Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Department of Animal Breeding and Genetics

Management practices' effect on milk production, somatic cell count and mastitis in Swedish organic dairy farms

Josefin Wingren

Master's Thesis / Swedish University of Agricultural Sciences
Department of Animal Breeding and Genetics
XXX
Uppsala 2018

Master's Thesis, 30 hp
Master's Programme
– Animal Science

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Department of Animal Breeding and Genetics

Management practices' effect on milk production, somatic cell count and mastitis in Swedish organic dairy farms

Skötselrutiners effekt på mjölkproduktion, celltal och mastit i ekologiska mjölkkobesättningar i Sverige

Josefin Wingren

Main supervisor:
Anna Wallenbeck, SLU, Department of Animal Breeding and Genetics and Department of Animal Environment and Health

Assisting supervisor:
Lotta Rydhmer, SLU, Department of Animal Breeding and Genetics

Examiner:
Susanne Eriksson, SLU, Department of Animal Breeding and Genetics

Credits: 30 hp
Course title: Degree project in Animal Science
Course code: EX0558
Programme: Master's Programme – Animal Science
Level: Advanced, A2E

Place of publication: Uppsala
Year of publication: 2018
Name of series: Examensarbete / Swedish University of Agriculture Sciences, Department of Animal Breeding and Genetics, XXX
On-line publication: http://epsilon.slu.se

Key words: organic dairy production, mastitis, somatic cell count, milk production, herd size, housing, management, milking routine

Table of contents

Abbreviation

ECM	Energy-corrected milk
LSM	Least square mean
SCC	Somatic cell count
SE	Standard error
Std	Standard deviation

Abstract

The most common animal health problem in organic dairy production is mastitis. It is considered to be one of the most serious welfare problem in dairy production, as well as an economic problem as it often leads to a reduced milk yield and reduced profit. To combat this problem, the focus in organic dairy production is laid on management strategies to e.g. reduce the use of antibiotics and improve the animal health and welfare. In 2015, the EU-funded project OrganicDairyHealth started in seven European countries, including Sweden. Within the project, an extensive survey on housing, management, health and production was sent out to organic dairy farmers in each country, and this thesis is based on the data from the Swedish survey. This master thesis' aim was to (1) describe Swedish organic dairy farms, and to (2) assess relationships between milk production, somatic cell count (SCC), mastitis incidence, farm characteristics and management practices in Swedish organic dairy production. The Swedish survey was sent out in January 2016 and the answers included information about the production year 2014. The analysed data set included answers from 58 organic farms, corresponding to 10.6% of all organic dairy farms in Sweden 2014, and the number of answers varied between questions in the extensive questionnaire. Based on the data from the survey, the average Swedish organic dairy farm had insulated stalls and loose housing with milking robot. The farms had an average herd size of 77 cows and produced on average 8791 kg energy-corrected milk per cow and year. The most common diseases were mastitis, milk fever, and claw diseases, with mastitis being the most widespread. Most farms used three or more hygiene routines at milking, with wet cleaning of the udder and using new cleaning material for each cow being the two most commonly used routines. The majority of farmers used antibiotics and/or drying off individual udder quarters to treat clinical mastitis. Furthermore, one fourth of the farmers used homeopathic treatment to treat clinical mastitis, although no farmers used homeopathy as the only treatment. Farms with milking robot had higher milk production and higher SCC, while farms with milk line had higher mastitis incidence. Herd size was the only factor that was associated with all examined outcome variables (milk production, SCC, and mastitis). Farms with large herds had high milk production, high SCC, and low mastitis incidence. To conclude, there were farm characteristics and management practices that were of importance for milk production, SCC, and mastitis incidence in Swedish organic dairy farms. Mastitis was the most common and widespread disease and the results from this study indicates that the mastitis incidence is associated with many farm characteristics and management practices. The variation in farm characteristics and management practices observed in this study, together with the indications of effects of these on milk production, SCC, and mastitis incidence, shows that there is not one typical Swedish organic dairy farm type, but a variety of farm types. Additionally, these results show that there is a need for development of farm specific management strategies that takes e.g. the specific housing, milking system, and health status of the farm into account.

Sammanfattning

Det vanligaste djurhälsoproblemet inom ekologisk mjölkproduktion är mastit. Det anses vara det mest allvarliga välfärdsproblemet inom mjölkproduktion, samtidigt som det är ett stort ekonomiskt problem som ofta leder till minskad mjölkproduktion och minskad vinst. För att motverka detta problem, läggs fokus inom ekologisk produktion på skötselstrategier för att exempelvis minska användandet av antibiotika och förbättra djurvälfärden. Under 2015 startades det EU-finansierade projektet OrganicDairyHealth, som omfattade sju europeiska länder, inklusive Sverige. Inom projektet skickades en omfattande enkät om inhysning, skötsel, hälsa och produktion ut till ekologiska mjölkbönder i varje land, och denna masteruppsats baseras på uppgifter från den svenska enkäten. Syftet med denna masteruppsats var att (1) beskriva ekologiska mjölkgårdar i Sverige, samt att (2) analysera samband mellan mjölkproduktion, celltal, frekvens av mastit, besättningsfaktorer, skötselrutiner vid mjölkning och behandling i ekologisk mjölkproduktion i Sverige. Den svenska enkäten skickades ut i januari 2016 och omfattade information från produktionsåret 2014. Datasetet som analyserades inkluderade svar från 58 ekologiska gårdar, vilket motsvarar 10.6% av alla ekologiska mjölkgårdar i Sverige 2014, och antalet svar varierade mellan frågorna i enkäten. Den genomsnittliga svenska ekologiska gården, baserat på information från enkäten, hade isolerat stall och lösdrift med mjölkningsrobot. Gårdarna hade en genomsnittlig besättningsstorlek på 77 mjölkkor och producerade i medel 8791 kg energi-korrigerad mjölk per ko och år. De vanligaste sjukdomarna var mastit, kalvningsförlamning och klövsjukdomar, varav mastit var mest utbredd. De flesta gårdarna använde tre eller fler mjölkningsrutiner, där de två vanligaste rutinerna var torr rengöring av spenarna och nytt rengöringsmedel till varje ko. Majoriteten av gårdarna använde antibiotika och/eller sinläggning av enskilda juverdelar för att behandla klinisk mastit. En fjärdedel av gårdarna använde homeopatisk behandling för att behandla klinisk mastit, dock använde ingen gård endast homeopatisk behandling. Gårdar med mjölkrobot hade högre mjölkproduktion och högre celltal, medan gårdar med rörmjölkning hade högre frekvens av mastit. Besättningsstorlek var den enda faktorn som påverkade alla undersökta variabler (mjölkproduktion, celltal och mastit), där gårdar med stor besättningsstorlek hade hög mjölkproduktion, högt celltal och låg frekvens av mastit. Sammanfattningsvis så fanns det besättningsfaktorer och skötselrutiner som hade en avgörande betydelse för mjölkproduktion, celltal och mastitfrekvens på ekologiska mjölkgårdar i Sverige. Mastit var den vanligaste och mest utbredda sjukdomen och resultatet från denna studie indikerar att frekvensen av mastit påverkas av många besättningsfaktorer och skötselrutiner. Variationen av besättningsfaktorer och skötselrutiner som observerats i denna studie, tillsammans med en indikerad effekt mellan dessa faktorer samt mjölkproduktion, celltal och mastitfrekvens, visar att det inte finns en typisk ekologisk mjölkgård i Sverige, utan en mängd olika gårdstyper. Detta resultat visar dessutom att det finns ett behov av utveckling av besättningsspecifika skötselstrategier som tar hänsyn till faktorer som exempelvis inhysning, mjölksystem och hälsostatus på gården.

Introduction

From the start of organic dairy production, focus have been on good management strategies to e.g. reduce the use of antibiotics, improve animal welfare, and reduce the environmental load. According to the International Federation of Organic Agriculture Movements (IFOAM), organic production should have a high focus on animal welfare and should meet the animals' behavioural needs. Moreover, the management should be focused on disease prevention (EU Council Regulation, 2007). Animal health and welfare should be promoted by preventative actions such as using suitable breeds, feed, feeding and breeding strategies, and using a housing system that fits the production. For example, loose housing system and home-grown feed are key characteristics in organic production (Hovi *et al.*, 2003).

It has been shown that the most common health problem and disease in organic production is mastitis (Lund & Algers, 2003; Kijlstra & van der Werf, 2005). Mastitis is considered to be one of the most serious animal welfare problem in dairy production and as it often leads to a reduced milk yield, and it causes losses in profit for the farmer (Kossaibati & Esslemont, 1997). However, the disease prevalence has in some studies been shown to be no different from conventional production (Lund & Algers, 2003; Fall *et al.*, 2008).

In 2015, an EU-funded project (OrganicDairyHealth, 2017) started in seven European countries, including Sweden. The projects' overall aim was to map similarities and differences in organic dairy production in European countries in order to develop a sustainable organic dairy production, and to examine organic dairy production in order to improve animal health and welfare through breeding and management. Within the project, a survey questionnaire was sent out to organic dairy farmers in each country, and the data from the Swedish survey is the basis of this master thesis.

The aim with this master thesis was to describe farm characteristics, milking routines, and treatment practices in Swedish organic dairy production. More specifically, the aim is to answer the following questions:

- What characterizes Swedish organic dairy farms?
- Are different farm characteristics associated with production level, SCC, or mastitis incidence in Swedish organic dairy production?
- Do different milking routines affect production level, SCC, or mastitis incidence in Swedish organic dairy production?

Literature review

Organic dairy production

In Sweden, the first organic milk was delivered in 1989 to the dairy Värmlandsmejerier (now called Milko) by nine producers and their 250 cows. In 1991, thirteen producers started delivering organic milk to Arla, the (now) largest dairy in Sweden. From there, the production of organic milk slowly started to increase, and in 1995, farmers could get subsidies for having an organic dairy production (Ekologiska Lantbrukarna, 2008). Since 1995, the organic milk production has increased, and in 2014 there were 548 organic dairy producers in Sweden and 14% of the dairy cows were in organically certified herds (Swedish Board of Agriculture, 2015; 2017a), and 12.7% of the milk that was delivered to Swedish dairies were organically produced (Swedish Board of Agriculture, 2017b).

Compared to conventional production, organic production has higher requirements for space, bedding and access to outdoor areas, to give the animals a better chance to move and display normal behaviour (von Borell & Sørensen, 2004). This has been shown to give consumers a positive attitude towards organic production, and it gives an added value to the organic products (Sundrum, 2001). In organic production, it is prohibited to use chemically synthesised allopathic or antibiotic treatments as a preventative measure. According to EU regulations, you should, when it is efficient, favour the use of phytotherapeutic, homeopathic, or other non-allopathic products such as trace elements, which should be used before the use of allopathic products or antibiotics (EU Commission Regulation, 2008). Yet it is also forbidden to withhold treatment to a sick animal, so you are allowed to use allopathic treatment for an animal which has been diagnosed by a veterinarian (EU Commission Regulation, 2008). However, when allopathic or antibiotic treatment have been used, there is a withdrawal period for the milk, which in Swedish organic production is twice the withdrawal length set by the Swedish National Food Administration (KRAV, 2017).

Even though the EU regulations favour the use of e.g. homeopathic treatment over antibiotics, the use of treatments differs between countries. In the US, it is more common to use non-allopathic treatments over allopathic when treating clinical mastitis (Pol & Ruegg, 2007). The organic regulations in the US state that an animal will lose its organic status as soon as its been treated with antibiotics, although they are not allowed to withhold medical treatment to a sick animal (U.S. Department of Agriculture (USDA), 2017). Within the EU, an animal can be treated up to three times within a year before it loses its organic status (EU Commission Regulation, 2008). But even within the EU there are differences in treatment management; in Sweden, it is more common to use antibiotics over homeopathic treatment (Hamilton *et al.*, 2002; Hammarberg, 2002), as in the Netherlands (Kijlstra & van der Werf, 2005), while in the United Kingdom (UK) it is more common to first use homeopathic treatment (Hovi & Roderick, 2000; Weller & Bowling, 2000). This difference is mainly due to tradition but is also due to local regulations. For example, in Sweden, veterinarians are not allowed to prescribe homeopathic treatments to sick animals, since it is not a scientifically approved method. The farmer her/himself may choose to use homeopathic treatment as a preventative measure, but there is no tradition to use it and focus is on other preventative measures such as good management, housing, environment, and breeding for longevity (Hammarberg, 2002). The European Academies Science Advisory Council (EASAC) has stated that it is unjust to require organic producers to use homeopathic treatment over scientifically proven treatments, based on the lack of robust evidence of efficiency. EASAC mean that claims of efficiency with homeopathy are explained by placebo effect, random variation, poor study design, and/or publication bias (EASAC, 2017).

Factors affecting milk production

In organic dairy production, it is common with a lower milk yield compared to conventional production (Hardeng & Edge, 2001; Hamilton *et al.*, 2006). This difference is logical in relation to the restrictions in organic production regarding e.g. feed (limited amount of concentrates, no vitamin supplements etc.) and use of antibiotic or parasitic treatment, which affect the cows' health, and later the milk yield (Hammarberg, 2002). However, lower milk production in organic production is not always the case. In a study by Fall *et al.* (2008), where organic and conventional managed cows were housed on the same farm and managed by the same staff, there were no difference in milk production between the different production types. The small difference that existed, was explained by different feeding regimes, i.e. conventionally managed cows had a higher energy density in the feed because of the higher amount of concentrates (Fall *et al.*, 2008). Cows housed in tie-stall have shown to have a higher milk yield than cows housed in free-stalls. Although the herd size is also a factor to consider. In small herds, the milk yield was shown to be lower in free-stall, but in larger herds, the milk yield was shown to be higher in free-stall housing (Simensen *et al.*, 2010). Swedish organic farms have been shown to more frequently use the Swedish Red over the high-yielding Holstein (54.3 and 35.5% vs. 45.8 and 46.9%, in organic and conventional farms, respectively), which could be one of the reasons for the lower milk production in organic farms. It has also been shown that organic farms to a larger extent use more uncommon (low-yielding) breeds such as Jersey or Swedish Polled (10.4 vs. 7.4%), which also in turn could affect the milk production (Ahlman, 2010).

Factors affecting somatic cell count

There is not a definite answer whether there is a general difference in average SCC between organic and conventional production. Studies have shown that cows in organic herds have higher (Hovi & Roderick, 2000, Ahlman, 2010), similar (Hardeng & Edge, 2001; Valle *et al.*, 2007; Haskell *et al.*, 2009), and lower (Hamilton *et al.*, 2006) SCC compared to cows in conventional herds. Although in a study by Ahlman (2010), the difference in SCC between organic and conventional production disappeared after adjustment for milk yield. There are however many management factors that affect the SCC, such as housing, environment, and season, but the SCC also naturally increases with progressing lactation and increasing age and parity. It has also been shown that type of breed affect the SCC, where high-yielding breeds such as Holstein have been shown to have higher SCC (Sharma *et al.*, 2011). The herd size has also been shown to affect the SCC, in a Norwegian study, large herds had higher bulk milk SCC, compared to a small herd size. However, the incidence of mastitis was lower in large herds (Simensen *et al.*, 2010). The opposite was shown in a UK study, where large herds had lower SCC than small herds (Haskell *et al.*, 2009).

Factors affecting mastitis

SCC is often used as an indicator for udder health and subclinical mastitis (Hardeng & Edge, 2001). In a study by Hovi and Roderick (2000), one third of organic herds, and 20% of conventional herds, had an average SCC over 200,000 cells/ml, a level which is often used as an indicator for subclinical mastitis. But even though the organic herds had higher incidence of subclinical mastitis, the organic herds had lower clinical mastitis incidence compared to conventional herds (36.4 vs. 48.9 cases per 100 cows per year) (Hovi & Roderick, 2000). Breed have been shown to also be a factor for subclinical mastitis, where the use of Simmental, Red Holstein, Brown Swiss, and Jersey has been associated with a higher risk of subclinical mastitis (Busato *et al.*, 2000; Doherr *et al.*, 2007). The differences between breeds could be partly explained by the different udder conformation (Busato *et al.*, 2000; Doherr *et al.*, 2007).

Cows housed in straw-based loose stalls have been shown to have higher incidence of clinical mastitis compared to cows housed in cubicle-based stalls. This may be because straw is associated with an increased risk of infectious organisms, which in turn have shown to increase the risk of mastitis (O'Mahony *et al.*, 2006). Similar results from a study by Weller and Bowling (2000) showed that the incidence of mastitis was more than double for cows housed on straw yards, compared to cows housed in cubicle sheds. Although cows housed on straw had a higher incidence of mastitis, there were no difference in SCC (Weller & Bowling, 2000). The opposite was shown in a study by Richert *et al.* (2013), where cows housed in stall barns had higher incidence of clinical mastitis, approximately 1.5 times higher, compared to cows in loose-stall housing.

In a study by Hardeng and Edge (2001), organic herds had an increased risk of mastitis as they had more cows in a higher lactation number, compared to conventional herds. However, they also showed that cows in organic herds had lower risk of getting mastitis in the weeks after calving than cows in conventional herds where the risk was twice as high (Hardeng & Edge, 2001). In a Norwegian study, organic farms had fewer cases of mastitis compared to conventional farms (17 vs. 31 per 100 cow year), however, this difference in number of mastitis cases may be because organic farmers called for a veterinarian fewer times, so less mastitis cases were reported, even though the different production types might have had similar frequency of mastitis (Valle *et al.*, 2007). This can be compared to a Swedish study, in which organic herds also had fewer mastitis cases compared to conventional herds (9.1 vs. 14.7 cases per 100 cows), and where the authors also suggested that the lower number of mastitis cases could be due to organic farmers calling for a veterinarian less often (Hamilton *et al.*, 2006).

Effect of different milking routines

A German study by Ivemeyer *et al.* (2017), which was also a part of the OrganicDairyHealth project, showed that the most common milking routines used by the organic farms included in the study were post-dipping (80%), fresh cleaning material for each cow (73%), and wearing gloves (66%). Although this varied with farm type; farms with a large herd size and high milk production always used post-dipping, whereas 60% of farms with small herds and low milk production used post-dipping. Farms with large herds also used internal teat sealer more frequently than farms with small herds (91 vs. 30%) (Ivemeyer *et al.*, 2017).

It has been shown that milking routine strongly affect the bulk tank SCC, where using two or more routines out of forestripping, pre- and post-dipping give less teat contamination, and thus lower SCC, than using none or one milking routine (Zucali *et al.*, 2011). Another study showed that the SCC was lower if the udder was not touched or washed only if it was dirty before milking, than if there were some kind of cleaning of the udder before milking (Haskell *et al.*, 2009). An earlier study has shown that milking routines that were associated with a low bulk tank SCC were use of post-milking teat disinfection and not drying after wet cleaning of the udder before milking (Barkema *et al.*, 1998).

In a study by Richert *et al.* (2013), forestripping during the milking routine was shown to increase the rate of clinical mastitis, while the use of pre-dipping was shown to decrease the rate. It was thought that the increase in identified cases of mastitis with forestripping was caused by more hands-on and sensitive detection (Richert *et al.*, 2013). This was also discussed by Peeler *et al.* (2000), where stripping foremilk before attaching the milk organ was a risk for mastitis, and the authors argued that checking the foremilk would result in a higher identification of mild cases of mastitis, which otherwise would go undetected and therefore not reported. Similarly, no post-milking has shown to negatively affect the udder health, due to increased risk of pathogens being able to use the left-over milk in the teat canal as substrate, which in turn can be a risk factor for mastitis (Ivemeyer *et al.*, 2009). The same was also evident in a later study by Wagenaar *et al.* (2011), where abandonment of post-milking was identified as one of five factors that affected the udder health (the other four being hard bedding, breed, alpine summer pasture, and calf feeding with mastitis milk).

It has been shown in a study by Peeler *et al.* (2000) that wearing gloves during milking increases the risk of mastitis, although the higher mastitis incidence could be because the personnel might not feel or are less aware that their hands are soiled if using gloves. Another reason could be that farmers that had problem with mastitis start to wear gloves, and will therefore increase the statistics for mastitis (Peeler *et al.*, 2000).

Effect of different treatment practices for clinical mastitis

Even though alternative treatments are favoured by the IFOAM, there is still no scientific evidence that alternative treatments such as homeopathy is effective (Doehring & Sundrum, 2016). Wagenaar *et al.* (2011) have shown that homeopathic-based treatments have no effect on udder health. However, it was also shown that for cows with a SCC higher than 200,000 cells/ml at drying off, and that were treated with homeopathic-based treatment, this had a positive effect on the udder health compared to an untreated group (Wagenaar *et al.*, 2011). In a study by Orjales *et al.* (2016) with Spanish organic farmers, it was shown that alternative treatments seem to be a good alternative for reducing the use of antibiotics, however, the farms that used alternative treatments had higher SCC than farms using allopathic treatments. It is also noteworthy that out of the farmers that used alternative treatments, the majority (83%) were satisfied or very satisfied with the effectiveness of alternative treatments and would continue to use it for treatment of mastitis (Orjales *et al.*, 2016). This could be a placebo effect, where organic farmers have lower expectations, and therefore are pleasantly surprised by a positive effect. Similarly, Pol and Ruegg (2007) showed in a US study that 74% of organic farmers were satisfied or very satisfied with the results after using alternative treatments (e.g. whey-based products, garlic tincture, aloe vera, vitamin C), compared to 40% of the conventional farmers, even though both production types had a similar cure rate for mastitis (Pol & Ruegg, 2007). It has been shown that organic farmers use alternative treatments to treat mastitis more frequently compared to conventional farms, treatments that are not usually recorded on the cows' health cards (Valle *et al.*, 2007).

Ivemeyer *et al.* (2017) have shown that one fourth of German farmers use antibiotics in combination with dry-off, and large herds used it more frequently than farms with small herds (33.1 vs. 5.3%). This difference could indicate that the large herds had more problem with mastitis, however the study does not show the mastitis incidence on the farms (Ivemeyer *et al.*, 2017). As the majority of antibiotic use in dairy production in Sweden come from treating mastitis (Växa Sverige, 2017a), and one of the goals with organic production is to reduce the use of antibiotics, it is essential to reduce the incidence of mastitis to reach the goal (Hamilton *et al.*, 2006). To be able to reduce the mastitis incidence it is important with preventative measures such as optimal management, housing, feeding, and breeding (Hammarberg, 2002; Hamilton *et al.*, 2006). In Sweden, both the use of antibiotics and incidence of clinical mastitis have slowly decreased during the last 15 years (Växa Sverige, 2017a).

In a Swedish study by Hamilton *et al.* (2002), most of the organic farmers would massage the udder with liniment, and perform frequent milking of the affected udder quarter if there were only minor changes in the milk. They would only call a veterinarian if the cow showed systemic signs for clinical mastitis (Hamilton *et al.*, 2002). In a later study, based on the same organic farms, six of the 26 farmers participating used homeopathic remedies to some extent, but not exclusively, although it was more common to use homeopathy for other illnesses or trauma, than for clinical mastitis. It was also shown that the incidence of veterinary treated clinical mastitis was lower than the actual incidence recorded by the farmers. It was suggested that the hesitation to call for a veterinarian was due to the high loss in profit due to the double withdrawal time. This could be one important reason for why the farmers were motivated to use homeopathic treatment (Hamilton *et al.*, 2006).

Hovi and Roderick (2000) have shown that for organic farmers in the UK, alternative treatments is the main type of treatment. It was used 56.3% of the cases, and homeopathic treatment was the most common alternative treatment, with 49.8% of the cases. Other alternative treatments were used 6.5% of the cases, and included uddermint, cold water massage, and aloe vera. This pattern was also reported in another study with organic farmers by Weller and Bowling (2000), where 56% of the cows with clinical mastitis were treated with alternative treatments, and some farmers always used alternative treatments to treat clinical mastitis.

Materials and methods

The project OrganicDairyHealth (2017) is part of Core Organic Plus, a network of several countries where research projects on organic food and farming systems are initiated. The OrganicDairyHealth project started in 2015 and had the aim to identify similarities and differences in organic dairy production in eight European countries in order to develop a sustainable organic dairy production, and to improve animal health and welfare through breeding and management. Within the project, each country had its own project group, and a survey were created which had the same base in all countries but were to some extent adjusted to each countries' circumstances. The questionnaire included questions about e.g. herd size, herd structure, and production. The questionnaire included more detailed questions than what was later used in the EU-project, so much of the data about organic production in Sweden were left un-studied. This master thesis is focused on that data.

Questionnaire

Using a survey questionnaire was chosen because it is an easy way to gather much quantitative data from many different farms all over Sweden. The web-based survey was carried out via the survey software tool Netigate (2017), and included detailed questions about e.g. housing, animal health, management practices, and production level from the production year of 2014, see questionnaire in Appendix 1. The survey was sent out via e-mail in January 2016 to 485 KRAV certified organic farms in Sweden, where 400 e-mails were delivered. The farmers were given two weeks to answer the survey. Out of the farmers that got the survey; 108 opened the survey, 90 started the survey, and 47 completed the entire survey. The average time spent on the survey were 50 ± 49 minutes (range 2-268 minutes). As the answers were saved the moment the farmers went on to the next question; the response rate (of the 58 used answers) varied between 55-100% depending on the question. For example, the questions about housing were first, so the response rate in this section was 100%, while for the questions about reproduction were last, so the response rate for those questions are the lowest. Before the survey was sent out, it was tested on two farmers to see if the survey was easy to follow and understand, and some minor corrections were made. The respondents in the survey (responses from the 58 farmers used) represents about 10.6% of the Swedish organic dairy herds in 2014 (there were in total 548 organic dairy farms in 2014; Swedish Board of Agriculture, 2017a).

The survey also included information about feed, diets, pasture strategy, preventative work of feed related diseases, reproduction techniques, breeding goals and selection, as well as housing for dry cows, heifers, and calves. This was excluded from this thesis due to few answers or poor quality on the data. Feed related diseases, such as milk fever and ketosis, was not included in any analyses in this thesis as information about feed was not included.

The raw data from the survey was downloaded directly from Netigate and then modified in Microsoft Excel, which later was the basis for the dataset used for estimation of descriptive statistical analyses. Some responders' answers were excluded; 9 responses were excluded as they had only answered the first two questions, and 23 responses were excluded as they had not specified information about at least two of the examined outcome variables (milk production, SCC, and mastitis). This left 58 respondents' answers included in the statistical analyses. To clarify; other than the 47 farmers that completed the whole survey, 11 other respondents' answers were included in the analyses as their answers were of relevance. In the survey, the farmers got to state if the information on production were based on their own estimation of the production or if it were based on the official milk recording. There were more farmers that stated that they estimated the information (55.2%), than farmers that stated that the information were from the official milk recording (44.8%).

Statistical analyses

The response variables chosen to be examined in the statistical analyses were milk production, SCC, and mastitis incidence. Each response variable (y-variable) was tested against the same predictor variables (x-variables) which were relevant for the aim for this thesis. Some variables were not included in any statistical analyses, and were only used to describe the farms.

The statistical analyses of the data were made in Minitab 18 (Minitab Inc., 2017) and SAS version 9.4 (SAS Institute, Inc., 2011). Minitab was used for overall descriptive statistics, and SAS for further descriptive statistics using procedures MEANS and FREQ. The statistical analysis was made with the general linear model procedure (GLM) in SAS. The GLM analyses were performed as univariate analyses; i.e. analyses with one response against one predictor variable. Univariate model analyses were chosen because of the small and limited data set which made it difficult to develop more complex models. However, in the GLM analyses where mastitis and SCC were response variables, milk production was added to the model as a continuous covariate variable to correct for production level, as milk production significantly affected the SCC and mastitis incidence, i.e. SCC and mastitis incidence was compared at the same milk production level. The p-value for the continuous variable for milk production and the other predictor variable in the model analysis are included in the result tables. During the building of the models, herd size was also tested and intended to be included as a continuous covariate variable in the model, but there was no significant relationship between herd size and the three response variables. Ultimately, the final models used were;

Milk production = X + e
SCC = X + milk production + e
Mastitis incidence = X + milk production + e

where X is one of the tested predictor variables (e.g. Table 1) and e is random residual.

For the analyses, the continuous predictor variables were classified into three groups (low, average, and high), see Table 1. The groups were based on the lower and upper quartiles. The questions about milking routine and clinical mastitis management originally had four alternatives (always, often, sometimes or never), which were converted into use (always, often, or sometimes) or do not use (never) (0/1 variable). Some predictor variables were not analysed due to few observations in one group (<9 observations), e.g. wet cleaning and new cleaning material for each cow, as well as the three different treatment practices for clinical mastitis.

Table 1. Limits for class-divided continuous covariate variables

Class variable	N_{total}	N_{low}	Limit for low group	N_{high}	Limit for high group
Milk production (kg ECM)	56	14	≤8341	14	≥9735
SCC (10^3 cells/ml)	45	10	≤170	10	≥240
Mastitis incidence (%)	42	11	≤5.0	11	≥14.3
Herd size (no.)	58	16	≤40	16	≥78
Dry period (days)	55	14	≤58	14	≥68
Age at first calving (months)	34	13	≤25.6	13	≥27
Calving interval (days)	32	10	≤375	10	≥398
Culling percentage	41	10	≤25.4	10	≥35.7

Results

Farm characteristics

Data from the farms are summarized in Table 2, which is compared to the earliest records of organic dairy production in Sweden from 2015 (Växa Sverige, 2017b).

Table 2. General descriptive statistics of the farms

	N	Mean ± std	Range	Swedish mean[1]
Herd size (no.)	54	77.6 ± 56.16	10.5–300	93
Milk production (kg ECM)	56	8791 ± 1465	5100–11,411	9044
Milk protein (%)	54	3.4 ± 0.25	3.0–4.43	3.4
Milk fat (%)	54	4.2 ± 0.36	3.1–5.4	4.1
SCC (10^3 cells/ml)	45	201.4 ± 50.44	94.0–337.0	269.0
Age at first calving (months)	34	26.3 ± 1.57	24.0–30.0	28.0
Calving interval (days)	32	384.4 ± 22.56	320–440.8	393.45
Dry period (days)	55	62.6 ± 10.63	30–92	–

[1] Average for Swedish organic dairy farms in 2015 (Växa Sverige, 2017b)

Milking system and housing

The majority of the farms used robot milking, as seen in Table 3. It was more common for the farms to have loose housing and insulated stall. One fourth of the farms had access to an outdoor area for the cows. These farms where mostly tie-stall farms, but there were four loose stall farms with access to an outdoor area. Most farmers used rubber matt or mattress as lying surface, and sawdust was the most common bedding material.

Table 3. Milking system and housing used on the farms

		N_{tot}	No. of farms	Percentage of farms
Milking system	Robot	56	27	48.2
	Milk line	56	15	26.8
	Parlour	56	14	25.0
Housing[1]	Loose stall	58	45	77.6
	Tie-stall	58	16	27.6
	Insulated stall	58	41	70.7
	Uninsulated stall	58	16	27.6
	Access to outdoor area	58	14	24.1
Lying surface	Rubber matt	58	24	41.4
	Mattress	58	24	41.4
	Other[2]	58	10	17.2
Bedding material	Sawdust	55	30	54.5
	Straw	55	14	25.5
	Other[3]	55	13	23.6

[1] Some farms had more than one kind of housing, e.g. both loose and tie-stall.
[2] Concrete, deep litter bed, both rubber matt and mattress, or both concrete and rubber matt.
[3] Peat, both straw and sawdust, mix of peat and sawdust, mix of wood shavings and sawdust, or wood shavings.

Animal health and mortality

The three most prevalent diseases on the farms was mastitis (9.6%), followed by milk fever (4.5%) and claw diseases (3.7%), as seen in Table 4 where they are compared with the national average of Swedish organic and conventional farms from 2014 (Växa Sverige, 2016; 2017a). The prevalence of other diseases was 2.6% for retained foetal membranes, 2.4% for ketosis, and 1.3% for lameness. All farms had some disease problem, with mastitis being the most widespread. Only three farms stated that they had no diagnosed case of mastitis, and 42.9% (18) of the farmers stated that they had ≥10% diagnosed cases of mastitis per year. On the farms, the average culling percentage was 30.3%, the percentage of euthanized cows (put down on the farm, not sent to slaughter) was 3.7%, and the percentage of self-dead cows was 0.7%.

Table 4. Average percentage of diagnosed and treated diseases and mortality on the farms

	N	Mean ± std (%)	Range (%)	Farms with ≥1 cases (% (no.))	Swedish mean
Animal health					
Mastitis	42	9.6 ± 6.70	0–31.4	92.9 (39)	12.5[a]
Milk fever	45	4.5 ± 3.95	0–17.9	80.0 (36)	2.8[a]
Claw diseases	41	3.7 ± 4.53	0–18.8	65.9 (27)	1.6[a]
Retained foetal membranes	42	2.6 ± 2.70	0–9.5	64.3 (27)	0.6[a]
Ketosis	44	2.4 ± 3.46	0–11.5	50.0 (22)	0.8[a]
Lameness	38	1.3 ± 2.14	0–7.7	36.8 (14)	–
Mortality					
Culled cows	41	30.3 ± 10.44	7.7–69.6	–	33.0[b]
Euthanized cows	43	3.7 ± 3.36	0–16.0	76.7 (33)	5.5[b, c]
Self-dead cows	43	0.7 ± 0.97	0–3.4	39.5 (17)	

[a] Average of Swedish organic and conventional dairy farms in 2014 (Växa Sverige, 2016)
[b] Average of Swedish organic and conventional dairy farms in 2014 (Växa Sverige, 2017a)
[c] Combined percentage of euthanized and self-dead cows.

Use of breeds

In the survey, the farmers got to specify which breeds they had and how the proportion of breeds looked on their farms, e.g. if they had Holstein and Swedish Red; how big proportion of the cows were of Holstein and how big proportion were of Swedish Red. As seen in Table 5, the two biggest proportions of breeds on a farm were Swedish Red (42%) and Holstein (39%). However, slightly more farms had Holstein than Swedish Red (87% and 82%, respectively). The majority of the farms had more than one breed (82%), and almost one third had other breeds such as Jersey or Brown Swiss. One third of the farms had crossbreeds, with Swedish Red×Holstein being the most common crossbreed (61.5% of the crosses, data not shown). The dominating breed on 42.1% farms were Holstein, followed by Swedish Red (39.8% of farms), and 18.4% of farms had crossbreeds or other breeds as the dominating breed on the farm.

Table 5. Breed composition on the farms

	N	Farms with breed (% (no.))	Percent of breed on farm, mean ± std	Range (%)
Holstein	38	87.2 (34)	39.3 ± 34.37	0–100
Swedish Red	39	82.1 (32)	41.7 ± 36.10	0–100
Other breeds[1]	39	30.8 (12)	11.9 ± 27.77	0–100
Crossbreeds[2]	39	33.3 (13)	6.7 ± 16.49	0–84

[1] Jersey, Swedish Mountain cattle, Swedish Polled, Brown Swiss, Fleckvieh, unspecified breed.
[2] Swedish Red×Holstein, Swedish Red×Jersey, Swedish Red×Ayrshire, Holstein×Fleckvieh, unspecified cross.

Milking routines

As seen in Table 6, the two most common milking routines used on the farms were new cleaning material for each cow and wet cleaning of the udder before milking (90 and 84%, respectively), while the least common milking routine on the farms were disinfecting of the milking organ during milking. Most farms (82%) used three or more types of routines.

Table 6. Milking routines on the farms

Milking routine	N	Farms that use routine (% (no.))	Farms that do not use routine (% (no.))
Dry cleaning of the udder before milking	39	64.1 (25)	35.9 (14)
Wet cleaning of the udder before milking	45	84.4 (38)	15.6 (7)
New cleaning material for each cow	41	90.2 (37)	9.8 (4)
New cleaning material for each teat	39	43.6 (17)	56.4 (22)
Uses intramammary teat seal	39	48.7 (19)	51.3 (20)
Uses gloves at milking	40	42.5 (17)	57.5 (23)
Disinfects milking organ during milking	42	28.6 (12)	71.4 (30)

Treatment practices for clinical mastitis

In general, most farmers used both antibiotics and drying off individual udder quarters to treat clinical mastitis, as seen in Table 7, where only six farmers used one of the two. One fourth of the farmers used homeopathic treatments, but all farmers that used homeopathic treatment used it in combination with other treatments for clinical mastitis.

Table 7. Treatment practices on the farms for clinical mastitis

Treatment of clinical mastitis	N	Farms that use treatment type (% (no.))	Farms that do not use treatment type (% (no.))
Antibiotic treatment	51	92.2 (47)	7.8 (4)
Drying off individual udder quarters	50	94.0 (47)	6.0 (3)
Homeopathic treatment	47	25.5 (12)	74.5 (35)

Effect of milking system

Milk production, SCC, and mastitis incidence differed between milking systems, see Table 8. Furthermore, there was only a significant difference for milk production, where farms with robot produced significantly more milk compared to farms with milking parlour ($p<0.013$).

Table 8. Effect of type of milking system on milk production (kg ECM), SCC (10^3 cells/ml), and mastitis (%), LSM ± SE

	N_{tot}	Milk line	N	Parlour	N	Robot	N	P-value[1]	P-value[2]
Milk production	55	8769 ± 363.3^{ab}	15	7983 ± 376.0^{a}	14	9185 ± 275.9^{b}	26	0.044	–
SCC	39	176.5 ± 15.70	10	205.4 ± 13.84	14	210.2 ± 11.28	20	0.199	0.143
Mastitis	44	12.0 ± 1.78	13	7.3 ± 1.90	12	9.5 ± 1.71	14	0.071	0.053

Different subscript letters within a row indicate pairwise differences at $p<0.05$.
[1] P-value for the predictor variable milking system (milk line, parlour, or robot) in the model.
[2] P-value for milk production as a continuous predictor variable in the model.

Effect of housing

The type of housing nor the type of lying surface or bedding material had an affect the milk production, SCC, or mastitis incidence, see Table 9-11.

Table 9. Effect of housing on milk production (kg ECM), SCC (10^3 cells/ml), and mastitis (%), LSM ± SE

	N_{tot}	Loose stall	N	Tie-stall	N	P-value[1]	P-value[2]
Milk production	53	9761 ± 222.9	40	9033 ± 391.0	13	0.549	–
SCC	43	208.5 ± 15.76	34	181.1 ± 16.36	9	0.187	0.090
Mastitis	40	8.3 ± 1.28	28	11.8 ± 1.89	12	0.069	0.045
	N_{tot}	**Insulated stall**	**N**	**Uninsulated stall**	**N**	**P-value[1]**	**P-value[2]**
Milk production	51	9014 ± 227.1	38	8216 ± 388.2	13	0.082	–
SCC	42	200.5 ± 8.45	31	215.1 ± 14.39	11	0.691	0.059
Mastitis	38	9.8 ± 1.10	27	6.8 ± 1.77	11	0.089	0.022
	N_{tot}	**Outdoor access**	**N**	**No outdoor access**	**N**	**P-value[1]**	**P-value[2]**
Milk production	56	8705 ± 395.0	14	8820 ± 228.1	42	0.802	–
SCC	45	194.2 ± 15.11	11	203.8 ± 8.59	34	0.523	0.137
Mastitis	40	11.6 ± 1.78	13	8.59 ± 1.23	27	0.111	0.031

[1] P-value for the predictor variable housing (loose or tie-stall, insulated or uninsulated stall, or access or no access to outdoor area) in the model.
[2] P-value for milk production as a continuous predictor variable in the model.

Table 10. Effect of lying surface on milk production (kg ECM), SCC (10^3 cells/ml), and mastitis (%), LSM ± SE

	N_{tot}	**Rubber matt**	**N**	**Mattress**	**N**	**Other**	**N**	**P-value[1]**	**P-value[2]**
Milk production	57	8776 ± 306	24	9023 ± 299	24	8211 ± 488	9	0.372	–
SCC	45	195.6 ± 11.82	18	211.2 ± 11.51	19	191.4 ± 18.09	8	0.413	0.178
Mastitis	42	11.1 ± 1.52	19	9.1 ± 1.67	15	6.8 ± 2.45	8	0.220	0.034

[1] P-value for the predictor variable lying surface (rubber matt, mattress, or other) in the model.
[2] P-value for milk production as a continuous predictor variable in the model.

Table 11. Effect of bedding material on milk production (kg ECM), SCC (10^3 cells/ml), and mastitis (%), LSM ± SE

	N_{tot}	**Straw**	**N**	**Sawdust**	**N**	**Other**	**N**	**P-value[1]**	**P-value[2]**
Milk production	51	9364 ± 428.0	11	8448 ± 273.2	27	9091 ± 392.7	13	0.150	–
SCC	41	194.5 ± 16.52	9	200.7 ± 10.05	24	216.5 ± 17.25	8	0.615	0.115
Mastitis	39	11.4 ± 2.36	8	8.2 ± 1.50	22	11.0 ± 2.23	9	0.240	0.052

[1] P-value for the predictor variable bedding material (straw, sawdust, or other) in the model.
[2] P-value for milk production as a continuous predictor variable in the model.

Effect of farm characteristics

There was a significant difference in milk production and mastitis incidence between farms with a small and large herd size, see Table 12. Farms with a large herd size had significantly higher milk production and lower mastitis incidence than farms with a small herd size ($p<0.018$ and $p<0.040$, respectively). Farms with a short calving interval had significantly lower mastitis than farms with a long calving interval ($p<0.041$). Farms that had average or high mastitis incidence had significantly higher milk production than farms with low mastitis incidence ($p<0.019$ and $p<0.036$, respectively).

Effect of milking routine

Whether the milking routines were used or not was not found to affect the milk production or mastitis incidence, as seen in Table 13. Farms that used dry cleaning before milking, compared to farms that did not, had significantly lower SCC ($p<0.014$).

Table 12. Effect of farm characteristics classes on milk production (kg ECM), SCC (10^3 cells/ml), and mastitis (%), LSM ± SE

	N_{tot}	Low	N	Average	N	High	N	P-value[1]	P-value[2]
Herd size		≤40				≥78			
Milk production	56	8175 ± 353.9[a]	16	8811 ± 283.1[ab]	25	9415 ± 365.5[b]	15	0.060	–
SCC	45	172.8 ± 13.76[a]	13	215.8 ± 10.65[b]	20	208.6 ± 13.94[ab]	12	0.023	0.471
Mastitis	40	11.8 ± 1.78[a]	13	9.8 ± 1.45[ab]	19	5.6 ± 2.23[b]	8	0.266	0.008
Culling percentage		≤25.4				≥35.7			
Milk production	41	8534 ± 486.7	10	8770 ± 335.9	21	8981 ± 486.7	10	0.811	–
SCC	40	195.1 ± 16.50	10	212.6 ± 11.64	20	183.4 ± 16.51	10	0.362	0.130
Mastitis	35	6.4 ± 2.61	7	9.3 ± 1.60	18	11.4 ± 2.15	10	0.179	0.074
Age at first calving		≤25.6				≥27.0			
Milk production	32	9235 ± 426.7	13	8889 ± 543.8	8	8182 ± 463.8	11	0.258	–
SCC	32	185.9 ± 14.18	13	184.4 ± 1.75	8	200.1 ± 15.57	11	0.948	0.064
Mastitis	27	10.8 ± 1.54[a]	10	5.7 ± 1.72[b]	8	8.8 ± 1.64[ab]	9	0.090	0.016
Dry days		≤58				≥68			
Milk production	53	8858 ± 409.7	14	8768 ± 306.6	25	8747 ± 409.7	14	0.979	–
SCC	44	208.3 ± 16.61	9	188.2 ± 10.85	21	216.2 ± 13.28	14	0.219	0.149
Mastitis	37	8.6 ± 1.84	9	8.2 ± 1.37	16	10.6 ± 1.58	12	0.510	0.012
Calving interval		≤375				≥398			
Milk production	31	8433 ± 517.1	9	9063 ± 447.8	12	9032 ± 490.5	10	0.588	–
SCC	30	207.7 ± 17.18	9	178.8 ± 14.74	12	192.2 ± 17.00	9	0.616	0.082
Mastitis	26	4.9 ± 2.67[a]	6	10.0 ± 2.04[ab]	10	12.2 ± 2.04[b]	10	0.060	0.122
Milk production		≤8341				≥9735			
SCC	45	168.3 ± 31.87	12	196.5 ± 11.51	21	243.3 ± 25.08	12	0.061	0.540
Mastitis	40	13.3 ± 3.78	12	9.5 ± 1.66	19	4.8 ± 3.56	9	0.178	0.050
SCC		≤170.0				≥240.0			
Milk production	45	8021 ± 464.3	10	8960 ± 293.6	25	9049 ± 464.3	10	0.196	–
Mastitis	37	9.3 ± 1.9	10	8.2 ± 1.35	18	8.9 ± 1.90	9	0.920	0.020
Mastitis		≤5.0				≥14.3			
Milk production	40	7818 ± 407.1[a]	11	9084 ± 318.3[b]	18	9074 ± 407.1[b]	11	0.041	–
SCC	37	202.0 ± 17.65	11	208.0 ± 13.22	18	185.8 ± 19.64	8	0.572	0.234

Different subscript letters within a row indicate pairwise differences at p<0.05.
[1] P-value for the predictor variable in the model.
[2] P-value for milk production as a continuous predictor variable in the model.

Table 13. Effect of milking routine on milk production (kg ECM), SCC (10^3 cells/ml), and mastitis (%), LSM ± SE

	N_{tot}	Farms that use type of routine	N	Farms that do not use type of routine	N	P-value[1]	P-value[2]
Dry cleaning of the udder before milking							
Milk production	38	8566 ± 309.5	24	8872 ± 405.3	14	0.552	–
SCC	35	185.8 ± 10.46	21	231.8 ± 12.83	14	0.006	0.266
Mastitis	34	9.5 ± 1.51	21	9.4 ± 1.92	13	0.998	0.050
New cleaning material for each teat							
Milk production	38	8756 ± 370.1	17	8817 ± 333.0	21	0.903	–
SCC	35	214.0 ± 12.99	16	193.8 ± 11.92	19	0.256	0.214
Mastitis	32	8.4 ± 1.82	15	10.5 ± 1.71	17	0.391	0.066
Uses intramammary teat seal							
Milk production	37	8970 ± 357.5	18	8576 ± 348.0	19	0.435	–
SCC	34	206.1 ± 13.22	17	200.7 ± 13.22	17	0.627	0.255
Mastitis	32	8.8 ± 1.74	16	10.6 ± 1.74	16	0.564	0.040
Uses gloves at milking							
Milk production	39	9083 ± 371.8	16	8603 ± 310.1	23	0.328	–
SCC	36	197.9 ± 13.65	15	208.5 ± 11.50	21	0.747	0.173
Mastitis	33	8.5 ± 1.81	15	10.4 ± 1.65	18	0.697	0.047
Disinfects milking organ during milking							
Milk production	41	8767 ± 446.1	12	8662 ± 287.0	29	0.843	–
SCC	38	191.8 ± 14.69	12	207.5 ± 9.97	26	0.421	0.127
Mastitis	35	11.1 ± 2.24	9	8.6 ± 1.32	26	0.403	0.027

[1] P-value for the predictor variable in the model.
[2] P-value for milk production as a continuous predictor variable in the model.

Discussion

Organic dairy production in Sweden

The general organic dairy farm within the data studied in this thesis had loose housing, insulated stall, rubber matt or mattress as a lying surface, sawdust as bedding material, and had milking robot. The farms had an average herd size of 77 lactating cows, produced on average 8791 kg ECM per cow and year, and had an average SCC of 201,440 cells/ml. These values are all lower than the Swedish average for organic dairy farms (Table 2, Växa Sverige, 2017b). The disease prevalence on the farms varied but the most common diagnosed and treated diseases were clinical mastitis (on average 9.6% of cows per farm), milk fever (4.5%), and claw diseases (3.7%). The average culling percentage was 30% of the cows on the farm, and the average percentage of euthanized and self-dead cows were 3.7% and 0.7%, respectively. The disease prevalence on the farms was somewhat different from the Swedish average, whereas the mortality was on the same level as the national average (Table 4, Växa Sverige, 2016; 2017a). However, the data on diseases and mortality from the national average is from the national milk recording data base, where cows from both organic and conventional production are included. There is no statistics on disease prevalence or mortality on organic farms only, so it is not certain whether the results of this study are comparable to the real average of organic dairy farms in Sweden. Additionally, important to note is that the results in this thesis are based on herd averages, while data from reports and other studies are in most cases average for individual cows. This means that you cannot fully compare the averages with each other, however, you do get an indication on general differences in levels.

Most farms in this thesis used three or more types of milking routines. New cleaning material for each cow (90% of the farms), wet cleaning of the udder before milking (84%), and dry cleaning before milking (64%) were the three most commonly used routines. Compared to a previous study by Ivemeyer *et al.* (2017), German organic farmers also use new cleaning material for each cow in most cases (73%). German farmers used gloves at milking more often than the Swedish farmers in this thesis (66 vs. 43%). This indicates that there is a variation in management practices used by organic dairy farmers between countries.

In general, all farmers in this thesis used antibiotics and/or drying off individual udder quarters to treat clinical mastitis, and 26% of the farmers used homeopathic treatment. However, none of the farmers used homeopathic treatment alone, but used it in combination with antibiotics and/or drying off udder quarters. The use of homeopathic treatment is similar to an earlier Swedish study by Hamilton *et al.* (2006), where 23% of the farmers used homeopathic treatment in combination with some other kind of non-homeopathic treatment, i.e. antibiotics or drying off udder quarters. However, most farmers in that study stated that they used homeopathic treatment for other illnesses or trauma than for clinical mastitis (Hamilton *et al.*, 2006). In the current survey, it was clearly asked for treatment for clinical mastitis. Compared to this study, and the study by Hamilton *et al.* (2006), homeopathy appears to be more commonly used in other countries, e.g. the UK where approximately half of the farmers uses homeopathy (Hovi & Roderick, 2000; Weller & Bowling, 2000).

The use of antibiotics in combination with drying off was more frequently used by the Swedish farmers in this thesis (83% of farmers) compared to a German study by Ivemeyer *et al.* (2017), where only one fourth of the organic farmers used antibiotic in combination with drying off. The EU Commission Regulation (2008) states that sick animals must be treated with allopathic or antibiotic remedies, i.e. it is illegal to withhold treatment from a sick animal in both Sweden and Germany. Furthermore, the definition of clinical mastitis may be different for Swedish and German farmers. The difference in treatment strategies for mastitis between organic dairy farmers in Sweden and Germany could also be due to different tradition in management practices among farmers and veterinarians, in combination with differences in national animal welfare legislation (SFS 2017:789; TierSchG, 2018) and organic certification regulations (SJVF 2017:42; OrganicRules, 2018).

Effect of farm characteristics

Association with milking system

In this thesis, the type of milking system was associated with the milk production and mastitis incidence, however, there were no association between milking system and SCC. Previous studies have shown differences in SCC between milking systems (Frössling *et al.*, 2017; Johansson *et al.*, 2017). However, these previous studies mainly studied the long-term effect on SCC after changing to a robot milking system, something that was not studied in this thesis. One study by Emanuelson and Nielsen (2017) found that farms with milk line and parlour had lower SCC compared to robot, and indicated that an increased SCC was an indicator for mastitis. The results from this thesis did show that farms with milking robot had significantly higher milk yield than farms with parlour, and farms with milk line had lower mastitis incidence than farms with parlour. A higher milk production for farms that use milking robot have been found in previous studies (Wagner-Storch & Palmer, 2003; Jacobs & Siegford, 2012), and might be caused by the increased number of milkings per day; up to three times in a milking robot system compared to two times in a parlour or milk line system. There are studies that have examined the effects of robot milking on mainly SCC, and signs of subclinical mastitis, however no studies were found that studied other types of milking systems and its effect on mastitis incidence. There is thus no clear conclusion whether there is an association between the type of milking system and mastitis incidence. The results from this thesis may indicate an association, however, as the data in this thesis is on farm level and not on cow level, nor have the milking system changed on the farms, this result might be controlled by other herd and management effects. To be able to say with certainty that the type of milking system influences the mastitis incidence and SCC, more studies are needed. However, it is important to note that not only the type of milking system will affect mastitis and SCC, but different management practices will have a great impact on the result.

Association with housing factors

There were no housing factors in this study that affected the milk production or SCC. Previous studies results do not show consensus, as cows housed in loose stalls have both been shown to have a lower (Simensen *et al.*, 2010) and a higher milk production (Rodrigues *et al.,* 2005) compared to cows housed in tie-stalls. There is lack of consensus in reports on associations between loose or tie-stall and level of SCC. Rodrigues *et al.* (2005) and Bauman *et al.* (2018) have found that cows housed in loose stalls have lower SCC compared to tie-stalls, while Simensen *et al.* (2010) have found similar result as in this study, i.e. no association between housing type and SCC. Rodrigues *et al.* (2005) discussed that the lower SCC and higher milk production in loose housing may be caused by the fact that farms with loose housing were larger and had better access to technical resources. They were also more likely to have routine maintenance of the milking system and to take samples of the milk for microbiological analysis (Rodrigues *et al.*, 2005). However, the difference between loose and tie-stalls might not only be caused by farm management or the cows' freedom to move, i.e. a larger area to be affected by, but might also be caused by other housing factors such as hygiene and type lying surface and bedding material. Some previous studies have found that the type of lying surface does affect the mastitis incidence and SCC, where cows housed on straw have been shown to have a higher mastitis incidence compared to non-bedded cubicles (Weller & Bowling, 2000; O'Mahony *et al.*, 2006), and cows housed on comfort mats have been shown to be associated with lower SCC (Gordon *et al.*, 2013). However, in this thesis, the type of lying surface or bedding material did not affect the milk production, SCC or mastitis incidence. This result might have been different if the number of farms in the study were higher, or if the data had been on cow level, and not on farm level.

The incidence of mastitis was, however, significant for most housing factors in this study; farms with tie-stall had significantly higher mastitis incidence than farms with loose stall, and a similar difference was seen between farms with insulated or uninsulated stalls. The higher mastitis incidence for cows housed in tie-stall might be caused by the lack of movement, i.e. lying on the same surface all day. This result is similar to previous studies, where it has been shown that cows housed in tie-stalls have a higher incidence of clinical mastitis compared to cows housed in loose stalls (Rodrigues *et al.*, 2005; Gordon *et al.*, 2013; Richert *et al.*, 2013). Richert *et al.* (2013) discussed that it was likely that this difference was caused by pathogens in the bedding or by the indirect effect of the housing type on the cows' hygiene. Furthermore, farms in this thesis where cows had access to an outdoor area had significantly higher mastitis incidence compared to farms without outdoor access. This could be caused by the increased exposure to dirt and bacteria outdoors, something that might increase the risk of mastitis. This was however not evident in a previous study by Popescu *et al.* (2013), where it was found that cows housed in tie-stall with access to an outdoor area for exercise had a lower mastitis incidence compared to cows that were housed in tie-stall without access to an outdoor area. However, no analysis between tie-stall farms with or without access to an outdoor area was done in this thesis, as there were too few farms with tie-stall to analyse, so it is not certain whether there was a difference in mastitis incidence between farms with the different tie-stall types in this thesis also. Nonetheless, studies on a cow level is needed to conclude the effect of outside access on factors such as mastitis incidence and SCC, especially from an organic management perspective.

Association with herd size

In this study, the herd size was associated with milk production, SCC, and mastitis incidence; farms with larger herds had higher milk yield, lower mastitis incidence, and higher SCC. This might be because large farms put more work into management and might have better technology than smaller farms, however, information on amount of work or technology on the farms was not collected. Larger farms have previously been found to be more likely to have routine maintenance of the milking system, use recommended pre-milking routines, sample the milk for microbiological analysis and to have frequent training of the staff, which was shown to be important for an increased milking efficiency (Rodrigues *et al.*, 2005). This thesis results support earlier studies that also have shown that with a larger herd size there is a lower mastitis incidence (Simensen *et al.*, 2010; Archer *et al.*, 2013) and higher SCC (Simensen *et al.*, 2010; Archer *et al.*, 2013; Emanuelson & Nielsen, 2017). However, the literature lack consensus, as some studies have found no difference in SCC with increased herd size (Bauman *et al.*, 2018), or have shown that farms with large groups have lower SCC (Haskell *et al.*, 2009). As its been shown that an increased herd size may also increase the SCC, Archer *et al.* (2013) discussed that it is of importance to have a good udder health management to reduce the risk of an increased SCC. While Haskell *et al.* (2009) considered that there might not be a direct relationship between herd size and SCC and discussed, similarly to Rodrigues *et al.* (2005), that larger farms might be more profitable and have more resources which encourages good hygiene routines.

Effect of hygiene routines at milking

There are scarce reports from studies examining the same types of hygiene routines at milking as included in this thesis. However, this thesis' results did not find that type of hygiene routine at milking had an association with milk production level or mastitis incidence, while there was one routine that were associated with the level of SCC; farms that used dry cleaning before milking had significantly lower SCC, compared to farms that did not use the routine. However, the information on hygiene routines from the farms are only based on what the farm use or do not use, i.e. there has been no change in routine, to see the results before and after. Thus, the result does not fully tell the truth, as well as it is, most likely, not whether the farm use or do not use dry cleaning before milking that is the only factor affecting the level of SCC. As it is more likely that there are other hygiene routines, as well as differences in conventional vs. organic management and housing, that is of importance. But this multifactorial effect on SCC or mastitis is difficult to examine and have not been previously studied. However, one previous study has shown that using dry cleaning of the udder before milking is associated with a lower mastitis incidence (O'Reilly *et al.*, 2006). A positive relationship between the level of mastitis and SCC has been found in previous studies (Sharma *et al.*, 2011).

In this thesis, there was no difference in mastitis incidence or SCC for farms that used or did not use intramammary teat seal. Previous studies have however shown that using intramammary teat seal will reduce the risk of mastitis and lower the SCC, as bacteria is unable to enter the teat canal and use the left-over milk as substrate and therefore grow and develop mastitis (Ivemeyer *et al.*, 2009; Williamson & Lacy-Hulbert, 2013). Using gloves at milking have in previous studies shown to increase the SCC and risk of mastitis, as you might not feel if your gloves are soiled and in turn soil the udder (Peeler *et al.*, 2000; O'Reilly *et al.*, 2006). This was however not evident in this thesis.

Method discussion

The data for this study was collected via an online survey. In the survey, the farmers reported whether the information on production (i.e. milk production, SCC, and mastitis incidence) were based on their own estimation (55.2%) or based on information from the official milk recording for the production year 2014 (44.8%). The fact that more than half of the respondents based their information on an estimation should be taken into consideration in the interpretation of the results, as the survey were given in January 2016 and the information the survey wanted was the production year of 2014. So, the information given could be an over- or underestimation and not be a true reflection of the production. However, given that farmers most likely know their own production, and the fact that the purpose of the survey was to collect qualitative and not quantitative data, the results should still give a good overall view of general characteristics of organic dairy production in Sweden. Another thing to consider is the fact that the data in this study is based on the farms yearly average, and not on cow averages per lactation.

Conclusion

There is a variation in farm characteristics and management practices on Swedish organic dairy farms. Furthermore, some farm characteristics are associated with milk production, SCC, and mastitis incidence. Increased herd size is associated with increased milk yield, increased SCC, and reduced mastitis incidence. However, as only few studies have been reported on these farm characteristics and management practices, and its relation to organic status, more detailed research on the subject of this thesis is needed.

Acknowledgements

I would like to thank my supervisor Anna Wallenbeck for her engaging support and help through this whole process. I want to thank my friends Jessica and Lisa for keeping me sane and grounded through everything. And finally, I want to thank my mom for being the strongest person in my life.

References

Ahlman, T. (2010). *Organic Dairy Production – Herd Characteristics and Genotype by Environment Interactions*. Doctoral Thesis, Swedish University of Agricultural Sciences, Uppsala.

Ahlman, T., Ljung, M., Rydhmer, L., Röcklinsberg, H., Strandberg, E. & Wallenbeck, A. (2014). Differences in preferences for breeding traits between organic and conventional dairy producers in Sweden. *Livestock Science*, 162, pp. 5-14.

Archer, S.C., Mc Coy, F., Wapenaar, W. & Green, M.J. (2013). Association of season and herd size with somatic cell count for cows in Irish, English, and Welsh dairy herds. *The Veterinary Journal*, 196(3), pp. 515-521.

Barkema, H.W., Schukken, Y.H., Lam, T.J.G.M., Beiboer, M.L., Benedictus, G. & Brand, A. (1998). Management practices associated with low, medium, and high somatic cell counts in bulk milk. *Journal of Dairy Science*, 81(7), pp. 1917-1927.

Bauman, C.A., Barkema, H.W., Dubuc, J., Keefe, G.P. & Kelton, D.F. (2018). Canadian National Dairy Study: Herd-level milk quality. *Journal of Dairy Science*, 101(3), pp. 2679-2691.

Bennedsgaard, T.W., Enevoldsen, C., Thamsborg, S.M. & Vaarst, M. (2003). Effect of Mastitis Treatment and Somatic Cell Counts on Milk Yield in Danish Organic Dairy Cows. *Journal of Dairy Science*, 86(10), pp. 3174-3183.

Busato, A., Trachsel, P., Schällibaum, M. & Blum, J.W. (2000). Udder health and risk factors for subclinical mastitis in organic dairy farms in Switzerland. *Preventive Veterinary Medicine*, 44(3), pp. 205-220.

Doehring, C. & Sundrum, A. (2016). Efficacy of homeopathy in livestock according to peer-reviewed publications from 1981 to 2014. *Veterinary Record*, 179(24), pp. 628-640.

Doherr, M.G., Roesch, M., Schaeren, W., Schallibaum, M. & Blum, J.W. (2007). Risk factors associated with subclinical mastitis in dairy cows on Swiss organic and conventional production system farms. *Veterinarni Medicina*, 52(11), pp. 487-495.

Emanuelson, U. & Nielsen, C. (2017). Short communication: Weak associations between mastitis control measures and bulk milk somatic cell counts in Swedish dairy herds. *Journal of Dairy Science*, 100(8), pp. 6572-6576.

European Academies Science Advisory Council (EASAC) (2017). *Homeopathic products and practices: assessing the evidence and ensuring consistency in regulating medical claims in the EU*. Available: http://mta.hu/data/EASAC_Homepathy_statement_web_final_2.pdf [2017-10-05]

Ekologiska Lantbrukarna (2008). *Växande marknad – Försäljning, volymer och trender för ekologisk mat* (Growing market – sales, volumes, and trends for organic food; in Swedish). Available: http://www2. ekolantbruk.se/pdf/3836.pdf [2017-10-05]

EU Commission Regulation (2017). *Commission Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control*. Available: http://eur-lex.europa.eu/eli/reg/2008/889/oj [2017-10-05]

EU Council Regulation (2017). *Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91*. Available: http://eur-lex.europa.eu/eli/reg/2007/834/oj [2017-10-05]

Fall, N., Forslund, K. & Emanuelson, U. (2008). Reproductive performance, general health, and longevity of dairy cows at a Swedish research farm with both organic and conventional production. *Livestock Science*, 118(1), pp. 11-19.

Frössling, J., Ohlson, A. & Hallén-Sandgren, C. (2017). Incidence and duration of increased somatic cell count in Swedish dairy cows and associations with milking system type. *Journal of Dairy Science*, 100(9), pp. 7368-7378.

Gordon, P.F., Van Den Borne, B.H., Reist, M., Kohler, S. & Doherr, M.G. (2013). Questionnaire-based study to assess the association between management practices and mastitis within tie-stall and free-stall dairy housing systems in Switzerland. *BMC Veterinary Research*, 9(1), pp. 200-210.

Hamilton, C., Forslund, K., Hansson, I., Emanuelson, U. & Ekman, T. (2002). Health of cows, calves and young stock on 26 organic dairy herds in Sweden. *Veterinary Record*, 150(16), pp. 503-508.

Hamilton, C., Emanuelson, U., Forslund, K., Hansson, I. & Ekman, T. (2006). Mastitis and related management factors in certified organic dairy herds in Sweden. *Acta Veterinaria Scandinavica*, 48(11), pp. 1-7.

Hammarberg, K.E. (2002). Animal Welfare in Relation to Standards in Organic Farming. *Acta Veterinaria Scandinavica*, 43(Suppl. 1), pp. 17-25.

Hardeng, F. & Edge, V.L. (2001). Mastitis, Ketosis, and Milk Fever in 31 Organic and 93 Conventional Norwegian Dairy Herds. *Journal of Dairy Science*, 84(12), pp. 2673-2679.

Haskell, M.J., Langford, F.M., Jack, M.C., Sherwood, L., Lawrence, A.B. & Rutherford, K.M.D. (2009). The effect of organic status and management practices on somatic cell counts on UK dairy farms. *Journal of Dairy Science*, 92(8), pp. 3775-3780.

Hovi, M. & Roderick, S. (2000). Mastitis and mastitis control strategies in organic milk. *Cattle Practice*, 8(3), pp. 259-264.

Hovi, M., Sundrum, A. & Thamsborg, S.M. (2003). Animal health and welfare in organic livestock production in Europe: current state and future challenges. *Livestock Production Science*, 80(1), pp. 41-53.

Ivemeyer, S., Walkenhorst, M., Heil, F., Notz, C., Maeschli, A., Butler, G. & Klocke, P. (2009). Management factors affecting udder health and effects of a one year extension program in organic dairy herds. *Animal*, 3(11), pp. 1596-1604.

Ivemeyer, S., Brinkmann, J., March, S., Simantke, C., Winckler, C. & Knierim, U. (2017). Major organic dairy farm types in Germany and their farm, herd, and management characteristics. *Organic Agriculture*, pp. 1-17. DOI: http://dx.doi.org/10.1007/s13165-017-0189-3

Jacobs, J.A. & Siegford, J.M. (2012). Invited review: The impact of automatic milking systems on dairy cow management, behavior, health, and welfare. *Journal of Dairy Science*, 95(5), pp. 2227–2247.

Johansson, M., Lundh, Å., De Vries, R. & Svennersten Sjaunja, K. (2017). Composition and enzymatic activity in bulk milk from dairy farms with conventional or robotic milking systems. *Journal of Dairy Research*, 84(2), pp. 154-158.

Kijlstra, A. & van der Werf, J. (2005). *Analysis of disease prevalence and medical treatments in organic dairy herds in the Netherlands.* In: Hovi, M., Walkenhorst, M. & Padel, S. (Eds.), Systems Development: Quality and Safety of Organic Livestock Products. Proceedings of the 4th SAFO Workshop, Frick Switzerland, University of Reading, pp. 157-164.

Kossaibati, M.A. & Esslemont, R.J. (1997). The costs of production diseases in dairy herds in England. *The Veterinary Journal*, 154(1), pp. 41-51.

KRAV (2017). *KRAVs regler 2017. 5.1.11.12. Karenstid vid läkemedelsbehandling* (KRAV regulations 2017. 5.1.11.12. Withdrawal time at medical treatment; in Swedish). Available: http://arkiv.krav.se/regler/kravs_regler_2017_flipp/index.html#118 [2017-10-27]

Lund, V. & Algers, B. (2003). Research on animal health and welfare in organic farming – a literature review. *Livestock Production Science*, 80(1), pp. 55-68.

Netigate (2017). Available: https://www.netigate.se [2017-08-29]

O'Mahony, M.C., Healy, A.M., O'Farrell, K.J. & Doherty, M.L. (2006). Animal health and disease therapy on organic dairy farms in the Republic of Ireland. *Veterinary Record*, 159(20), pp. 680-682.

O'Reilly, K.M., Green, M.J., Peeler, E.J., Fitzpatrick, J.L. & Green, L.E. (2006). Investigation of risk factors for clinical mastitis in British dairy herds with bulk milk somatic cell counts less than 150,000 cells/ml. *Veterinary Record*, 158(19), pp. 649-653.

OrganicDairyHealth (2017). *CORE Organic research projects: OrganicDairyHealth*. Available: http://coreorganicplus.org/research-projects/%20ORGANICDAIRYHEALTH/ [2017-09-18]

Orjales, I., López-Alonso, M., Rodríguez-Bermúdez, R., Rey-Crespo, F., Villar, A. & Miranda, M. (2016). Use of homeopathy in organic dairy farming in Spain. *Homeopathy*, 105(1), pp. 102-108.

OrganicRules (2018). *Description of the German organic certification system (2009).* Available: http://organicrules.org/1750/1/Description_GermanOrganicCertificationSystem_2009.pdf [2018-02-20]

Peeler, E.J., Green, M.J., Fitzpatrick, J.L., Morgan, K.L. & Green, L.E. (2000). Risk Factors Associated with Clinical Mastitis in Low Somatic Cell Count British Dairy Herds. *Journal of Dairy Science*, 83(11), pp. 2464-2472.

Pol, M. & Ruegg, P.L. (2007). Treatment Practices and Quantification of Antimicrobial Drug Usage in Conventional and Organic Dairy Farms in Wisconsin. *Journal of Dairy Science*, 90(1), pp. 249-261.

Popescu, S., Borda, C., Diugan, E.A., Spinu, M., Groza, I.S. & Sandru, C.D. (2013). Dairy cows welfare quality in tie-stall housing system with or without access to exercise. *Acta Veterinaria Scandinavica*, 55(1), pp. 43-43.

Richert, R.M., Cicconi, K.M., Gamroth, M.J., Schukken, Y.H., Stiglbauer, K.E. & Ruegg, P.L. (2013). Risk factors for clinical mastitis, ketosis, and pneumonia in dairy cattle on organic and small conventional farms in the United States. *Journal of Dairy Science*, 96(7), pp. 4269-4285.

SFS 2017:789. *Djurskyddsförordning (1988:539)* (Animal Welfare Regulation (1988:539); in Swedish). Stockholm: Ministry of Enterprise and Innovation.

Sharma, N., Singh, N.K. & Bhadwal, M.S. (2011). Relationship of Somatic Cell Count and Mastitis: An Overview. *Asian-Australasian Journal of Animal Sciences*, 24(3), pp. 429-438.

Simensen, E., Østerås, O., Bøe, K.E., Kielland, C., Ruud, L.E. & Næss, G. (2010). Housing system and herd size interactions in Norwegian dairy herds; associations with performance and disease incidence. *Acta Veterinaria Scandinavica*, 52(14), pp. 1-9.

SJVFS 2017:42. *Föreskrifter om ändring i Statens jordbruksverks föreskrifter (SJVFS 2015:29) om ekologisk produktion och kontroll av ekologisk produktion* (Regulations on changes of the Swedish Board of Agricultural Regulations (SJVFS 2015:29) on organic production and control of organic production; in Swedish). Jönköping: Swedish Board of Agriculture.

Sundrum, A. (2001). Organic livestock farming: A critical review. *Livestock Production Science*, 67(3), pp. 207-215.

Swedish Board of Agriculture (2015). *Jordbruksstatistisk sammanställning 2015* (Agricultural statistical summary 2015; in Swedish). JO 34 SM 1701. Jönköping: Swedish Board of Agriculture.

Swedish Board of Agriculture (2017a). *Statistik djurhållning: Ekologisk djurhållning 2016* (Statistics animal husbandry: Organic animal husbandry 2016; in Swedish). JO 26 SM 1701. Jönköping: Swedish Board of Agriculture.

Swedish Board of Agriculture (2017b). *Statistik animalieproduktion: Ekologisk animalieproduktion 2016* (Statistics animal production: Organic animal production 2016; in Swedish). JO 27 SM 1701. Jönköping: Swedish Board of Agriculture.

TierSchG (2018). *The German Animal Welfare Act (TierSchG).* Available: http://hirnforschung.kyb.mpg.de/en/the-law/the-german-animal-welfare-act.html [2018-02-20]

U.S. Department of Agriculture (USDA) (2017). *Organic Livestock Requirements*. Available: https://www.ams.usda.gov/sites/default/files/media/Organic%20Livestock%20Requirements.pdf [2017-10-05]

Valle, P.S., Lien, G., Flaten, O., Koesling, M. & Ebbesvik, M. (2007). Herd health and health management in organic versus conventional dairy herds in Norway. *Livestock Science*, 112(1), pp. 123-132.

Williamson, J.H. & Lacy-Hulbert, S.J. (2013). Effect of disinfecting teats post-milking or pre- and post-milking on intramammary infection and somatic cell count. *New Zealand Veterinary Journal*, 61(5), pp. 262-268.

von Borell, E. & Sørensen, J.T. (2004). Organic livestock production in Europe: aims, rules and trends with special emphasis on animal health and welfare. *Livestock Production Science*, 90(1), pp. 3-9.

Växa Sverige (2016). *Husdjursstatistik 2015* (Farm animal statistics 2015; in Swedish). Available: https://www.vxa.se/globalassets/dokument/statistik/husdjursstatistik-arsredovisning-2015.pdf [2017-09-20]

Växa Sverige (2017a). *Djurhälsovårdens redovisning 2015-2016* (Animal health care report 2015-2016; in Swedish). Available: https://www.vxa.se/globalassets/dokument/statistik/djurhalsovardens-arsredo visning_2015_16.pdf [2017-09-15]

Växa Sverige (2017b). *Husdjursstatistik 2016* (Farm animal statistics 2016; in Swedish). Available: https://www.vxa.se/globalassets/dokument/statistik/husdjursstatistik2016.pdf [2017-09-20]

Wagenaar, J.P., Klocke, P., Butler, G., Smolders, G., Nielsen, J.H., Canever, A. & Leifert, C. (2011). Effect of production system, alternative treatments and calf rearing system on udder health in organic dairy cows. *NJAS - Wageningen Journal of Life Sciences*, 58(3), pp. 157-162.

Wagner-Storch, A. M. & Palmer, R.W. (2003). Feeding behavior, milking behavior, and milk yields of cows milked in a parlor versus and automatic milking system. *Journal of Dairy Science*, 86(4), pp. 1494-1502.

Weller, R.F. & Bowling, P.J. (2000). Health status of dairy herds in organic farming. *Veterinary Record*, 146(3), pp. 80-81.

Zucali, M., Bava, L., Tamburini, A., Brasca, M., Vanoni, L. & Sandrucci, A. (2011). Effects of season, milking routine and cow cleanliness on bacterial and somatic cell counts of bulk tank milk. *Journal of Dairy Research*, 78(4), pp. 436-441.

Appendix 1: Survey questionnaire

The following questions are from the survey that was sent out to Swedish organic farmers in January 2016. The survey also included questions about e.g. feed, feeding, breeding strategy and selection that are not included here or in this master thesis.

PART 3: HOUSING ENVIRONMENT

Cross the options that are present in your herd for each animal category, several options per animal category is possible.

Housing

Loose stall

❒ Lactating cows
❒ Dry cows
❒ Heifers
❒ Calves

Tie-stall

❒ Lactating cows
❒ Dry cows
❒ Heifers
❒ Calves

Uninsulated stall

❒ Lactating cows
❒ Dry cows
❒ Heifers
❒ Calves

Insulated stall

❒ Lactating cows
❒ Dry cows
❒ Heifers
❒ Calves

Access to outdoor area

❒ Lactating cows
❒ Dry cows
❒ Heifers
❒ Calves

Other housing (describe freely) ______________
____
____

Lying surface

Concrete

❒ Lactating cows
❒ Dry cows
❒ Heifers
❒ Calves

Rubber matt

❒ Lactating cows
❒ Dry cows
❒ Heifers
❒ Calves

Mattress

❒ Lactating cows
❒ Dry cows
❒ Heifers
❒ Calves

Deep litter

❒ Lactating cows
❒ Dry cows
❒ Heifers
❒ Calves

Bedding material: Straw

❒ Lactating cows
❒ Dry cows
❒ Heifers
❒ Calves

Bedding material: Sawdust

❒ Lactating cows
❒ Dry cows
❒ Heifers
❒ Calves

Bedding material: Peat

❒ Lactating cows
❒ Dry cows
❒ Heifers
❒ Calves

Other lying surface or bedding material (describe freely) ______________
____
____

Milking system

One option is possible.

❒ Milk line
❒ Milking parlour
❒ Milking robot

Other milking system (describe freely) ____________________

PART 4: HERD SIZE, STRUCTURE, AND PRODUCTION YEAR 2014

The information below is based on information from:

❒ Official milk recording ❒ Own estimation (“qualified guess”)

Number of lactating cows (average year 2014): ____________________
Average milk production per cow year 2014 (kg ECM): ____________________
Milk protein percentage (average 2014): ____________________
Milk fat percentage (average 2014): ____________________
Average length of dry period in 2014 (number of days): ____________________

PART 5: ANIMAL HEALTH MANAGEMENT IN THE HERD

Choose the option about preventative work that is present in your herd, one option is possible per milking routine or management of clinical mastitis.

Milking routine

	Always	Often	Sometimes	Never
Dry cleaning of the teats before milking	❒	❒	❒	❒
Wet cleaning of the teats before milking	❒	❒	❒	❒
New cleaning material for each cow	❒	❒	❒	❒
New cleaning material for each teat	❒	❒	❒	❒
Uses intramammary teat seal	❒	❒	❒	❒
Uses gloves at milking	❒	❒	❒	❒
Disinfects milking organ during milking	❒	❒	❒	❒

Other work for mastitis prevention (describe freely) ____________________

Management of clinical mastitis

	Always	Often	Sometimes	Never
Antibiotic treatment	❒	❒	❒	❒
Drying off individual udder quarters	❒	❒	❒	❒
Homeopathic treatment	❒	❒	❒	❒

Other management of clinical mastitis (describe freely) ____________________

Somatic cell count, average 2014, uncorrected: ____________________

Number of diagnosed and medically treated cases of (during 2014):

Mastitis: ____________________
Retained placenta: ____________________
Milk fever: ____________________
Ketosis: ____________________
Claw diseases: ____________________
Lameness: ____________________

Culling and mortality during 2014:

Number of culled cows: ____________________
Number of euthanized cows (put down on farm): ____________________
Number of self-dead cows: ____________________

PART 7: RECRUITMENT AND BREEDING FOR THE PRODUCTION YEAR 2014

Calving interval (approx. average, number of days): ____________________
Average age at first calving (average 2014): ____________________

Breeds in the herd

Breed 1 name: __________ Proportion of cows in the herd that are of breed 1 (%): __________
Breed 2 name: __________ Proportion of cows in the herd that are of breed 2 (%): __________
Breed 3 name: __________ Proportion of cows in the herd that are of breed 3 (%): __________
Breed 4 name: __________ Proportion of cows in the herd that are of breed 4 (%): __________

Crossbreed 1 name of breeds in cross: ____________________
Proportion of cows in the herd that are of crossbreed 1 (%): ____________________
Crossbreed 2 name of breeds in cross: ____________________
Proportion of cows in the herd that are of crossbreed 2 (%): ____________________

Other about breeds in the herd (describe freely): ____________________