COMPARISON OF MASTITIS INCIDENCE BETWEEN AN ORGANIC AND CONVENTIONAL DAIRY HERD

A dissertation presented in part fulfilment of the requirements for the degree of Bachelor of Science Honours in Animal Science

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New Zealand

Kirsty Louise Melissa McLeod
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1. ABSTRACT

Globally, there is a growing market for organically produced dairy products. Fonterra Co-operative Dairy Company is seeking to take advantage of this growing demand by increasing its supply of organic milk producers. Very little formal research has been performed on organic dairying on New Zealand’s pastoral based systems, especially on mastitis. Much research has been published on organic systems in other countries, however, these systems differ greatly to New Zealand’s pastoral-based system. This suggests that findings of these studies may not accurately represent New Zealand organic farms. Mastitis is the most costly and predominant disease in New Zealand dairy systems. It represents an ongoing problem particularly in organic herds as the use of antibiotics is prohibited. This two-year study was part of the larger organic and conventional dairy systems trial located on adjacent farmlets at the Dairy Cattle Research Unit of Massey University. The mastitis incidence of the organic and conventional herds in this trial was assessed. In the 2004/2005 and 2005/2006 seasons, single quarter foremilk samples were taken from both herds on four occasions during calving, 14 days post-calving, mid-lactation and at dry-off. Milk samples were cultured for bacterial analysis. Individual-cow somatic cell counts (SCC) were obtained from monthly herd tests. The percentage of cows infected with *Staphylococcus aureus* and *Streptococcus uberis* was generally higher in the organic herd than the conventional herd. However, these differences were only significant at mid-lactation 2005/2006 for *Staphylococcus aureus* and dry-off 2005/2006 for *Streptococcus uberis*. Over the past five years of the trial, the incidence of *Staphylococcus aureus* infection has steadily increased in both the organic and conventional herds. In contrast, the incidence of *Streptococcus uberis* infections has stayed relatively stable in both the organic and conventional herds. In 2004/2005, mean lactation SCCs were similar for the organic and conventional herds at 93,065 and 78,830 cells/ml respectively. In 2005/2006, the organic herd had a higher SCC at 101,943 cells/ml, than the conventional herd at
63,738 cells/ml. This difference was significant for the first time since the trial began. The New Zealand dairy industry would benefit from further organic research to obtain long-term trends on mastitis bacteriology and SCC in organic systems.
2. ACKNOWLEDGEMENTS

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6. INTRODUCTION

Globally, there is a growing market for dairy products produced organically. The increased demand for organic food is being driven by rising public concerns for food safety, animal welfare and the environmental impact of intensive livestock systems (Sato et al. 2005). The public also believes that organic products are residue-free, environmentally friendly, taste better and are healthier (Rosati & Aumaitre 2004).

In New Zealand, Fonterra Co-operative Dairy Company is seeking to take advantage of the increased demand for organic milk products, and increase its suppliers of organic milk. In 2000, there were seven farms supplying organic milk to Fonterra. In 2005, this had increased to 60 farms, and by 2009, Fonterra aims to have 200 organic milk suppliers. To help achieve this, Fonterra is currently offering a premium of 20% on milksolids payments as an incentive to encourage more farmers to convert to an organic dairy system (Rural Delivery 2005).

Very little formal research has been performed on organic dairy farming on New Zealand’s pastoral-based dairy system, especially on mastitis. There is considerable published research available on organic dairy farming in America and Europe, especially the Nordic countries. However, these farms have completely different dairy systems to those in New Zealand, and results are unlikely to be an accurate representation of New Zealand’s pastoral farming systems.

Research is needed to add to the limited knowledge of organic udder health in New Zealand. New Zealand farmers need applicable quantitative research on organic dairy systems and mastitis in order to make informed decisions in considering converting their enterprise into an organic dairy system (Nauta et al.
2006). Such research could help to attract farmers to organic farming, especially at times of low milksolid payout. This may increase the number of organic milk suppliers in New Zealand, which would enable Fonterra to take advantage of the growing global demand for organic dairy products.

The goal of this research is to compare mastitis incidence between an organic and conventional dairy herd under a New Zealand pastoral-based farming system. Differences in the incidence of *Staphylococcus aureus* and *Streptococcus uberis* infections at four critical stages of lactation were identified and somatic cell count (SCC) patterns followed at monthly intervals throughout lactation. This is will add research data to the very limited local knowledge on organic-cow udder health in New Zealand. This will provide the New Zealand dairy industry with applicable, practical timely information, on organics and mastitis, thus allowing informed decisions on the organic dairy farming in New Zealand to be made.

### 6.1 MASTITIS

Mastitis is inflammation of the mammary gland. It is characterised by several physical and chemical alterations of the milk as well as corresponding pathological changes to the mammary tissue depending on the type of injury (Hamann 2005). Any foreign material or injury to the mammary gland can lead to mastitis however, infectious micro-organisms are the predominant cause (Hamann 2005). In New Zealand, the predominant mastitis-causing bacterium is *Streptococcus uberis* and *Staphylococcus aureus* is also the cause of a large number of mastitis cases. Pathogens such as these enter the teat canal and colonise into the ductal system and alveoli. This triggers an inflammatory response, which depending on the size of the reaction, leads to the signs of mastitis.
Mastitis can be classified according to its severity. That is the extent of the reaction and inflammation to the invasion of the pathogenic bacteria. Clinical mastitis can be diagnosed from several visible signs. The milk secretion is abnormal and can be watery, clotty and flaky. The clots are agglomerations of tissue debris, leukocytes and proteins (Levesque 2004). Moderate clinical mastitis is characterised by abnormal milk as well as a visibly inflamed udder that may be hard, red, hot and painful. In severe cases, clinical mastitis is also accompanied by systemic illness (Levesque 2004). Subclinical mastitis does not exhibit such visible signs, however, increases in SCC, increased milk conductivity, milk enzymes and or other changes in milk composition are associated with the small inflammation of the mammary gland that occurs (Levesque 2004; Silva Arteaga 2005). Subclinical mastitis can develop to clinical mastitis at varying rates; however, it can also spontaneously heal (Levesque 2004).

The immune response and corresponding inflammation of the mammary gland in reaction to pathogenic invasion, compromises the mammary glands tight junctions. This action disrupts the tight regulation of milk components and their concentrations. Table 6.1 shows a summary of some of the changes in milk composition that occur in mastitis milk as a comparison to normal milk composition. Such changes in milk composition have great affects on the processing properties of the milk.
Table 6.1 Changes in milk composition of high somatic cell count (SCC) milk in relation to normal milk composition (Silva Arteaga 2005).

<table>
<thead>
<tr>
<th>Components</th>
<th>Normal Milk (%)</th>
<th>High SCC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids - non fat</td>
<td>8.90</td>
<td>8.80</td>
</tr>
<tr>
<td>Fat</td>
<td>3.50</td>
<td>3.20</td>
</tr>
<tr>
<td>Lactose</td>
<td>4.90</td>
<td>4.40</td>
</tr>
<tr>
<td>Total protein</td>
<td>3.61</td>
<td>3.56</td>
</tr>
<tr>
<td>Total casein</td>
<td>2.80</td>
<td>2.30</td>
</tr>
<tr>
<td>Whey protein</td>
<td>0.80</td>
<td>1.30</td>
</tr>
<tr>
<td>Serum albumin</td>
<td>0.02</td>
<td>0.07</td>
</tr>
<tr>
<td>Lactoferrin</td>
<td>0.02</td>
<td>0.10</td>
</tr>
<tr>
<td>Immunoglobulins</td>
<td>0.20</td>
<td>0.60</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.05</td>
<td>0.10</td>
</tr>
<tr>
<td>Chloride</td>
<td>0.09</td>
<td>0.14</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.17</td>
<td>0.15</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.12</td>
<td>0.04</td>
</tr>
</tbody>
</table>

In conjunction with altered milk composition, quarters with high SCC also have reduced milk yield. This occurs because of the rupturing of the secretory cell tight junctions, which leads to a decrease in lactose concentration as it moves down the concentration gradient and out of the cell. Lactose is a major osmotic regulator and a reduction in lactose concentration will mean less water is drawn into the milk resulting in reduced milk volumes.

Mastitis is a very costly disease of dairy farming. Not only is there the expense of mastitis treatment such as the antibiotic costs as well as extra labour involved in treatment but there is also the loss of income from reduced milk production associated with high SCC as well as discard milk. In New Zealand during the 1991/1992 season, it was estimated the losses associated with an average SCC of 400,000 cells/ml was around $15,500 per herd. The breakdown of this cost is shown in table 6.2.
Table 6.2 Estimated losses for the producer as a consequence of mastitis with an average somatic cell count of 400,000 cells/ml for the 1991/1992 season (Silva Arteaga 2005)

<table>
<thead>
<tr>
<th>Source of Loss</th>
<th>Cost to Producer ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of milk production</td>
<td>9,905.00</td>
</tr>
<tr>
<td>Labour related to clinical mastitis</td>
<td>163.86</td>
</tr>
<tr>
<td>Antibiotics used in clinical mastitis</td>
<td>216.51</td>
</tr>
<tr>
<td>Discarded milk</td>
<td>62.68</td>
</tr>
<tr>
<td>Labour related to dry cow therapy</td>
<td>27.6</td>
</tr>
<tr>
<td>Dry cow therapy antibiotics</td>
<td>459.48</td>
</tr>
<tr>
<td>Culling</td>
<td>4,614.00</td>
</tr>
<tr>
<td><strong>Total costs</strong></td>
<td><strong>15,449.13</strong></td>
</tr>
</tbody>
</table>

When considering the high cost mastitis has to the dairy system, prevention and fast efficient treatment of any mastitis case is vital. Mastitis can be prevented through strict hygiene methods during milking as well as proper milking machine use and maintenance. Post-milking disinfection also aids in the prevention of intramammary infections (Tikofsky & Zadoks 2005). In conventional systems, cows that have mastitis are treated with antibiotics during lactation (Tikofsky & Zadoks 2005). Long acting antibiotics such as dry cow therapy can also be used to prevent and cure infections at dry-off and over the dry period.

6.2 ORGANIC MILK PRODUCTION SYSTEMS

An organic system can be defined as a “holistic production management system which promotes and enhances agroecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasises the use of management practices in preference to the use of off-farm inputs and where possible, cultural, biological and mechanical methods as opposed to using synthetic materials.” (USDA 2000). The main difference between conventional and organic systems is the avoidance of the use of synthetic materials and the goal of improved animal welfare (AgriQuality 2006a).

There are varying standards and regulations governing organic dairy farming. New Zealand has an AgriQuality organic certification; however, there is also European Union (EU) and United States Department of Agriculture (USDA)
organic regulations. As of August 2007, all New Zealand organic dairy farms will be governed by the USDA regulations. The USDA organic regulations can be considered much stricter than the AgriQuality and EU regulations. There are two main points that distinguish dairy farming under USDA regulations compared to other regulations, with regard to mastitis. Firstly, management of organic livestock health is done through preventative practices and veterinary biologics (AgriQuality 2006a). It is only when these measures are inadequate in preventing sickness that synthetic medicines may be administered. When an animal has been treated with synthetic medicines, milk and other products can no longer be supplied as organic produce (AgriQuality 2006b). Secondly, once a dairy animal has been converted to organic, if it is treated with antibiotics or synthetic materials after gaining organic status, it loses this status forever. However, conventional dairy animals that have been treated with antibiotics in the past can be converted to organic status through continuous organic management for one year prior to milk been sold as organic. In spite of the large disincentive to use synthetic medicine on sick organic animals, the USDA regulations also state that management must not allow any medical treatment to be withheld from a sick animal in an effort to preserve its organic status. All appropriated medications must be used to restore animals to full health when methods acceptable to organic production fail.
7. LITERATURE REVIEW

7.1 BACKGROUND

Mastitis is the dominant disease problem in organic dairy systems (Vaasrt et al. 2003). This disease must be controlled through the maintenance of the health and wellbeing of the cow without the use of antibiotics. Farmers considering converting to an organic system need relevant information on mastitis to enable them to make informed decisions and plan for any changes that may occur (Nauta et al. 2006). At present, a trial at the Dairy Cattle Research Unit (DCRU), Massey University, Palmerston North, is comparing an organic dairy system with a conventional system. Two sets of mastitis data have been published from this trial and these represent the only research data available about mastitis, for an organic herd, in New Zealand.

This review aims to investigate New Zealand organic mastitis research, SCC and bacteriology, summarising and comparing it to New Zealand conventional mastitis knowledge. Key findings from organic udder health research in other countries will be summarised and compared with New Zealand organic and conventional mastitis knowledge. This literature review will identify and discuss the areas where research in organic udder health in New Zealand is needed.

7.2 BACTERIOLOGY

7.2.1 PREVIOUS ORGANIC RESEARCH

Research from the DCRU organic and conventional dairy systems comparison trial by Silva Arteaga (2005), represents the only comparative bacteriology data for a organic herd in New Zealand.
Incidence of *Staphylococcus aureus* infection was generally low at calving and then increased throughout lactation to dry-off for both the organic and conventional herd (Figure 7.1). This pattern agrees with prior research on conventional New Zealand dairy herds (McDougall 1998). Danish organic herds also presented this pattern of *Staphylococcus aureus* infection with the majority of infections in late lactation and around dry-off (Vaarst & Enevoldsen 1997). The peak in infection by *Staphylococcus aureus* at dry-off, could be due to reduced milk yield (less milk to flush the bacteria out of the gland), phagocytes starting to engulf milk residues instead of bacteria, or to environmental changes (Silva Arteaga 2005). Despite this general pattern, the organic and conventional herd both peaked in infection at 14 day post-calving, 27.9% and 11.5% respectively of each herd. However, the incidence of infection at 14 days post-calving was very similar to the dry-off sample (Figure 7.1). As seen in figure 7.1 and table 7.1, the organic herd had a higher incidence of *Staphylococcus aureus* infection per cow and per quarter than the conventional herd at all sampling periods. These differences were significant at all four sampling periods, except for *Staphylococcus aureus* infection per cow at dry-off (Silva Arteaga 2005).
Table 7.1 Percentage of quarters infected with *Staphylococcus aureus* and *Streptococcus uberis* for an organic or conventional herd at four sampling periods (Silva Arteaga 2005).

<table>
<thead>
<tr>
<th></th>
<th>Mid-lactation</th>
<th></th>
<th>Dry-off</th>
<th></th>
<th>Calving</th>
<th></th>
<th>14 days post-calving</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Org</td>
<td>Conv</td>
<td>Sig</td>
<td>Org</td>
<td>Conv</td>
<td>Sig</td>
<td>Org</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td>7.9</td>
<td>1.7</td>
<td>***</td>
<td>9.9</td>
<td>3.2</td>
<td>*</td>
<td>5.9</td>
</tr>
<tr>
<td><em>S. uberis</em></td>
<td>1.7</td>
<td>2.1</td>
<td>NS</td>
<td>2.6</td>
<td>0.8</td>
<td>NS</td>
<td>9.0</td>
</tr>
</tbody>
</table>

In contrast to *Staphylococcus aureus* infection, the incidence of *Streptococcus uberis* infection was highest at calving, declining as the season progressed (Figure 7.1). This again agrees with the general pattern of infection for New Zealand conventional cows (McDougall 1998). This pattern of infection was seen in both the organic and conventional herds, although the conventional herd’s infection rate began to increase again around dry-off. In comparison to the incidence of *Staphylococcus aureus*, the incidence *Streptococcus uberis* infected cows and quarters were similar in both the organic and conventional herds and differences were not significant at any stage of lactation.

### 7.2.2 AFFECT OF DAIRY SYSTEM ON MASTITIS MICROBIOLOGY

The incidence of specific pathogenic intramammary infection depends on the system in which the dairy herd is managed. Dairy farming in New Zealand is predominantly pastoral-based year round grazing. In this type of system, *Streptococcus uberis*, *Staphylococcus aureus*, Coagulase negative staphylococcus and *Streptococcus dysgalactiae* are the dominant pathogenic bacteria (Table 7.2). The minor pathogens are *Corynebacterium* spp., coliforms (*Escherichia coli*, *Pseudomonas* spp. and *Hafnia* spp.) and Bacilliis spp. (McDougall 1998). Gram-negative bacteria generally have a very low incidence in New Zealand because cows are grazed outside rather than being housed year round (Woolford & Lacy-Hulbert 1996). In countries like Norway and Denmark where cows are housed, the major bacteria are *Staphylococcus aureus*, *Streptococcus dysgalactiae* and Coagulase negative staphylococcus (Vaarst & Enevoldsen 1997).
Table 7.2  Prevalence of bacterial species from 578 quarters presented with clinical mastitis in New Zealand (McDougall 1998).

<table>
<thead>
<tr>
<th>Culture result</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streptococcus uberis</td>
<td>74.7</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>2.9</td>
</tr>
<tr>
<td>Streptococcus dysgalactiae</td>
<td>4.2</td>
</tr>
<tr>
<td>Coliforms</td>
<td>4.7</td>
</tr>
<tr>
<td>Coagulase negative staphylococcus</td>
<td>10.2</td>
</tr>
<tr>
<td>Others</td>
<td>3.3</td>
</tr>
</tbody>
</table>

* as a % of all bacteria positive quarters

*Streptococcus uberis* is the predominant pathogenic bacteria causing mastitis in New Zealand because it is an environmental bacterium. In New Zealand, cows are often calved on small areas of pasture and are shifted along muddy races (McDougall 1998). This increases the risk of infection at a time when the mammary glands physical defence mechanisms are compromised and the udder is often leaking milk. The incidence of mastitis due to environmental pathogen usually declines in New Zealand’s dry summers, when the dry environmental conditions reduce the exposure of cows to such pathogens (Pankey et al. 1996).

In housed systems, *Streptococcus uberis* is associated with dirty wet bedding and the incidence of infection due to this bacteria can be reduced easily with good hygiene and management of the stalls (Weller & Davies 1998).

In contrast to *Streptococcus uberis*, *Staphylococcus aureus* is a contagious pathogenic bacteria (Silva Arteaga 2005). Infections associated with this bacterium are usually due to ineffective milking hygiene practices. This is because *Staphylococcus aureus* is present on the cow’s skin and streak canals, and can easily be spread to other cows during milking (Vaarst & Enevoldsen 1997). As New Zealand’s system of dairy farming is very different from those in Europe and the USA, there is a need to study the incidence and bacteriology of mastitis in pastoral systems under organic and conventional management.
7.3 SOMATIC CELL COUNTS

7.3.1 PREVIOUS NEW ZEALAND RESEARCH

SCC is an international indication of mastitis, the inflammation of the mammary gland. It is also a sign of the level of cow stress and thus has implications in animal welfare (Rosati & Aumaitre 2004). The level of SCC is important as it is related to milk production and thus high SCCs reduces the financial performance of the herd (Weller & Davies 1998). It is also important to have low SCC as somatic cells alter the processing qualities of the milk. The current EU limit for SCC is 400,000 cells/ml. In order for this to occur a herd would need to contain approximately 40% infected cows and 17% infected quarters (Woolford & Lacy-Hulbert 1996).

The trial at Massey University’s DCRU, comparing organic and conventional dairy systems, has been running since August 2001. AgriQuality organic certification was gained in 2003. In the 2001/2002 season, during the conversion period, there was no significant difference in SCC between the organic and conventional herds. The organic herd had a SCC of 84,886 cells/ml, while the conventional herd was slightly lower at 71,091 cells/ml (Lopez-Villalobos et al. 2003). The percentage of acute SCC cases was also similar for both herds at 3.3% (this is the number of herd test results that exceeded 500,000 cells/ml divided by the total number of herd test SCC records (Lopez-Villalobos et al. 2003)). In the 2002/2003 season, when organic certification was still being obtained, the organic herds SCC had increased to 86,474 cells/ml, while the conventional herd SCC declined to 53,036 cells/ml (Agricultural Services, Personal Communication, 2006). In the 2003/2004 season, when organic certification had been obtained, SCC for both the organic and conventional herds had increased. The organic herd had a slightly higher SCC at 116,000 cells/ml than the conventional herd at 102,000 cells/ml (Silva Arteaga 2005).
Lopez-Villalobos et al. (2003) observed that the SCC for both the organic and conventional herds was high in early lactation, decreasing during mid-lactation and increasing again around dry-off. Research by Silva Arteaga (2005), also observed a similar SCC pattern (Figure 7.2). New Zealand can have pronounced seasonal fluctuation in SCC due to the dilution by milk volume, which peaks five to six weeks post-calving and then slowly declines. However, any significant elevation in SCC measured more than 3 days after calving, is not due to physiological factors but instead would be due to an intramammary infection (Woolford & Lacy-Hulbert 1996).

Figure 7.2 Monthly average somatic cell counts (log\(_e\)SCC) for an organic and conventional herd throughout the 2003-2004 season (♦ conventional) (□ organic) I = SE(Silva Arteaga 2005).

SCC can be considered a reliable indicator of the presence of intramammary infection. Although the thresholds are arguable, it has been suggested that SCCs exceeding 120,000 cells/ml for a heifer or primiparous cow and 150,000 cells/ml for a multiparous cow are indicative of an intramammary infection (Woolford & Lacy-Hulbert 1996). Silva Arteaga (2005) observed the percentage of an organic and conventional herd with SCC below 200,000 cells/ml and exceeding 400,000 cells/ml (Figure 7.3). On average, 75% of the organic and
77% of the conventional herd had SCC below 200,000 cells/ml and were considered unlikely to have intramammary infections. The overall percentage of the herds, exceeding 400,000 cells/ml, was on average 15% for the organic and 11% of the conventional herd. Although the organic herd was slightly worse in both categories, with more cows in the high SCC category and less in the low SCC category, overall, there was no significant difference between the two herds (Silva Arteaga 2005).

Figure 7.3 Percentage of cows with somatic cell counts (SCC) below 200,000 or above 400,000 cells/ml from monthly herd tests for an organic and conventional herd in the 2003/2004 season (▲ conventional <200,000)(■ organic <200,000)(× conventional >400,000)(◆ organic >400,000) (Silva Arteaga 2005).

7.3.2 PREVIOUS OVERSEAS RESEARCH

In contrast to the limited New Zealand organic SCC data, there is much published research available in other countries, especially Europe and the USA. Generally, SCCs from overseas trials have provided controversial data that varies greatly for both organic and conventional herds. This leads to the suspicion that SCC data is collected and analysed in different manners in the different published research.
Research from Norway suggests that overall cows from organic dairy herds have slightly high mean SCC than conventional herds (Hardeng & Edge 2001). Other data from Norway found that although conventional herds are treated with antibiotics three times more than organic herds, SCCs are relatively similar (Bennedsgaard et al. 2003). This was similar to Danish findings where in the years 1990 to 1993, the bulk SCC (bSCC) for organic herds was generally the same or lower than those of conventional herds despite low antibiotic use (Bennedsgaard et al. 2003).

Weller & Cooper (1996) found that in the first year of conversion to an organic system the mean bSCC for a organic herd was 270,700 cells/ml. In the second year, this increased up to 299,100 cells/ml. This was in English and Welsh herds in a system year round calving, with cows housed during the winter. In England, a single organic herd’s milk was sampled monthly and was also found to have SCC above 200,000 cells/ml in their first two conversion years. In year one, the mean SCC was 234,640 cells/ml and in the second year it was 214,080 cells/ml (Weller & Davies 1998). In Denmark, the mean SCC for an organic herd in the first year after conversion was 358,000 cells/ml and the second year was 317,500 cells/ml (Table 7.3) (Vaasrt et al. 2003). All of these studies showed mean SCC above 200,000 cells/ml in the first two years of converting to organic. These values were much higher than the mean SCC from the DCRU trial, which in the first year had 84,886 cells/ml with 86,474 cells/ml in the second year (Lopez-Villalobos et al., 2003; Agricultural Service, Personal Communication, December 2006). This could possible be due to SCC being obtained from individual monthly herd tests instead of bulk milk as well as natural logarithmic transformation. This makes comparisons between different research difficult.
Table 7.3 Mean somatic cell count (SCC) around time of conversion to organic dairy farming for 20 herds in Denmark (Vaasrt et al. 2003).

<table>
<thead>
<tr>
<th>Year converted</th>
<th>Years from conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-1</td>
</tr>
<tr>
<td>1999</td>
<td>317,000</td>
</tr>
<tr>
<td>2000</td>
<td>275,000</td>
</tr>
<tr>
<td>Average</td>
<td>296,000</td>
</tr>
</tbody>
</table>

Such large differences in SCC between New Zealand and Europe would also be due to predominately housed systems in Europe and the USA, whereas New Zealand cows including the herds at the DCRU are on pasture all year round. SCC can reach high levels in cows housed on deep litter stalls (Weller & Davies 1998). It is also interesting to note that most of the SCC research utilises bulk milk sampling to obtain mean SCC. In New Zealand, cows suspected to have high somatic cell counts often have their milk withheld from the vat to avoid penalties for high SCC. Thus, monthly milk samples from all cows gives a much better representation of the herds mean SCC.

Although actual SCC cannot be accurately compared across published research data, the relationship between organic and conventional herd in this research can be compared. Sato et al. (2005) found mean bSCC to be 263,000 cells/ml for organic herds and 285,000 cells/ml for conventional herds in Wisconsin, USA. This difference was not statistically different suggesting little difference in SCC between the organic and conventional herds (Sato et al. 2005). In France, organic and conventional herds were similar with 45% and 46% of the herds respectively, having SCC below 300,000 cells/ml. There was also similar percentages of the organic and conventional herds in the SCC ranges of 200,000 to 400,000 cells/ml and over 400,000 cells/ml as seen in table 7.4 (Rosati & Aumaitre 2004). However, there has been studies in which SCC have been quite different between organic and conventional herds. The mean SCC for the single organic herd followed in England by Weller & Davies (1998) was 243,533 cells/ml over the six year period. The authors observed that this was much higher than the majority of conventional herds in England. When data from 12,000
convention herds was analysed, 54.3% had SCC between 100,000 and 200,000 cells/ml and 13.4% had SCC below 100,000 cells/ml.

Table 7.4  Bulk somatic cell counts for organic and conventional dairy herds in France (Rosati & Aumaitre 2004).

<table>
<thead>
<tr>
<th>Cell counts ($\times 10^3$/ml)</th>
<th>&lt;300</th>
<th>200–400</th>
<th>&gt;400</th>
</tr>
</thead>
<tbody>
<tr>
<td>264 Herds, certified or in accession (%)</td>
<td>45%</td>
<td>44</td>
<td>12</td>
</tr>
<tr>
<td>Conventional herds (average) (%)</td>
<td>46%</td>
<td>40</td>
<td>14</td>
</tr>
</tbody>
</table>

7.3.3 LONG-TERM TRENDS IN SCC

Norwegian research has shown that an organic herd can have increases in SCC up to their sixth lactation and beyond (Hardeng & Edge 2001). The research showed the conventional herd SCC also increased over five lactations; however, it was significantly lower than the organic herd in the sixth lactation (Table 7.5). The only other stage when the two herds differed significantly was in the second lactation when the organic herd had significantly lower SCC than the convention herd. This was surprising and contrasts with most research in which organic herds have significantly higher SCC than conventional herds in the second lactation. Weller & Davies (1998) also found that SCC from organic herds increased up to the sixth lactation (Table 7.5). However, in contrast to findings of Weller & Davies (1998), Hardeng & Edge (2001) did not find consistent increases as the years of the study passed and the SCC were also far higher. Results from Nauta et al. (2006) agrees with the general trend for long-term increases in SCC from organic herds. They found that long-standing organic farms had high SCC.
Table 7.5  Long-term trends in somatic cell counts for a conventional and two organic herds as time and lactation number since organic conversion progresses.

<table>
<thead>
<tr>
<th>Mean SCC</th>
<th>Author</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>Hardeng &amp; Edge 2001</td>
<td>55,000</td>
<td>80,600</td>
<td>91,800</td>
<td>101,500</td>
<td>108,900</td>
<td>116,700</td>
</tr>
<tr>
<td>Organic</td>
<td>Hardeng &amp; Edge 2001</td>
<td>54,000</td>
<td>68,700</td>
<td>92,700</td>
<td>92,700</td>
<td>116,800</td>
<td>169,000</td>
</tr>
<tr>
<td>Organic</td>
<td>Weller &amp; Davies 1998</td>
<td>234,640</td>
<td>214,080</td>
<td>292,450</td>
<td>200,880</td>
<td>256,400</td>
<td>262,750</td>
</tr>
</tbody>
</table>

Nauta et al. (2006) studied the effect that conversion to organic dairy farming had on somatic cell score (SCS). As seen in figure 7.4, SCS starts to steadily increase about two years before conversion. This indicates that farmers are perhaps changing their management methods in anticipation of converting to an organic system (Nauta et al. 2006). After converting to organics, the farms had an increase in SCS of 0.17 units. With a population mean SCS of 150,000 this increase is equal to a SCS of 50,000 over seven years (Nauta et al. 2006). The long-term change in SCC and SCS for organic herds are interesting as they indicate that the organic environment is continuing to change even after six years of organic management (Nauta et al. 2006).

Figure 7.4  Effect of converting to organics (BIO) on somatic cell score (SCS) (Nauta et al. 2006).

7.4 MASTITIS DETECTION & DIAGNOSIS

Clinical mastitis can be identified by swollen, hard, hot udders or noticeable clots or changes in milk consistency (McDougall 1998). Subclinical mastitis does not present such signs but can be identified by high SCC, increased milk
conductivity, milk enzymes and or other changes in milk composition (Silva Arteaga 2005). Milk sampling and microbiological examination can also be used to detect mastitis and diagnose the causative pathogenic bacteria (Silva Arteaga 2005).

Controversy exists over the number and frequency of milk samples required for accurate diagnosis of mastitis and the responsible bacteria. The methods can be single, duplicate or consecutive sampling. Single and duplicate samples are taken from a single milkings, whereas consecutive sampling requires taking a collection of two or more samples at several separate milkings separated by an interval of at least one day (Sears et al. 1990; Silva Arteaga 2005). Single samples have been shown to be adequate to identify bacteria from infected quarters. However, bacteria like *Staphylococcus aureus* have two shedding cycles (Sears et al. 1990). In experimental challenges, it was found that there was a 25% chance of a false negative culture with single milk samples (Sears et al. 1990). There was a 74.5% probability of at least one true positive culture with single samples, 94% probability with two consecutive samples and 98% probability with three consecutive sample (Sears et al. 1990). Therefore, higher accuracy of detection is obtained with duplicate or consecutive sampling. However, constraints such as time, budget, logistics and practicality often mean that diagnosis must be made from single samples. If steps are taken to reduce contamination, and sampling is in accordance with the National Mastitis Council milk sampling protocols for aseptic sampling, results from single samples can be considered to give proper diagnosis. Additional samples can always be taken in doubtful cases (Silva Arteaga 2005).
7.5 CONCLUSION

Global demand for organic dairy products is steadily increasing and Fonterra wishes to take advantage of this by increasing its number of organic milk suppliers. Considerable amounts of organic research have been done in Europe and America, however very little has been done on dairy farms in New Zealand’s pastoral-based system, especially on mastitis. Mastitis has been found to be the dominant disease problem in organic dairy systems and must be controlled through prevention rather than conventional treatments because antibiotics are prohibited. Without local knowledge, New Zealand farmers are unable to make an informed decision on whether to convert to organic dairying farming or remain conventional.

Dairying in New Zealand is based on pastoral systems and is therefore likely to have different incidences and types of pathogenic bacterial infections, than housed systems from other countries. In New Zealand, dairy cows generally have a higher incidence of environmental bacteria such as *Streptococcus uberis* than contagious bacteria. In contrast, housed systems are more likely to have higher incidence of contagious pathogenic bacteria such as *Staphylococcus aureus* than environmental bacteria. New Zealand’s only research on organic bacteriology, found that the incidence of *Staphylococcus aureus* infection increased over lactation. The organic herd had significantly high incidence of *Staphylococcus aureus* infection than the conventional herd at most sampling periods. In contrast, *Streptococcus uberis* incidence declined over lactation and the incidence of infection in the organic herd did not differ significantly from the conventional herd at any stage. The use of single milk sampling, as used in this research, has been found to provide adequate accuracy in diagnosis of infection of pathogenic bacteria.

SCCs are good indicators of the presence of mastitis. In the one New Zealand trial on organics and mastitis, the first two years after conversion the organic herd
had SCC of 84,886 cells/ml and 86,000 cells/ml respectively. This was higher than the adjacently managed conventional herd, which had SCC of 71,091 cells/ml and 53,000 cells/ml in the first two years of the trial. The long-term trend for organic systems from overseas research, is that SCC appears to increase over the years after conversion up to at least the sixth year.

New Zealand is an all year round pastoral grazing system that differs greatly from housed dairy systems in other countries. The research available from these overseas systems may not be specifically applicable to New Zealand’s systems. More New Zealand organic research is required to enable those in the industry to make informed decisions and judgements about organic dairy farming in New Zealand dairy systems.
8. MATERIALS AND METHODS

8.1 THE FARMLETS

In 2001, an organic and conventional dairy systems comparisons trial was established at the Dairy Cattle Research Unit (DCRU), Massey University, Palmerston North, New Zealand. There 40 hectares was split evenly into two neighbouring farmlets of which one was managed conventionally and the other organically. The existing dairy herd at the DCRU was split into two herds based on breeding worth, production worth, weight, age and somatic cell counts. The organic farmlet obtained AgriQuality organic certification in 2003 and began receiving a 20% premium on milksolids from Fonterra.

The organic and conventional herds are milked in a ten-bail walk-through cow shed under a strict milking procedure. The organic herd is always milked prior to the conventional herd and there are two separate vats for the organic and conventional milk. All the plants and vats are cleaned with organically acceptable chemicals to maintain hygiene standards and avoid contamination of the milk. Milk tanker compositional samples and dockets monitored this daily. Antibiotic treated conventional cows were milked last to avoid contamination of milk supply with prohibited substances. High somatic cell count (SCC) organic cows were milked into a test bucket or have reoccurring mastitis quarters dried off.

8.2 MILK SAMPLING

Foremilk samples were taken from all milking quarters of all cows at four sampling periods. This was at the first milking or within twenty-four hours of calving (July to September 2005), 14 days post-calving (August to October
2005), mid-lactation (January 2006) and at the last milking before dry off (March to April 2006). These periods represent critical stages of lactation.

8.2.1 MILK SAMPLING PROTOCOLS

Aseptic milk sampling was undertaken in accordance to the National Mastitis Council milk sampling protocols to help reduce contamination during sample collection. Sterile plastic bottles with screw top caps were labelled with a waterproof vivid to identify cow and quarter. Cotton swabs soaked in 70% isopropyl solution were used to clean each quarter teat end. A new swab was used with each quarter, cleaning from the far quarters first and then those on the near side. Alcohol evaporates quickly, reducing drying time and contributes no bactericidal residue to the milk sample.

Samples were taken from the near quarters first and the far quarters after this. The first few streams of milk from the teat were discarded to clear the teat canal. The bottle lid was removed and held in the same hand near to the bottle. Bottles were held as horizontal as possible to avoid contamination of sample with debris from the udder. Samples of 3 mL or more were taken and the cap replaced on the bottle as quickly as possible. The inside of the cap and bottle were not touch by the sampler’s hands or teat at any stage of sampling. Samples were submitted to New Zealand Veterinary Pathology Limited at Massey University, Palmerston North for culturing and bacteria isolation and identification.

Single foremilk quarter samples were taken due to labour, logistics and budget constraints as well as practicality. Samplers included Massey University staff and veterinary students.
8.3 SOMATIC CELL COUNTS
In both conventional and organic dairy systems, high somatic cell count milk is withheld from the vat to avoid penalties for high SCC. For this reason, SCC data was not collected from the bulk milk in the vat but instead obtained from monthly herd tests throughout lactation, undertaken by LIC. Individual cow SCC data was obtained several days later via LIC’s MINDA computer software at the DCRU.

8.4 HISTORICAL DATA
Milk sampling data for the 2003/2004 and 2004/2005 season was obtained from historical data from a previous trial conducted in these years. Historical SCC data was obtained from previous records held in the MINDA program, records stored at Massey University Agricultural Services and previous research on the 2001/2002 season.

8.5 DRY-OFF PROCEDURES
At dry-off, sixteen cows from the conventional herd received dry-cow therapy (DCT). The rest of the conventional herd were not treated and were naturally dried off after their last milking. The organic herd did not receive DCT due to United States Department of Agriculture (USDA) organic regulations.

8.6 STATISTICAL ANALYSIS
Due to culling and replacement of cows during the 2004/2005 and 2005/2006 seasons, the number and identity of the cows present at each milk sampling were different. For this reason data was analysed separately for each sampling period using the PROC GENMOD procedure of SAS 8.02 (2001). A logit function was used to transform the data before analysis. The model considered the effect of system, season and sampling period. Models were run for the presence
Staphylococcus aureus and Streptococcus uberis bacteria as well as non-infected cows.

SCCs from individual monthly herd tests were recorded for both the organic and conventional herds. This data underwent natural logarithmic transformation and was analysed using the PROC GLM procedure of SAS 8.02 (2001). The model considered the effect of the dairy system, seasons and month of herd test. SCC were analysed for the percentage of the organic and conventional herd with SCC either below 200,000 cells/ml or above 400,000 cells/ml. A logit function was used to transform the data before analysis. Data was analysed using the PROC GENMOD procedure of SAS 8.02 (2001). The model considered the effect of system and month of lactation.
9. RESULTS

9.1 BACTERIOLOGY

9.1.1 STAPHYLOCOCCUS AUREUS INFECTIONS

The percentage of cows infected with *Staphylococcus aureus* in the 2004/2005 season for each herd is shown in table 9.1. During the 2004/2005 season, there was no significant difference in infection between the organic or conventional herd. This was also the case for the majority of the 2005/2006 samples, however, at mid-lactation the organic herd had a significantly higher incidence of *Staphylococcus aureus*. Over both the 2004/2005 and 2005/2006 seasons, the organic herd had a consistently higher percentage of infected cows than the conventional herd, except at dry-off in 2006.

Table 9.1  Percentage of organic and conventional cows sampled with *Staphylococcus aureus* infections in at least one quarter at the four milk-sampling periods in the 2004/2005 and 2005/2006 seasons. Lsmeans expressed as the percentage of total cows and the significance of the differences between the two herds at the four samplings.

<table>
<thead>
<tr>
<th></th>
<th>Calving</th>
<th>14 days post-calving</th>
<th>Mid-lactation</th>
<th>Dry-off</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Org</td>
<td>Conv</td>
<td>Sig</td>
<td>Org</td>
</tr>
<tr>
<td>2004/2005</td>
<td>13</td>
<td>0</td>
<td>NS</td>
<td>28</td>
</tr>
<tr>
<td>2005/2006</td>
<td>35</td>
<td>26</td>
<td>NS</td>
<td>27</td>
</tr>
</tbody>
</table>

NS=Non significant; *= p <0.05

The percentage of quarters infected with *Staphylococcus aureus* for the organic and conventional herds is shown in Table 9.2. In both 2004/2005 and 2005/2006, the organic herd had a higher incidence of infection than the conventional herd at all sample periods. For reasons beyond the authors' control, statistical tests and the significance of these results are not available.
Table 9.2 Percentage of quarters sampled, positive for *Staphylococcus aureus*, in the organic and conventional herds at the four milk-sampling periods of the 2004/2005 and 2005/2006 seasons.

<table>
<thead>
<tr>
<th></th>
<th>Calving</th>
<th>14 days post-calving</th>
<th>Mid-lactation</th>
<th>Dry-off</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Org</td>
<td>Conv</td>
<td>Org</td>
<td>Conv</td>
</tr>
<tr>
<td>2004/2005</td>
<td>5</td>
<td>0</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>2005/2006</td>
<td>19</td>
<td>10</td>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>

All the data that has been collected and analyzed to date on the percentage of cows infected with *Staphylococcus aureus* in the organic and conventional herds, is presented in figure 9.1. This includes mid-lactation and dry-off in 2003/2004 and calving, 14 days post-calving, mid-lactation and dry-off in 2004/2005 and 2005/2006. Infection has generally increased in both the organic and conventional herds over the two and a half seasons studied. *Staphylococcus aureus* infections peaked at dry-off in all seasons. The organic herd has always had a consistently higher percentage of infected cows than the conventional herd, except at dry-off in 2006. However, differences between incidence of infection for the organic and conventional herd were only significant at mid-lactation 2003/2004, and mid-lactation 2005/2006.
Figure 9.1  Long-term trends of percentage of cows infected with *Staphylococcus aureus* in the organic and conventional herd over two and a half seasons (2003/2004, 2004/2005, 2005/2006) (◇ organic) (■ conventional) *= p < 0.05

% of cows infected

0 10 20 30 40 50 60 70 80 90

Mid-lactation 03/04  Dry-off 03/04  Calving 04/05 14 days post-calving 04/05  Mid-lactation 04/05  Dry-off 04/05  Calving 05/06 14 days post-calving 05/06  Mid-lactation 05/06  Dry-off 05/06

Sampling period

9.1.2 STREPTOCOCCUS UBERIS INFECTIONS

Table 9.3 shows the percentage of cows in the organic and conventional herds that were infected with *Streptococcus uberis* in the 2004/2005 and 2005/2006 season. Differences between the organic and conventional herds in infections of this bacteria were small. However, at dry-off 2005/2006, the organic herd had a significantly higher percentage of cows infected with *Streptococcus uberis.*
Table 9.3 Percentage of organic and conventional cows sampled with *Streptococcus uberis* infections in at least one quarter at the four milk-sampling periods in the 2004/2005 and 2005/2006 season. Lsmeans expressed as the percentage of total cows and the significance of the difference between the two herds at the four samplings.

<table>
<thead>
<tr>
<th></th>
<th>Calving</th>
<th>14 days post-calving</th>
<th>Mid-lactation</th>
<th>Dry-off</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Org</td>
<td>Conv</td>
<td>Sig</td>
<td>Org</td>
</tr>
<tr>
<td><strong>2004/2005</strong></td>
<td>24</td>
<td>18</td>
<td>NS</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td><strong>Org</strong></td>
<td><strong>Conv</strong></td>
<td><strong>Sig</strong></td>
<td><strong>Org</strong></td>
</tr>
<tr>
<td><strong>2005/2006</strong></td>
<td>27</td>
<td>19</td>
<td>NS</td>
<td>11</td>
</tr>
</tbody>
</table>

NS=Non significant; ***= p<0.001

The percentage of quarters positive for growth of *Streptococcus uberis* for the organic and conventional herds is shown in table 9.4. The difference between the two herds was small in both the 2004/2005 and 2005/2006 seasons. At dry-off 2004/2005, the conventional herd had a higher percentage of infected quarters than the organic herd, however, for reasons beyond the authors control, statistical tests and the significance of these results are not available.

Table 9.4 Percentage of quarters sampled, positive for *Streptococcus uberis*, in the organic and conventional herds at the four milk-sampling periods of the 2004/2005 and 2005/2006 seasons.

<table>
<thead>
<tr>
<th></th>
<th>Calving</th>
<th>14 days post-calving</th>
<th>Mid-lactation</th>
<th>Dry-off</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Org</td>
<td>Conv</td>
<td>Org</td>
<td>Conv</td>
</tr>
<tr>
<td><strong>2004/2005</strong></td>
<td>8</td>
<td>8</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>2005/2006</strong></td>
<td>9</td>
<td>8</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

All the data available on the percentage of cows infected with *Streptococcus uberis* in the organic and conventional herds is presented in figure 9.2. The incidence of infection is generally similar in both herds, but at dry-off 2005/2006, the organic herd had a significantly higher incidence of infection than the conventional herd. At dry-off 2004/2005, the conventional herd had a higher infection rate than the organic herd, however, this difference only approached significance. The trend and pattern of *Streptococcus uberis* infection is relatively
constant, with the highest incidence at calving, in marked contrast to the pattern for *Staphylococcus aureus*.

**Figure 9.2** Long-term trends of percentage of cows infected with *Streptococcus uberis* in the organic and conventional herd over two and a half seasons (2003/2004, 2004/2005, 2005/2006) (◇ organic) (■ conventional) ***= p < 0.001

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### 9.1.3 NO INFECTIONS

The percentage of the cows in the organic and conventional herds that were identified as being free of infection from any bacteria at each of the four sampling periods is shown in table 9.5. In the 2004/2005 season, there was no significant difference in the percentage of infection-free cows in the organic and conventional herd. In 2005/2006, the conventional herd had a significantly higher number of cows that were infection free at the 14 days post-calving and mid-lactation samples.
Table 9.5 Percentage of organic and conventional cows sampled with no infection in any quarters, at the four milk-sampling periods in the 2004/2005 and 2005/2006 season. Lsmeans expressed as the percentage of total cows and the significance of the difference between the two herds at the four samplings.

<table>
<thead>
<tr>
<th></th>
<th>Calving</th>
<th>14 days post-calving</th>
<th>Mid-lactation</th>
<th>Dry-off</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Org</td>
<td>Conv</td>
<td>Org</td>
<td>Conv</td>
</tr>
<tr>
<td>2004/2005</td>
<td>24</td>
<td>16</td>
<td>NS</td>
<td>23</td>
</tr>
<tr>
<td>2005/2006</td>
<td>53</td>
<td>64</td>
<td>NS</td>
<td>52</td>
</tr>
</tbody>
</table>

NS=Non significant; *= p <0.05

Table 9.6 shows that the percentage of quarters with no bacterial growth was higher for the conventional herd than the organic herd at all samplings in both seasons. The incidence of quarters free of infection tended to be highest at the mid to later stages of lactation in 2004/2005. However, in 2005/2006 the incidence of infection free quarters was generally greatest in early to mid lactation.

Table 9.6 Percentage of quarters sampled, with no growth, in the organic and conventional herds at the four milk-sampling periods of the 2004/2005 and 2005/2006 seasons.

<table>
<thead>
<tr>
<th></th>
<th>Calving</th>
<th>14 days post-calving</th>
<th>Mid-lactation</th>
<th>Dry-off</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Org</td>
<td>Conv</td>
<td>Org</td>
<td>Conv</td>
</tr>
<tr>
<td>2004/2005</td>
<td>54</td>
<td>56</td>
<td>63</td>
<td>70</td>
</tr>
<tr>
<td>2005/2006</td>
<td>73</td>
<td>83</td>
<td>80</td>
<td>94</td>
</tr>
</tbody>
</table>

All the data that has been collected and analyzed to date on the percentage of cows free of infection in both the organic and conventional herds, is presented in figure 9.3. This included mid-lactation and dry-off in 2003/2004 and calving, 14 days post-calving, mid-lactation and dry-off in 2004/2005 and 2005/2006. The percentage of cows with no infection was relatively similar for both the organic and conventional herds in the 2003/2004 and 2004/2005 seasons. However, in 2005/2006, the conventional herd had a much higher percentage of cows free of infection compared to the organic herd. Generally, as the trial progressed, there
appears to be an increasing percentage of the organic and conventional herds that are remaining free of infection.

Figure 9.3 Long-term trends of percentage of cows free of mammary gland infection in the organic and conventional over two and a half seasons (2003/2004, 2004/2005, 2005/2006) (◊ organic) (■ conventional) *= p < 0.05

9.2 SOMATIC CELL COUNTS

9.2.1 2004/2005 SEASON

Monthly individual herd tests from the 2004/2005 season were analyzed and the mean lactation SCCs for the organic and conventional herds are presented in table 9.7. There was no significant difference in mean lactation SCC between the organic and conventional herds in the 2004/2005 season.
Table 9.7  Lsmeans for somatic cell counts (SCC) from individual monthly herd tests of the organic and conventional herds during the 2004/2005 season, natural logarithmic SCC (LSCC) and the statistical significance.

<table>
<thead>
<tr>
<th></th>
<th>SCC (cells/ml)</th>
<th>LSCC</th>
<th>Std error</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic</td>
<td>93,065</td>
<td>4.97</td>
<td>0.0354</td>
<td>NS</td>
</tr>
<tr>
<td>Conventional</td>
<td>78,830</td>
<td>4.90</td>
<td>0.0321</td>
<td></td>
</tr>
</tbody>
</table>

NS= Non significant

Individual SCCs were transformed using a natural logarithm and averaged for each monthly herd test. The results are shown in figure 9.4. The SCCs were relatively similar for both the organic and conventional herds throughout lactation except in September when the organic herd had a significantly higher SCC than the organic herd.

Figure 9.4  Monthly average natural logarithmic somatic cell counts (loge SCC) throughout the 2004/2005 season for organic and conventional herds (◊ organic) (■ conventional) I = SE
9.2.2 2005/2006 SEASON

Mean lactation SCC (calculated as for Table 9.7) for the organic and conventional herds in the 2005/2006 season are presented in table 9.8. The mean SCC was greater for the organic herd than the conventional herd. This difference was highly significant.

Table 9.8 Lsmeans for somatic cell counts (SCC) from individual herd tests of the organic and conventional herds during the 2005/2006 season, natural logarithmic SCC (LSCC) and the statistical significance.

<table>
<thead>
<tr>
<th></th>
<th>Lsmeans</th>
<th></th>
<th></th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SCC (cells/ml)</td>
<td>LSCC</td>
<td>Std error</td>
<td>****</td>
</tr>
<tr>
<td>Organic</td>
<td>101,943</td>
<td>5.01</td>
<td>0.0359</td>
<td>****</td>
</tr>
<tr>
<td>Conventional</td>
<td>63,738</td>
<td>4.80</td>
<td>0.0306</td>
<td></td>
</tr>
</tbody>
</table>

****= p<0.0001

The transformed monthly lactation SCC (as for Figure 9.4) for the organic and conventional herds in the 2005/2006 season is shown in figure 9.5. At the August, September and November herd tests, the organic herd had significantly higher SCC than the conventional herd. During late lactation, the mean SCC was generally similar for both organic and conventional herds.
Figure 9.5 Monthly average natural logarithmic somatic cell counts (log\(_e\)SCC) throughout the 2005/2006 season for the organic and conventional herds (◇ organic) (■ conventional) I = SE

![Graph showing monthly average natural logarithmic somatic cell counts (log\(_e\)SCC) for organic and conventional herds.](image)

9.2.3 COWS WITH HIGH OR LOW SOMATIC CELL COUNTS

From the herd tests analyzed in 2004/2005 and 2005/2006, the percentage of cows with SCC below 200,000 cells/ml and above 400,000 cells/ml for each herd was calculated (Figure 9.6). In early lactation, the conventional herd had a higher percentage of cows with SCC less than 200,000 cells/ml than the organic herd. This difference was significant in August and especially in September. Percentage of cows with SCC below 200,000 cells/ml was generally higher in the conventional herd than the organic herd.

The percentage of cows with SCC above 400,000 cells/ml was similar for both the organic and conventional herds for the majority of lactation (Figure 9.6). However, in September and February the organic herd had a significantly higher portion of these high SCC cows than the conventional herd.
9.2.4 LONG-TERM TREND IN SCC

From the data available for five seasons of the trial, the organic herd has always had a higher SCC than the conventional herd. This difference was highly significant in 2005/2006. The 2005/2006 season is the first season in which there was a significant difference between the organic and conventional herds. The data for the organic herd shows an increase in SCC to the 2003/2004 season whereas the conventional herd SCC declines in 2002/2003 before peaking in 2003/2004. From here, the conventional herds mean lactation SCC has declined, while the organic SCC has fluctuated (Figure 9.7).
Figure 9.7  Long-term trend of mean lactation somatic cell count for the organic and conventional herd over four seasons (◊ organic) (■ conventional).
10. DISCUSSION

10.1 BACTERIOLOGY

10.1.1 STAPHYLOCOCCUS AUREUS

*Staphylococcus aureus* is one of the predominant mastitis pathogens in New Zealand dairy farming (McDougall 1998). Infection of *Staphylococcus aureus* is important as it is generally associated with high SCCs. This has implications for milk quality especially with subclinical mastitis when the infection may not have been identified and milk is still entering the vat. Effective prevention of infection by *Staphylococcus aureus* is particularly important because it is difficult to eliminate this organism once it has established, even with the use of antibiotics (Alan Thatcher, personal communication, 2006).

During the 2004/2005 and 2005/2006 seasons followed in this study, the organic herd always had a higher percentage of cows infected with *Staphylococcus aureus* than the conventional herd (Table 9.1). However, this difference was generally not significant except at mid-lactation 2005/2006, when 56% of the organic cows were infected, compared with 23% in the conventional herd. In 2003/2004, of which only mid-lactation and dry-off were sampled and analyzed, the organic herd also had a higher incidence of infection although only the difference at mid-lactation was significant (18% versus 5%; p <0.05) (Silva Arteaga 2005). Silva Arteaga (2005) also looked at calving and 14 days post-calving in the 2004/2005 season as did the present study. The results and differences were the same in both studies, however there was variation in the significance of these differences at these sampling times. The present study found that there was no significant difference at both calving and 14 days post-calving although both were approaching significance, whereas the previous study
found that the differences at both these sampling times were significant (Silva Arteaga 2005).

The percentage of total quarters sampled that were infected with *Staphylococcus aureus* was also analysed (Table 9.2). This gave a representation of the actual infection at each sample period in contrast to the potential maximum infection that could have occurred. Cows were classified as infected regardless of whether they had one quarter or four quarters infected. The analysis of quarters infected provides a fuller picture of the infection within the cows in each herd. The pattern of infection was identical to the per cow analysis, as the organic herd consistently showed a higher infection rate.

The general pattern of infection of *Staphylococcus aureus* was that infection was lowest around calving and then increased over lactation to peak at dry-off. This pattern was similar for both the organic and conventional herd in both the 2004/2005 and 2005/2006 seasons (Figure 9.1). This agrees with the pattern of infection for New Zealand dairy herds found by McDougall (1998). Infection of organic Danish herds with *Staphylococcus aureus* also exhibited this pattern. The majority of these herds had the highest incidence of infection occurring in late lactation and around dry-off (Vaarst & Enevoldsen 1997).

At dry-off 2004/2005 and 2005/2006, both herds had particularly high incidence of infection with *Staphylococcus aureus*. In 2004/2005, at dry-off, the infection of the organic herd was 50% and the conventional 28%. In the 2005/2006 season these figures were increased drastically to 77% for the organic herd and 74% for the conventional herd, however, this difference was not significant. Despite such high *Staphylococcus aureus* infection at dry-off in both herds, the incidence of clinical mastitis was not exceptionally high in either herd at this time. Herd infection rates this high are commercially unacceptable. In February 2006, the DCRU had a change of management and did not have a permanent manager employed until the following season. It is suspected that milking procedures
such as teat spraying every cow after milking were not maintained, thus leading to the spread of the contagious *Staphylococcus aureus* bacteria throughout both herds.

As infection rates of *Staphylococcus aureus* were so high at dry-off this study investigated the fate of all the *Staphylococcus aureus* infected cows by observing their infection rates of *Staphylococcus aureus* at calving the next season. The organic cows infected at dry-off were not treated with dry cow therapy (DCT) due to the strict USDA regulations under which the organic herd is managed. Of the organic cows infected with *Staphylococcus aureus* at dry-off and retained in the herd, 29% still had a *Staphylococcus aureus* infection at calving the next season. Of the conventional cows infected at dry-off and treated with DCT, 17% still had a *Staphylococcus aureus* infection at calving. Of the conventional cows not treated but retained in the herd, 27% were still infected at calving. These infection rates are simply an observation of the status of the cows that were infected at dry-off in 2005/2006, at calving in 2006/2007. It does not account for new infections in the rest of the herd. Of the *Staphylococcus aureus* infected cows at dry-off, 18% of the organic and 21% of the conventional cows were culled. These cows were excluded from analyses described above.

The organic and conventional comparison trial at the DCRU began in the 2001/2002 season. However, prior to the present study, bacteriological data has only been collected for the 2003/2004 season, representing the only comparative bacteriological data available for an organic herd in New Zealand (Silva Arteaga et al. 2005). The present study has investigated the bacteriology of the organic and conventional herds over the 2004/2005 and 2005/2006 seasons. The trends of *Staphylococcus aureus* infection of both the organic and conventional herds over three seasons are presented in figure 9.1. Throughout the three seasons, the organic herd has always had a higher incidence of *Staphylococcus aureus* infection than the organic herd. However, the overall trend appears that the infection of both herds is increasing as the trial progresses. This therefore does
not suggest that there is a problem with one particular herd or system but rather that there is a farm management or milking hygiene issue that is leading to increased infection in both herds. *Staphylococcus aureus* is a contagious pathogen and it is possible that insufficient care has been taken to prevent transmission of the bacteria between cows and herds. It is possible that the resumption of an acid sanitizer rinse of the cups is required after the organic herd has been milked in an attempt to minimise transmission of bacteria between the two herds.

10.1.2 STREPTOCOCCUS UBERIS

*Streptococcus uberis* is the predominant pathogenic microorganism causing mastitis in New Zealand (McDougall 1998). This is due to a combination of the fact that *Streptococcus uberis* is an environmental bacterium and that the majority of dairy farms in New Zealand are grazing pastoral-based systems all year round. Despite this, the incidences of Streptococcus uberis infections in the conventional and organic herd in this trial were generally lower than the incidence of *Staphylococcus aureus* infection at the four sampling periods throughout lactation in both the 2004/2005 and 2005/2006 seasons.

The incidence of infection of *Streptococcus uberis* for the organic and conventional herds in both seasons was relatively similar. Only at dry-off 2005/2006 was there a significant difference between the two herds, with a higher incidence of infection in the organic herd compared to the conventional (7% versus 0%; p<0.001). However, at dry-off 2004/2005 the conventional herd had a much higher incidence of *Streptococcus uberis* infection than the organic herd. However, this difference only approached significance.

*Streptococcus uberis* infections tended to be highest at calving with declining infection as lactation progressed (Table 9.3 and 9.4). This was the case for both herds in 2005/2006. This pattern generally agrees with research from other New
Zealand conventional herds (McDougall 1998). New Zealand’s dry summers tend to reduce the risk of cow exposure to *Streptococcus uberis* because there is less mud to transfer the bacteria to the mammary gland in late lactation (McDougall 1998). The 2004/2005 season was in contrast to this general pattern. In this season, *Streptococcus uberis* infections declined over lactation, but peaked at dry-off especially for the conventional herd (Table 9.3). With quite a dry late summer and autumn in 2005, this jump in *Streptococcus uberis* infections is uncharacteristic of the infection pattern of this bacteria and was unexpected (Ministry of Agriculture and Forestry 2005). From the bacteriological data that has been collected over the seasons 2003/2004 to 2005/2006, there appears to be no general trend in incidence of infection in either herd (Figure 9.2).

10.1.3 NO INFECTION

This study analyzed the incidence of *Staphylococcus aureus* and *Streptococcus uberis* infections in an organic and conventional herd. However, sampling not only identified the incidence of these bacteria but also several others that cause mastitis. These bacteria included Coagulase-negative *staphylococcus* (CNS), *Escherichia coli*, *Streptococcus dysgalactiae*, *Enterococcus* species and Corynebacterium species. As the incidence of infection of these species were not analyzed in this study, it is important that the incidence of cows with no infections be reported. In the 2004/2005 season, there was no significant difference in the percentage of cows free of infection, between the organic and conventional herd. In 2005/2006, at 14 days post-calving and mid-lactation the conventional herd contained a higher percentage of cows and quarters that were free of infection (Table 9.5 and 9.6). From all the data available, it appears that the percentage of cows in both the organic and conventional herds that are free of infection is increasing as the trial progresses (Figure 9.3).
10.2 SOMATIC CELL COUNTS

10.2.1 MEAN LACTATION SOMATIC CELL COUNTS

SCC is an international expression of mastitis and milk quality. It is an indicator of the presence of udder disease, mainly mastitis (Rosati & Aumaitre 2004). Somatic cell count data was obtained from individual cow monthly herd tests throughout the 2004/2005 and 2005/2006 seasons. This differs to some studies where SCC was obtained from bulk milk, which does not allow for milk that is withheld from the vat due to high SCC, thus can underestimate SCC. Natural logarithms were taken of the SCC data to remove the large effect on the mean of cows with very high values for SCC.

Least square mean (Lsmean) values for lactation SCC from the 2004/2005 season were relatively similar for the organic and conventional herd throughout lactation. The organic and conventional herds differed significantly only in September, when the conventional herd had a sharp drop in SCC (Figure 9.4). This seems relatively unusual as the conventional herd would have been finishing calving and typically, it would be expected that SCC would generally be higher in this month due to this. The relatively similar pattern and level of SCC between the two herds during this season is reflected in the similar mean lactation SCC. The organic herd had a slightly higher mean lactation SCC at 93,065 cells/ml but this was not significantly different from the conventional herd at 78,830 cells/ml (Table 9.7). In the 2005/2006, the mean lactation SCC of the organic herd was much higher at 101,943 cells/ml. In contrast, the mean SCC for the conventional herd had decreased from the previous season to 63,738 cells/ml (Table 9.8). The organic herd therefore had a much higher mean SCC than the conventional herd and this difference was highly significant. Figure 9.5 shows the pattern and level of the Lsmeans of the transformed SCC for both herds in 2005/2006. Despite relatively similar SCC in late lactation, the large differences in early lactation between the herds were great enough to make the overall mean lactation SCC significantly different.
10.2.2 COWS WITH LOW OR HIGH SOMATIC CELL COUNTS

Cows with SCC above 300,000 cells/ml probably have an intramammary infection in one or more quarters or are recovering from an infection (Levesque 2004). Thus, cows with SCC above 400,000 cells/ml are highly likely to have an intramammary infection in at least one quarter if not more. From the 2004/2005 and 2005/2006 data analyzed, it was found that the percentage of cows with SCC above 400,000 cells/ml remained below twenty percent at all stages of lactation for both herds. Generally, the organic herd had a higher proportion of cows with SCC above 400,000 cells/ml but the differences between the two herds were small (Figure 9.6). However, in September and February the organic herd did have a significantly higher proportion of these higher SCC cows than the conventional herd. The pattern as seen in figure 9.6, is relatively similar to that found in the 2003/2004 season, when no consistent difference were found between the herds for the percentage of cows with SCC above 400,000 (Silva Arteaga 2005).

Individual cow SCCs below 200,000 cells/ml indicates that the cow probably does not have an intramammary infection. However, because the cow’s SCC is a mix of the individual quarter SCCs, a SCC of 200,000 cells/ml could have resulted from three quarters with SCC at 20,000 cells/ml but one at 540,000 cells/ml, thus that cow would have an intramammary infection (Levesque 2004). For the purpose of this study, we used SCC of 200,000 cells/ml and below as the threshold that indicates a cow is probably not infected. In the 2004/2005 and 2005/2006 seasons analyzed, the organic herd had fewer of these low SCC cows in early lactation. This difference was significant in August and especially September. In the 2003/2004 season, there was not such a large difference seen in the early stages of lactation. Instead the percentage of cows with SCC below 200,000 cells/ml was not consistently different between the organic and conventional herds (Silva Arteaga 2005).
10.2.3 LONG-TERM TRENDS IN SCC

Somatic cell counts have been collected from herd tests of both the organic and conventional herds since the trial started in 2001/2002. In the first year of the trial, prior to organic certification, the mean lactation SCC for the organic herd was 84,886 cells/ml and the conventional was 71,091 cells/ml (Lopez-Villalobos et al. 2003). Figure 9.7 shows that SCCs for both herds generally increased until 2003/2004, which was when organic certification was obtained. In this season the organic herd had a mean lactation SCC of 116,000 cells/ml while the conventional herd was at 102,000 cells/ml (Silva Arteaga 2005). From here, the conventional herd SCC has continued to decline as results of this study has shown. However, the organic herd’s SCC, which had that initially started to decline in 2004/2005, began to increase again in 2005/2006. The 2005/2006 season represents the only season in which there has been a significant difference between the two herds as the organic had a much higher SCC than the conventional herd. Herd SCC are greatly dependent on farm management. Changes in farm management over the seasons would have affected the SCC of both herds as some farm managers would have been stricter than others with regard to milking hygiene and procedures such as teat spraying.

Data from Europe has found that SCCs in the first year of conversion to an organic system ranged from 234,640 cells/ml (individual SCCs, untransformed) to 270,700 cells/ml and 358,000 cells/ml (bSCC) (Weller & Cooper 1996; Weller & Davies 1998; Vaasrt et al. 2003). During the second year after conversion, the SCC ranged from 214,080 (individual SCC, untransformed) to 299,100 cells/ml and 317,500 cells/ml (bSCC) (Weller & Cooper 1996; Weller & Davies 1998; Vaasrt et al. 2003). However, as previously mentioned, SCC data can vary greatly depending on the collection method, bSCC or individual SCC, and data transformation and analysis used in different trials. SCCs often undergo natural logarithmic transformation to remove the large effect cows with high SCC have
on the mean. The majority of the studies in Europe are surveys of commercial organic herd’s bulk milk. If high SCC milk is withheld from the bulk milk on these farms, the SCC presented in these European studies will be underestimated. However, when bSCC are used and high SCC cows are withheld from the vat this can have a similar action on the mean as logarithmic transformation of the data. These varying means of SCC collection and analysis makes direct comparisons of SCC between studies difficult.

Generally, the above research from other countries, has found that in the first two years after conversion, the organic herds followed all had SCC above 200,000 cells/ml. A comparison of the present study with this data is difficult as the data collected was from individual SCC, which underwent natural logarithmic transformation unlike the data presented above. SCC collected and analysed for the organic herd in the first two years of the trial never exceeded 86,474 cells/ml, however, bSCC were above 200,000 cells/ml, although exact bSCC are unknown.

In long-term research from Norway it has shown that organic herd SCCs can increase up to the sixth lactation and beyond (Hardeng & Edge 2001). In that study, the conventional herd investigated also had increases in SCC over this period, however, it had significantly lower SCCs than the organic herd in the sixth lactation. This pattern appears is quite different to the SCC of the organic and conventional herd that was followed in this study. Over the five years of the trial, SCC peaked for both herds in the third year of the trial and then decreased. In the fifth season, the organic herd had an increase in SCC while the conventional herds SCC continued to decrease creating a significant difference (Figure 9.6).

Overseas research has found conflicting results as to whether there are overall significant differences in SCCs between organic and conventional herds. The present trial has found that the organic herd has slightly higher Lsmean SCC in early lactation, a significantly higher Lsmean SCC in the fifth lactation of the trial.
(2005/2006) and a smaller percentage of low SCC cows compared to the conventional herd. Overall, it appears that the organic herd has had worse SCCs than the conventional herd especially in the 2005/2006 season. Although prior to the 2005/2006 season, the organic herd only had slightly high SCCs than the organic herd, these differences were not significant. Sato et al. (2005) found there was no significant difference in SCC between the organic and conventional herds studied in Wisconsin, USA. However, the bulk of European research has concluded that generally organic herds have higher mean SCC than conventional herds (Weller & Davies 1998; Hardeng & Edge 2001; Bennedsgaard et al. 2003). However, the size of this difference varies greatly.
11. CONCLUSIONS

*Staphylococcus aureus* is a contagious pathogen that is particularly hard to eliminate once established, even with the use of antibiotics. Thus, prevention of the transmission and infection of this bacteria is of primary importance especially with an organic herd. The organic herd studied always had a higher incidence of *Staphylococcus aureus* infection than the conventional herd throughout both the 2004/2005 and 2005/2006 seasons, but this was only significant at mid-lactation 2005/2006. Infection of both herds followed the typical pattern for this pathogen with increasing infection incidence as lactation progressed. Both the organic and conventional herds dried off in both the 2004/2005 and 2005/2006 seasons with very high incidences of *Staphylococcus aureus* infections. Incidence of *Staphylococcus aureus* infection in both the organic and conventional herds has increased over the five seasons of the trial. This suggests that there is an on farm issue leading to the increasing incidence of infection of this bacteria rather than a system or herd issue. Steps such as implementing an acid sanitizer rinse of cups between milking of the organic and conventional herd to prevent transmission, and culling of infected cows to reduce exposure of uninfected animals to this pathogen, need to be taken to prevent increasing infection rates in future seasons.

*Streptococcus uberis* is an environment pathogen and is thus the predominant cause of mastitis in New Zealand dairy herds. Despite this, infection rates of *Streptococcus uberis* were well below the incidence of the contagious *Staphylococcus aureus* infections for the organic and conventional herds in both the seasons studied. The incidences of infection of *Streptococcus uberis* in the organic and conventional herds were similar. Only at dry-off 2005/2006 did the organic herd have a significantly higher incidence of infection than the conventional herd, suggesting that overall there was little difference between the
two herds in infection of *Streptococcus uberis*. Overall, the long-term trend of *Streptococcus uberis* infections appears relatively stable over three years.

Although only the incidence of *Staphylococcus aureus* and *Streptococcus uberis* infections were reported in this study, it is important to note that the remaining herd was not entirely free of infection. Milk sampling also identified the presence of the microorganisms, Coagulase-negative staphylococci (CNS), *Escherichia coli*, *Streptococcus dysgalactiae*, Enterococcus species and Corynebacterium species. As the incidence of these species was not reported, the incidence of cows free of infection was analyzed and presented. Overall, there was little difference in the percentage of these infection-free cows between the organic and conventional herd especially in 2004/2005. However, the conventional herd did have significantly more cows free of infection at 14 days post-calving and mid-lactation in 2005/2006.

Somatic cell counts are an indication of udder inflammation and the presence of udder disease, mainly mastitis. SCCs in this study were obtained from individual monthly herd tests rather than bSCC, which can underestimate SCC. Throughout the trial, the data collected has shown that the organic herd has always had higher SCC than the conventional herd. However, this difference was only significant for the first time in the 2005/2006 season. Difference in data collection and analysis makes comparisons between New Zealand SCC data and that of published overseas data difficult. However, the vast differences in dairy systems between New Zealand and other countries such as Europe and the USA would suggest that New Zealand requires local organic research on mastitis.

New Zealand organic farms are governed by USDA organic regulations as of August 2007. These regulations state that organic cows cannot be treated with conventional medicines except in the case where animal welfare is compromised. Therefore, it is vital that organic herd managers take great steps to maintain milking hygiene and cow health in order to prevent infections
especially of contagious pathogens such as *Staphylococcus aureus*. Skilled herd managers should be able to prevent and control mastitis in organic herds as done in conventional herds through the implementation of good milking practices and thus preventing rather than relying on treatment of mastitis to maintain cow health and milk quality.
12. REFERENCES


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