further study are:

- The use of multiple suckling to improve uptake of roughage after weaning.
- The effect of suckling on udder health of the calf.
- Cause, incidence and prevention of diarrhoea in suckling systems.
- The effect of suckling on the prevalence of infectious diseases.
- The risk of inter-suckling with cows which have been allowed to suckle as calves.
- Problems with decreased milk ejection.

The expectations for the effects on the long term are high with farmers and experts. Suckling systems are thought to contribute positively to a durable cow in the future. Many farm aspects contribute to durability of cows. Comparisons on durability between farms which make use of suckling and farms that use bucket feeding are not so relevant. Comparison of durability of animals within farms are less biased.
To study the long term effects the suckling calves should be followed several lactations. At Farm I the durability of cows which were allowed to suckle as calves could be compared with older animals which were bucket fed as calves. The two treatment groups at farm II are also suitable for a comparison, with the advantage that data on weight development, are available of both treatment groups. However, this is only possible when the housing and management for these two groups stay exactly the same. The milk production in the first lactation of the two groups, bucket-fed calves and suckling calves at farm II is interesting to study. The following could be useful to collect in the following years:

- Age at first insemination
- Age at conception,
- Body weight at first calving
- Milk production in first lactation
- Udder health

When studying the production of non-suckler and suckler cows, one should be alert on the incident of milk ‘borrowing’. Individual housing of cow calf pairs will prevent this bias.

Another important aspect is disease transmission. The prevention of contamination prevalent infectious diseases is difficult. The development of a disease resistance and immunity should be studied. This in order to develop animal welfare friendly preventive measures, which are in agreement with the Dutch policy note on welfare (2002). It is the system that should change or develop towards the needs of the animals and animals husbandry systems should be an environment in which they can express their natural behaviour.

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List of appendices

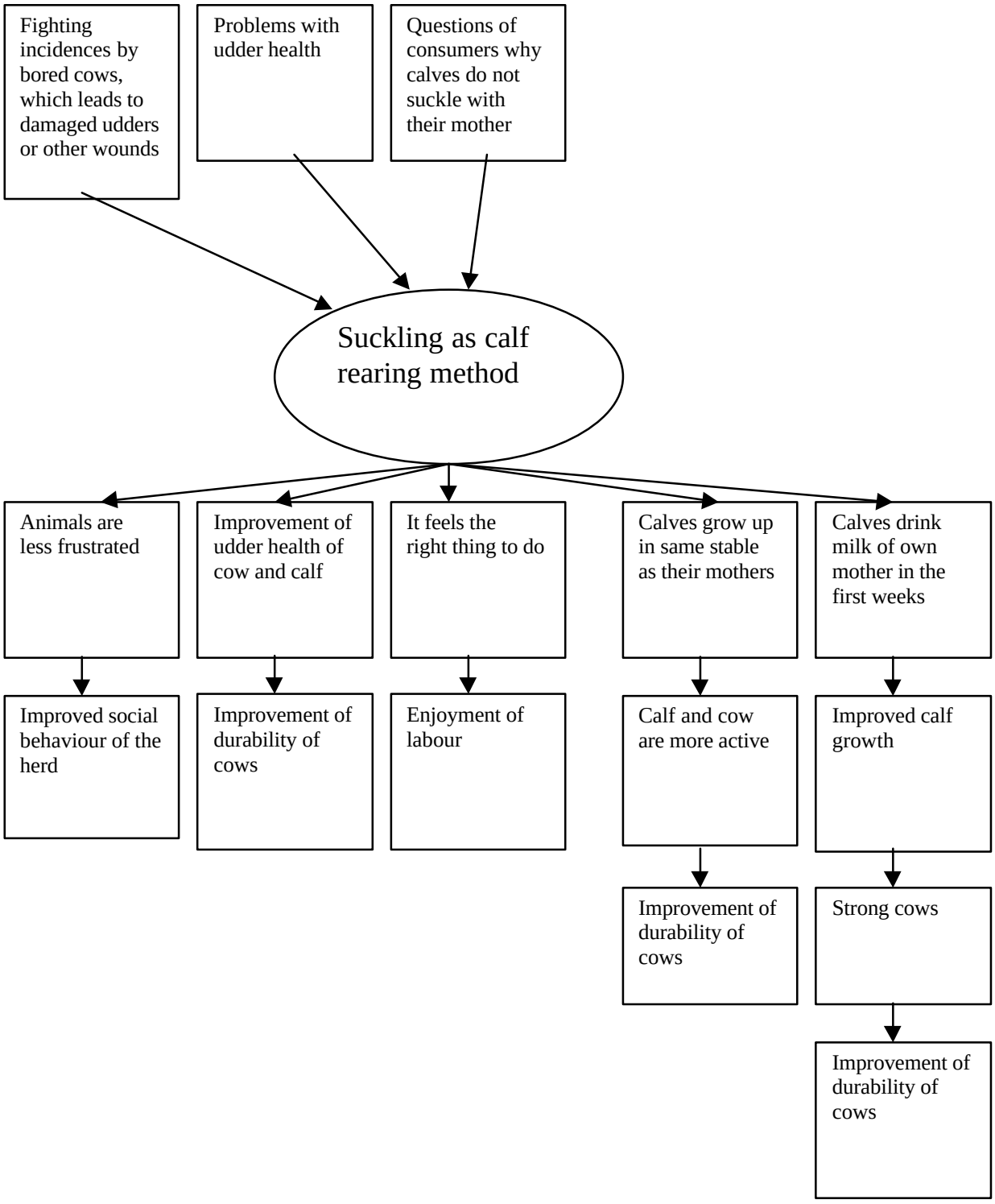
Appendix I The farmers and experts interviewed

The farmers

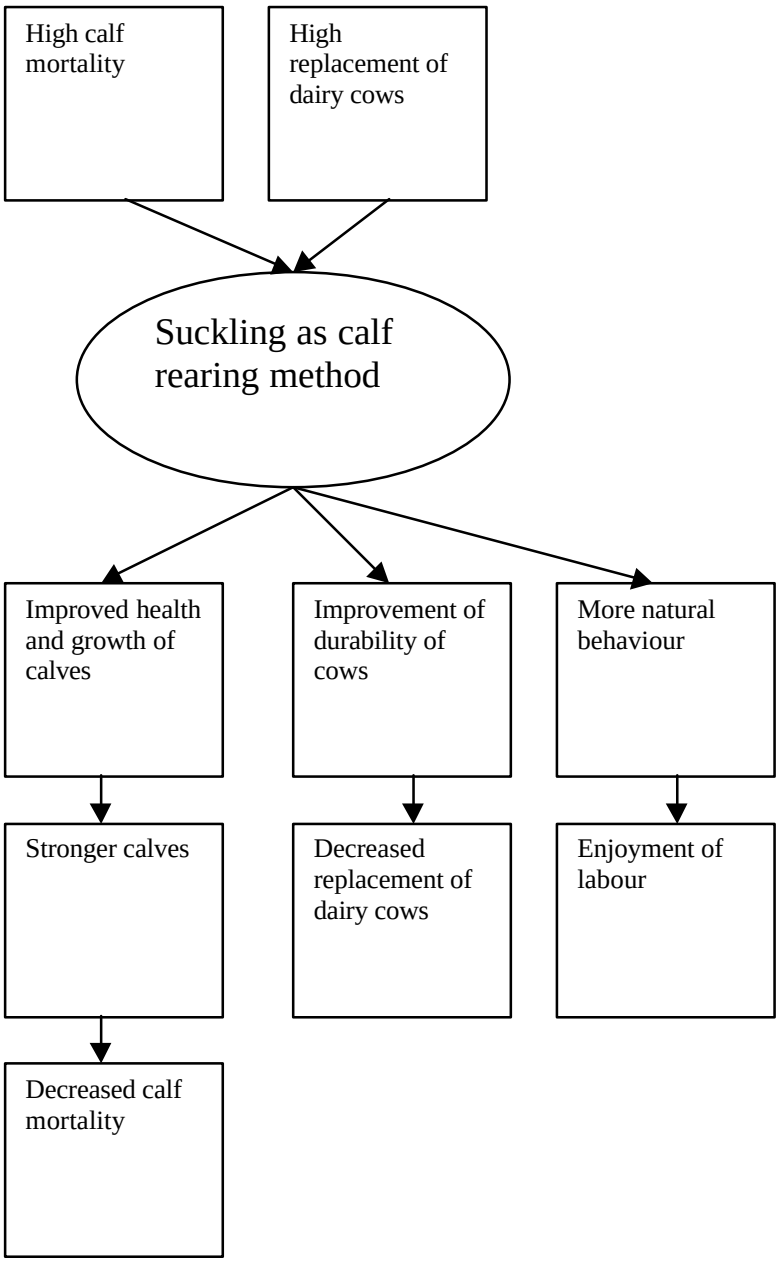
Arie Voskuilen, Conventional farmer, using a single suckling suckling system with additional milking for 10 year. Suckling period 14 –30 days.
Age Obdam, Bio Dynamic farmer, used suckling a single suckling system without additional milking in extensive beef production and wants to experiment with single suckling with additional milking in his dairy herd.
Bernard Hennepman, Organic farmer, experimenting for 1 year with single suckling systems with additional milking for bull calves only, suckling period 10 days.
Hendrik Langhout, Organic dairy farmer, experimenting for 6 months with a single suckling sytem with additional milking.
Jan Vrolijk, Bio Dynamic farmer, experimenting for 1 year with single suckling with additional milking and a multiple suckling sytem.
Jeroen Konijn, Organic farmer, using a suckling system with additional milking for several years, suckling period 3-4 days.
Kees van Wijnen, Conventional farmer, using suckling systems with additional milking for several years, suckling period 10 days.

Experts
Annah van der Worp, Alternative therapist, specialized in animal communication. Teacher of the study group for alternative therapies in diary farming. Her husband is experimenting with suckling systems at their organic dairy farm.
Alien Bor, Alternative therapist, specialized in the use of ethereal oils and animal communication. Organized a study group for alternative therapies in dairy farming.
Francien de Jonge, Ethologist, specialised in animal welfare an human-animal relationships. Working at the group animal and society at the university of Utrecht.
Liesbeth Ellinger, Homeopath for pets and farm animals. Teaches different courses on Homeopathy.

Appendix II Objective tree of first farmer



Appendix III Objective tree of second farmer



Appendix IV Explanation of the arguments and quotes in objective tree of farmers and experts

Arguments of experts were indicated by (EXP) to distinguish them from practical experiences of farmers (FARMER). All arguments in the problem tree were numbered.

Reasons and causes for a change in rearing system

A. Obliged feeding of cow milk, Dutch organic Farmers are obliged to feed cow milk to their calves in the first 3 months. (FARMER)
B. Diarrhoea problems, for several farmers were diarrhoea problems in the bucket feeding system reason to experiment with different rearing systems.(FARMER)
C. High cell count and mastitis, High cell count and mastitis are a major problem in dairy farming. Suckling seems beneficial against cell count and mastitis incidence. A suckling period seems to be positive for udder health of cow and suckling calf. (FARMER & EXP) See box 2
D. Public opinion, Consumers visiting farms asked questions and were often not aware of the immediate separation of the calf. (FARMER)
E. Development social behaviour/ herds. The development of social behaviour at young age from mother and peer-group mates contributes a more stable social order at later age. Especially in herds with horned cows this stable social order decreases the risk of conflicts with bodily harm, butting wounds. (FARMER & EXP) See also box I.

Economical benefits

1. Less Labour. Farmers state the labour involved is easy and less time consuming. “The first half week it is alone with its mother, all care is given, later the calf drinks when it wants and sleeps when it wants, it is so easy” (FARMER).
2. Intake colostrum. Good intake of colostum because portions are small, often and fresh (FARMER).
3. Less diarrhoea. The incidence decreases, some farmers experience no problems at all with diarrhoea (FARMER).
4. Increased growth The suckling calves grow better. Strong calves (FARMER).
5. Use of ‘waste’ milk, the milk given by the cows exceeding the quote of the farm is used for the claves and not wasted (FARMER).
6. Longer use of cows. We use ‘output’ cows as nurse cows, these would otherwise be sold because of cell count problems or with hoof problems (not able to walk on slatted floors anymore) can be used as nurse cow (FARMER).

Social and cultural arguments

7. Creativity of cows When cows have rest and welfare they become creative (FARMER).
8. Energetic value of milk. The animals give milk with a better energetic value when kept more natural(EXP).
9. Emotionally strong. Contact of mother and young gives animals a strong emotional basis(EXP).
10. Pleasure and enjoyment. Six of the seven farmers indicate they appreciate the suckling system because they enjoy watching the cow with their calves, enjoy the behaviour displayed by playing calves and enjoy the labour involved in husbandry of suckling calves (FARMER).

11. Challenge. Some farmers experience it, as a challenge to keep improving and developing their farms and showing that systems can change (FARMER).

Welfare and naturalness

12. Respect for the animal. You treat and keep the animal with respect (EXP).
13. Richer environment. Calves experience a richer environment, more stimuli from other calves, cows and environment. Small adaptations of the system can contribute to animal welfare, think of variation in the environment. Predictability and control of factors in the environment are important. However not in a way that environment becomes boring. Something nice is only appreciated when it is not there all the time. One candy is nice and special, however one candy when you just ate 100 of them is not special anymore (EXP).
14. Maternal behaviour. Cows can display maternal behaviour; in some systems cows other as the mother can also show maternal and grooming behaviour towards the calves (FARMER & EXP).
15. Less frustration. Animals waste less energy on frustration due to the constraints of the system (EXP).
16. Active cows. The calf stimulates the cow in its activity post partum, which has on its turn positive effects on the retention of fetal membranes feed and nutrient uptake related diseases (FARMER).
17. Lively calves. The calves are activated, stimulated by their mother and are described as lively calves. The vitality and liveliness of calves is bigger (FARMER).
18. No cross suckling. No suckling on ears and tails etc during the suckling period (FARMER).
19. Development of social behaviour. Positive effect on social behaviour, a stable social order decreases the risk of conflicts (FARM & EXP)(see also box 1).
20. Naturalness. When designing housing systems the natural behaviour of animals should be the starting point however you're always making compromises between what is good for the animal and what is good for the farmer (FARMER & EXP).

Economic costs

21. Fear of inter-suckling. Several farmers are afraid suckler calves will inter suckle as cows (milk stealing and udder suckling in older animals) Some farmers allow therefore only bull calves to suckle and no female calves for replacement. However none of the farmers has ever experienced problems with inter suckling (FARMER).
22. No control on colostrum intake. There is no control on the intake of colostrum or milk. Alertness of the farmer is very important to detect mal nutrition and diarrhoea (FARMER).
23. Decreased milk ejection. Some farmers experience sometimes poor milk let down of a suckler cow (FARMER).
24. Para TBC. No farmers experienced problems with Para TBC on their farm. The problems they experience are the regulations, since KKM (quality certificate in the Dutch dairy sector) asked farmers to be active to combat Para TBC (FARMER & EXP).
25. Stable adjustments. Your system has to be suitable, you have to be prepared and make some adjustments in the stable (FARMER).
26. More diarrhoea In contrast with other farmers, one farmer experiences more diarrhoea with suckling calves. Problems arise in separateing the cow and calf for a longer time, during milking and feeding, the calf drinks to much in one time when she returns. In

case of diarrhoea I remove the cow and the calf is not allowed to suckle anymore (FARMER).

27. Milk costs. The milk consumption of calves in not controlled. In the first 10 days the milk consumption is not experienced as a problem. After 10 days the milk consumption becomes substantial. I don't leave the calves longer as 10 days with the mother, a longer period costs to much. The firs month is not a problem, the second and third month are more difficult. I don't know how much the calves drink, never really thought about it, but in the end it has to be paid (FARMER).
28. Transfer cell count. Feeding milk with a high cell count caused by an Aureus bacterial infection can cause settlement of this bacteria in the tissues of the calf. This can increase the risk of mastitis at late age. Using cows with a high cell count as foster mother is therefore disapproved by some of the farmers. In contrast with other farmers who want to use especially the 'output' cow with a high cell count as foster mother (FARMER).

Negative effects on welfare and naturalness

29. Wild calves. One of the farmers has experience with a suckler cows in a nature reserve for beef production. These calves were hard to handle, they were from a typical beef breed and not used to human contact (FARMER).
30. Restlessness after weaning After separation/ weaning of cow and calf some farmers have problems with restlessness in of the cows. After separation the cows are sometimes restless and sometimes not. Whoever has the longest breath, when the cow is complaining to much, then I bring her to her calf again. When I wean separate the calves (after 14-30 days with their mother) they call the first days. When they are separated directly after birth, they don't call. After separation we give the calves Ignatia and more attention (FARMER). Ignatia is a homeopathic product used by several farmers, see also Box III.