Institutionen för husdjursgenetik

Comparison of milk production and fertility of dairy cows in conventional and ecological farms

by

Josefin Walldén

Handledare:
Erling Strandberg

Examensarbete 271
2005

Examensarbete ingår som en obligatorisk del i utbildningen och syftar till att under handledning ge de studerande träning i att självständigt och på ett vetenskapligt sätt lösa en uppgift. Föreliggande uppsats är således ett elevarbete och dess innehåll, resultat och slutsatser bör bedömas mot denna bakgrund.

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Agrovoc: **Dairy cows, organic farming, milk yield, reproductive performance**

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Contents

Abstract

Fertility and production traits of SRB and SLB cows in Swedish organic and conventional dairy production were compared in this study. Data were collected from the Swedish milk-recording system and the Swedish certification organization for organic production (KRAV). In the study 794 092 cow lactation records between year 1997 and 2002 were used. Four fertility measures were defined: number of days between calving and last insemination (cli), number of days between calving and first insemination (cfi), number of days between first and last insemination (fli) and number of inseminations per service period (nins). Three production measures were defined: 305-days milk yield (milk), fat yield (fat) and protein yield (prot). Only records from the first lactation were used. The most complete model included the effects of production system, year of lactation, herd-year size, season and milk yield as well as the two-way interactions between system and all main effects. In addition to that also the two-way interaction between year of lactation and herd-year size was analyzed. Without adjustment for milk yield in the model, both breeds had better fertility in organic production. However, when milk yield was included, only SLB had better fertility in organic production while SRB had better fertility in conventional production. The general trend over time showed that SLB has a deteriorating fertility and that fertility for both breeds was better in larger herds. The fertility deteriorates as the milk yield increases, this was a general trend except for the first milk class which deviated from the rest of the classes. There was no interaction between the effect of season and system on fertility. Cows calving in July-August were found to have best fertility, measured as calving to last insemination.

Introduction

Organic farming has developed in the recent years and the trend for this alternative way of production is now increasing (Lampkin, 2001). The legislation for organic farming includes, among other things, special rules for feed, health management, husbandry and housing (Padel *et al*., 2004). This creates potentially important differences in environmental conditions between conventional and organic systems. When two environments diverge from one another like this, a phenomenon called Genotype by Environment interaction (GxE) can occur. There can be differences in animals' ability to adapt to different environments. This implies that some animals are genetically better than others at producing in an organic production system.

There is a need to initiate studies on the subject, especially when GxE seems to be more important for durability traits, which are essential in organic breeding (Nauta, 2001). At the moment there are hardly any comparisons between organic and conventional production systems, neither on genetic nor on phenotypic level. The aim of this study is to determine whether differences exist between the two systems with respect to production and fertility traits. Such differences are interesting *per se* but may also be an important starting point for further studies on GxE.

Literature review

Organic production

Guidelines to formalize an alternative production system to the progress in conventional production were founded already in 1924 by a private association. Nowadays, the basic standards of the International Federation of Organic Farming Movements (IFOAM) are applied worldwide (Schaumann, 1995). IFOAM is an umbrella organization whose mission is to lead, unite and assist the organic movement (www.IFOAM.org). This organization sets the basic standards for what can be labeled as organic. These standards are then elaborated into more detailed standards by national or local certification organizations (Anon., 1999a). In Sweden the certification organization for organic production is called KRAV. It is a co-operative owned by 29 member businesses and organizations. KRAV is approved by the EU and the regulations decided by the co-operative have to be according to EC regulation, however, the regulation can be made stricter in Sweden (http://arkiv.krav.se).

The concept of organic farming aims at creating a sustainable agroecological system based on local resources (Lund and Röcklinsberg, 2001) and on a concept tending towards functional integrity (Boelling *et al.*, 2003). This term, functional integrity, stipulates that crucial elements of the system are reproduced over time in the system itself, in a way that depends on previous system states (Phillips and Tind Sørensen, 1993).

The system of organic farming has during the last two decades been continuously growing. Between 1990 and 2000, the area farmed according to organic rules increased by approximately 32% per year within the EU and corresponded to almost 3% of the total utilized agricultural area in year 2000 (Lampkin, 2001). Dairy production is an important branch in organic livestock production, and constitutes 50-60% of the total organic cattle population in several European countries. In these countries the organic milk now has a market share of 10-20% (Anon., 1999b). According to KRAV, there were 471 dairy producers with a total of 22 218 dairy cows registered as organic in Sweden in the year of 2003 (http://statistik.krav.se).

Organic vs. conventional farming

Organic farming differs from conventional farming in many ways. In general, the organic farming standards laid down in European legislation prohibit the use of chemical fertilizers, chemicals and pharmaceuticals. But organic farming systems differ also in aspects relating to biological, economic and ethical choices (COBL, 1977). Apart from these differences, organic farming can also differ within the margins of the system itself. In the Netherlands for example, some farmers keep animals in mixed farming systems, where they have to produce milk on a diet of roughage and arable surpluses. Most farmers however keep animals in highly specialized systems, where the animals are fed roughage and concentrates (Nauta, 2001).

When studying organic farms it is important to know the conversion year. There are several reasons for this, e.g. the organic standards are revised and changed regularly. Furthermore organic feedstuffs have become significantly more available in the market which allows other kind of rations today compared to earlier years (Lund and Algers, 2003).

Conventional and organic dairy herds were compared in a Norwegian study focusing on reproductive performance. The result showed that natural breeding was used more in the organic herds, accounting for 19-27% of pregnancies compared with 3-5% in the conventional herds (Reksen *et al.*, 1999). This result could be explained by the EU regulations on organic farming which stipulates that the proportion of artificial insemination has to be reduced as much as possible. According to Harder *et al.* (2004), a reduction of AI below 50% leads to high losses in discounted profit. Additional problems with natural service bulls are that they have fewer daughters and therefore the accuracy of the estimated breeding values decreases when the proportion of AI is reduced (Harder *et al.*, 2004). The Norwegian study also emphasized that the annual replacement in the organic herds was 12% lower than in conventional herds. The reproductive efficiency of the organic cows deteriorated significantly during the winter compared with conventional cows. This was discovered when adjustment was made for yield, breeding season, service and parity. The deterioration was explained by the fact that during the winter, the cows' energy needs could not be met with the maximum of 20% concentrates in the feeding rations (Reksen *et al.*, 1999).

Genotype x Environment interaction

Animals' ability to respond to changes in their environment by altering their phenotype is called environmental sensitivity (Falconer and Mackay, 1996). This adaptation is at least partly genetically based and can be expressed at the biochemical, physiological, behavioral and other levels of the organism (Schlichting and Smith, 2002). Genotype by environment interaction is a result of differences in environmental sensitivity between individuals, in other words, two genotypes do not have the same difference between their phenotypes when put in two environments (Falconer and Mackay, 1996).

Breeding value estimation as well as selection and mating systems are all influenced by GxE (Nauta *et al.*, 2002). The importance of GxE depends on the difference between organic and conventional systems. If the difference is small, no GxE is expected and the animals are ranked the same in different environments (Pryce *et al.*, 2004). This allows combining data from several systems (Nauta *et al.*, 2002) because genetic evaluations of all traits that are needed are available. In this case a special organic index is most suited (Pryce *et al.*, 2004). If the difference is large, and this leads to strong GxE this implies that data have little information value across systems. This might require breeding value estimation separately for organic versus conventional systems (Nauta *et al.*, 2002) and it could be a good idea to use genetic evaluations specific to organic herds. Furthermore, this could also be the most efficient and economic solution if there are enough farms to make the evaluation feasible. Across-country organic evaluations can be a realistic alternative to ensure that enough animals are included. This may also open for across-country progeny testing specific for organic production. AI makes this technically possible but the problem with this solution is that it is very expensive and perhaps also not completely ethically acceptable (Pryce *et al.*, 2004).

Important traits in organic production

Although conventional breeding organizations are operating worldwide and nowadays favor highly productive lines which replace original breeds, different ways of farming and thus also organic farming, may require a different genotype. These animals must be capable of adapting to local conditions (Boehncke, 1998). Organic systems will inevitably include high proportions of home-grown foodstuffs, both because organic standards stipulate a minimum proportion of forage in diets and because purchased organic concentrates are expensive (Pryce *et al.*, 2001). The animals should therefore be able to maintain themselves and a good production on locally produced food. This is just one example indicating that organic production demands animals with special characters. The animals should also be able to thrive in a loose housing and outdoor system, be resistant to diseases and be able to search for food (Pryce *et al.*, 2004). Highly productive breeds may need an improved environment (Peters, 1993) and breeds and lines used in conventional systems are not necessarily capable of coping well with conditions in organic farming. The flexibility and the ability of the breeds to adapt are questioned. An alternative to a separate organic breed would be to use local or rare breeds which are believed to be more adapted and robust (Sundrum, 2001).

Functional traits are very important in organic breeding and are defined as those characteristics of an animal which increase the efficiency by reducing the costs. They include the trait complexes health, fertility, calving ease, efficiency of feed utilization and milkability (Groen *et al.*,1997). In organic dairy breeding, the trait persistency is also important because by improving persistency, the concentrate intake can be reduced (Harder *et al.*, 2004). Ecological organizations emphasize the importance of functional traits, especially functional longevity in the total merit index (Groen *et al.*, 1997). An increase of the economic weights for functional traits by 50% leads to tolerable decreases in the selection response of production traits, with regard to a more ecologically oriented breeding goal (Harder *et al.*, 2004).

Another trait that can be of great importance in organic breeding is body condition score (BCS), a visual and tactile estimation of the amount of fat over back and rear. Since a long time, this has been used to indirectly observe feeding levels but several recent studies have shown that this also is of genetic importance. The connection with fertility makes BCS very interesting when it comes to breeding and the correlation with fertility is fairly high. Genetic differences in the shape of the lactation curve and BCS, and possibly even over environments, can help to identify animals that are best compatible with organic production (Pryce *et al.*, 2004). If the lactation-curve is flat, it is likely to be easier to feed cows solely with home-grown fodder. It is also suggested that a flatter, more persistent lactation creates less metabolic stress, potentially contributing to better health and fertility (Bapst, 2001). This means that a flatter lactation curve could be a way of avoiding short periods of feed deficits in organic herds (Pryce *et al.*, 2004), and therefore the persistency of lactation are important for organic dairy production (Bapst, 2001).

Crossbreds

In all production systems, it is important for dairy farmers to choose breeds and possibly crosses that are most suited to their systems and the markets that their milk is sold in. It has been shown earlier that crossbred animals generally show greater disease resistance and overall fitness than their purebred counterparts due to heterosis (Harris *et al.*, 1996). Even though cross breeding is fairly uncommon in dairy production, it could be an attractive option for organic breeders. These crossbreds can be very useful in difficult conditions. Organic production can be put into this category of environments with its restrictions and standard levels for the usage of medicine and prophylactic methods/treatments, feeding levels, forage etc (Pryce *et al.*, 2004). However, Brotherstone *et al.* (2004) has investigated if there is any benefit of crossbreeding to organic farmers. In this study they found no useful heterosis for any of the production traits, but they did find heterosis for somatic cell count (SCC) in all first-cross animals for all breeds. Similar genes control SCC and mastitis, so by crossbreeding, advantage can be taken of heterosis for SCC to reduce the incidence of mastitis in the herd. Mastitis is today the major reason for culling in the dairy production and because of the regulations regarding the use of antibiotics in organic production, a method to decrease frequency of this disease is particularly important to organic farmers. However, according to the result of this study it is not evident that farmers in organic systems should consider crossbreeding as a first option to improve profitability.

The use of conventionally bred animals

In cattle, pig and poultry production it is today virtually impossible to find animals that have been bred specifically for organic production systems. Most farmers therefore use animals from conventional breeding companies although the suitability of these animals for organic environments is unknown (Nauta, 2001). Endendijk *et al.* (2001) argue that the lack of organically bred animals is due to that there is no clear vision on organic breeding, and that this is the reason why an alternative breeding system has not been established.

EU legislation for organic production prohibits embryo transfer (ET) and other reproduction techniques, apart from artificial insemination (AI), in organic farming. These techniques are commonly used by breeding companies, especially Holstein breeding (Nauta, 2001). According to Endendijk *et al.* (2001), it would not be long before the abbreviation ET will be appended to the names of most breeding sires. This means that by using sires from such breeding, organic farmers are indirectly making use of these techniques (Nauta, 2001) and this ban on genetic modification creates the question; can conventional bulls really be used at all in organic production (Pryce *et al*., 2004).

According to a Danish survey 8 % of all dairy bull calves born on organic dairy farms were killed, 66 % were sold to conventional farms, 6 % were sold to organic farms and 20 % remained on the farm of birth. The main reasons for not keeping the calves in order of decreasing importance were: lack of stall capacity, expected poor production economy and shortage of own foodstuff. The recommendations of minimum 60% of roughage in the daily feed ration, and grazing for 150 days in a year makes rearing of male calves as bulls difficult and therefore steer production is more common. Co-operation with farmers with plant production should be strengthened to stimulate rearing of dairy breed bull calves in an organic way and to optimize utilization of the resources in organic farming (Nielsen and Thamsborg, 2002).

Today organic farmers and those converting their farming system from a conventional to an organic one, usually keep their former livestock (Boelling *et al.*, 2003). In the future, the decision to keep the former animals will be made partly depending on the wish and need for maintaining genetic diversity in the organic farming system. This decision also depends on the genetic ability for the required adaptation to the circumstances specific in organic farming, such as feeding and health care (Nauta *et al.*, 2002). A genotype well adapted to and performing well in a conventional farming system, might not do so in an organic farming system (Boelling *et al.*, 2003).

EU regulation 1844/1999 states that 'in the choice of breeds or strains, account must be taken of the capacity of animals [to adapt] to local conditions, their vitality and their resistance to disease' (Pryce *et al.*, 2004). The 3-year, 1999-2001, project Network for Animal Health and Welfare in Organic Agriculture (NAHWOA) recommends that the central feature of this EU regulation should be given more weight in the development of organic livestock systems. The project partnership also thought that the breeding strategies should be selected for each farm in recognition of the fact that each farm is a specific system with specific needs. The strategies need to take into consideration the requirements of organic feeding standards and their implications on the type of livestock that are suitable for organic systems (Hovi *et al.*, 2003). Furthermore from a welfare perspective, the interaction between the animal and its environment can be thought of as a critical determinant of welfare (Fraser *et al.*,1997) and it follows that welfare will tend to be higher the better the match between genotype and environment (Lawrence *et al.*, 2001). For example a cow with high genetic potential for milk production may be, in spite of relatively low production levels, at risk from energy deficiency in early lactation and may, consequently, suffer from metabolic disorders and poor fertility (Hovi *et al.*, 2003).

Breeding goals and programs

The situation for organic dairy breeders has been unsatisfactory for a long time. On one hand, the development of the conventional breed has not pursued the same aims as organic breeding goals, and on the other hand, the official breeding associations do not offer any strategies for organic farmers (Bapst, 2001). There are two general trends though, that can be observed in animal breeding. To begin with the breeding goals which originally used to contain only production traits tend to be developed further to broader breeding goals which also include functional traits. As a consequence, breeding values are estimated not only for production, but also for a broad range of functional traits for breeding animals. This offers opportunities for a second general trend, customized selection indices. This trend is still less pronounced than the first one (Boelling *et al.*, 2003).

In terms of breeding strategies it is of relevance whether the difference between breeding organic and conventional farming systems is large enough to allow sire rankings to alter dramatically. For example, the production environments in the UK and NZ are on average very different, thus there is re-ranking of sires between these countries. According to Pryce *et al*. (2001) a relevant question when discussing organic breeding is whether we really need to breed cows to suit the system or if we should alter systems where possible to suit the animals.

The ecological system includes not only the manifold interactions between organisms and their environment but also physiological relationships within the organism itself (Capra, 1997). Therefore a total merit index has to deal with characters which are indicators of the inner balance of an organism, like health and fertility traits (Baumung *et al.*, 2001). Bapst (2001) and Baumung *et al.* (2001) has compared a Swiss ecological index with a conventional one. The results showed that the organic index had a relative weight of 24 % for performance traits and 76% for functional traits whereas corresponding conventional weights were 57% and 43%, respectively. The use of existing selection index for organic production depends mainly on three things; 1) if the right traits are available and registered, 2) if the weights of the different traits are suited for an organic environment and 3) if the genetic development of the conventional system suits organic systems. To be able to decide if existing breeding programs fulfill the needs of organic livestock, estimates of GxE would be useful. Without information about GxE, existing genetic evaluations could be used assuming that there is no re-ranking of animals. If there, on the other hand, are good reasons to believe that there would occur a significant re-ranking, Pryce *et al* (2004) suggested that crossbreeding or some other alternative strategy may be a suitable option.

In Switzerland a rapid increase of organic farmers began in 1995 and simultaneously the problems of high yielding, high genetic merit cows under organic conditions became obvious. On these grounds an umbrella organization of all cattle breeders in Switzerland decided to found the introduction of a total breeding value that was to be developed especially for organic breeding. This organic total breeding value is dependent on the acceptance of the service among farmers and the demand for sires with good organic total breeding values (Bapst, 2001). Furthermore, work has also begun in Austria on the development of so-called ‘Ecological Indices’ in cattle breeding. These includes in addition to production traits, fitness or functional traits (Baumung *et al.*, 2001). So far available data are combined and connected in a new way and bulls receive, as well as a regular breeding value, an ecological breeding value. Whether GxE cause the data collected in conventional farming systems to distort the ecological breeding values, remains to be seen (Boelling *et al.*, 2003).

Even though there is today few breeding program that produces animals aimed for organic production (Pryce *et al.*, 2004), there is an interest among organic farmers in programs that are better adapted to the main goals of organic farming, such as animal feeding without concentrates and good lifetime production (Bakels and Postler, 1986). Organic farmers are also interested in a more natural way of breeding without the use of artificial techniques and that also takes the interaction of genotype and environment into consideration (Endendijk *et al.*, 2001). Regardless of breed the primary breeding goal for organic production should include disease resistance and longevity. Another important area is the increasing reliance on forage in organic production, whereas the tendency in conventional production points to an increased usage of concentrate in the rations (Pryce *et al.*, 2004).

In a German study, performed by Harder *et al.* (2004) organic cattle breeding program was compared with a conventional breeding program. The conventional breeding program was found to be clearly superior to the organic one in all parameters. This was mainly due to the population size in the conventional system, resulting in improved selection of bull sires. Annual monetary genetic gain changed in this study with variation of test capacity and number of test bulls. The optimum for the monetary genetic gain was located at a test capacity of 50%, 30 test bulls and 99 daughters per test bull. Furthermore an increased number of daughter records had a positive effect on this gain. In this study the results indicates that the composition of the monetary genetic gain is changed favoring the functional traits when 100 or more daughter records is used per test bull (Harder *et al.*, 2004).

According to Boelling *et al.* (2003), the development has come to a crossroads where it has to be decided whether organic farming should be generalized and carried out together with conventional farming, or whether it should be conducted apart. The common view on how the future farming systems should look like is changing from the ‘modern’ farm towards a broader range of multi-functional farming systems, including modern farms that are essential for food security at high food safety standards, including farms that have a function in recreation and nature development, and including organic farming systems. Hypothesizing that specific farming systems need specific goals, animal breeders need to find out what should be aimed for in general and specifically for each farming system.

Material and method

A dataset with records on Swedish SRB and SLB cows were obtained from the Swedish milk-recording system. The data contained information about identification number, herdnumber, 305-days production information and fertility records between year 1996 and 2003. Four fertility measures were defined: number of days between calving and last insemination (cli), number of days between calving and first insemination (cfi), number of days between first and last inseminations (fli) and number of inseminations per service period (nins). Three production measures were defined: milk (milk), fat (fat) and protein (prot). All traits were measured in first lactation.

Information on herds included in organic production during 1996 until 2003 were collected from the Swedish certification organization KRAV. This dataset contained addresses of the producers and production place numbers of the herds for each year. The datasets from KRAV and the Swedish milk-recording system were then compared by herd identification number (production place number) in order to identify cows in the Swedish milk-registration scheme that were registered as organic. The herd identification number was missing in 923 of the registered organic herd-years. These were excluded from the organic material and handled as conventional herds. The data editing made it possible to determine for each cow record from a certain year whether it was created in a conventional or organic system. Due to the amount of data the two breeds had to be analyzed separately.

During the year of 1996 there were few registered organic producers in Sweden and because of that, this year was excluded from the study. The records from year 2003 were not complete and they were also deleted in order to get reliable results. The number of records remaining, in total 794 026, are shown in table 1.

Table 1. Number of cow records.

	SLB	**SRB**
Conventional	365 852	422 928
Organic	5 246	8 445
Total	371 098	431 373

Statistical analysis

The statistical analysis program SAS (SAS Institute Inc., Cary, North Carolina, USA) version 8e was used for editing and analyzing the animal data. Averages were calculated with PROC MEANS and frequencies with PROC FREQ.

Using PROC GLM in SAS software, the effects of production system, year of lactation, herd-year size, season and milk yield as well as the two-way interactions between those were analyzed for fertility and production traits.

The most complete model was set as:

$$Y_{ijklmn} = syst_i + yr_j + hsize_k + season_l + milk_m + (syst * yr_{ij} + \ldots\ldots + syst * milkcls_{im}) + e_{ijklmn}$$

where,

Y_{ijklmn} = dependent variable, either the value of fertility (cfi, cli, fli or, nins) or production (milk, fat or, prot).
$syst_i$ = fixed effect of system, conventional or organic.
yr_j = fixed effect of year of lactation (1997-2002).
$hsize_k$ = fixed effect of herd-year size. This effect was divided into 6 classes, 1-5, 6-10, 11-15, 16-20, 21-25 and 26 and more first lactating cows.
$season_l$ = fixed effect of season. This effect were divided into 6 classes, Jan-Feb, Mar-Apr, May-Jun, Jul-Aug, Sep-Oct and Nov-Dec.
$milk_m$ = fixed effect of milk yield. This effect was divided into 7 classes, up to 5000 kilogram ECM per year, 5001-6000 kg, 6001-7000 kg, 7001-8000 kg, 8001-9000, 9001-10 000 kg, 10 001 kg and more. The effect of milk yield was not included in the model when the dependent variable was production.
$syst*yr_{ij}+\ldots$ = two-way interaction effects between system and all other main effects, and between year of lactation and herd-year size.
e_{ijklmn} = random residual effect.

The results from the statistical analysis were plotted using Microsoft Excel 2002.

Results

All main effects were statistically significant. The effects of the two-way interactions were often found to be significant for the production and fertility traits (table 2). The two-way interaction between system and milk class is not illustrated in the table but were found to have no significant effect on any of the fertility measures for either of the two breeds, except for cli in SRB. The interaction between system and season was not significant. However, even for the interactions that had a significant effect there was a trend over time that was similar for both systems. The reason for the significant interactions seemed to be that certain years or classes deviated from the overall trend, but it was not possible to interpret the interactions in a meaningful way. For example, the two-way interaction between system and herd-year size had a significant effect on milk yield (fig 1.) The interaction for SLB is most likely due to the fluctuations seen for classes 4 and 5. These classes also had larger standard error than in the same classes for SRB cows. All together, this indicated that the interaction between these variables could not be considered as important.

Table 2. Significance of two-way interactions.

	SRB			SLB		
Trait	syst x yr	syst x hsize	hsize x yr	syst x yr	syst x hsize	hsize x yr
Cli	ns	sign	sign	ns	sign	sign
Cfi	ns	sign	sign	ns	sign	sign
Fli	ns	ns	ns	sign	sign	sign
Nins	ns	ns	ns	ns	ns	sign
Milk	sign	ns	sign	sign	sign	sign
Fat	sign	ns	sign	sign	sign	sign
Prot	sign	ns	sign	sign	sign	sign

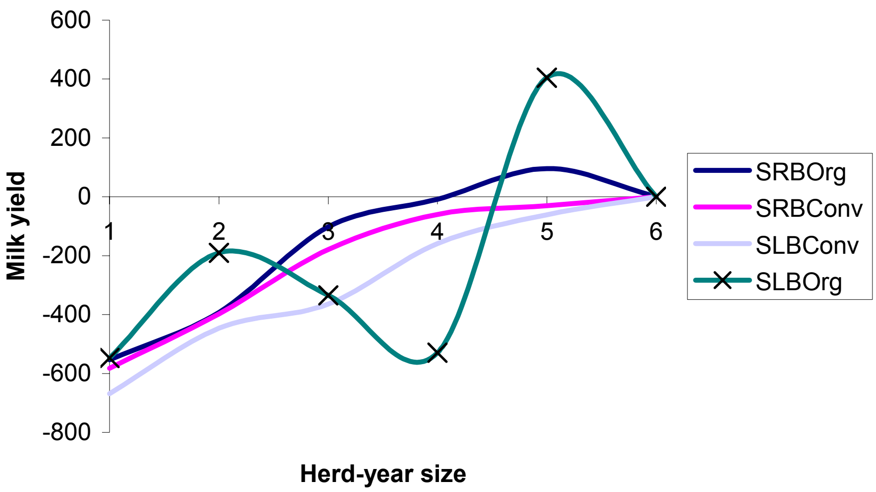

Figure 1. Two-way interaction between system and herd-year size.

The production measures (milk, fat and prot) were found to follow a trend similar for the two breeds. All three measures are increasing over time and the values are higher the bigger the herds. The trend is stagnating around the year of 2000 in all three production measures (fig 2). This trend can also be seen in overall milk recording statistics (www.statistik.svenskmjolk.se/tables/anslutning05.pdf).

Raw averages showed that organic cows had better fertility than conventional ones. The GLM analysis of fertility in SRB cows without regard to milk yield revealed a similar difference. However, when production was adjusted for, conventional SRB cows showed better fertility, with shorter intervals, than organic SRB cows. For SLB, the difference between systems was much lower than with out adjustment for milk but still fertility in organic herds was better and nins was lower (table 3).

Table 3. Effect of conventional system on fertility traits for SRB and SLB cows, with and witout adjustment for production in the model (Organic is set as zero).

	Without adj. for prod.		With adj. for prod.	
Trait	SRB	SLB	SRB	SLB
Cfi	0.7048	3.032	-0.4413	1.1129
Cli	3.3636	8.307	-1.9892	2.1605
Fli	2.8719	5.2851	-1.3860	1.0492
Nins	0.0637	0.1282	-0.0467	0.0312

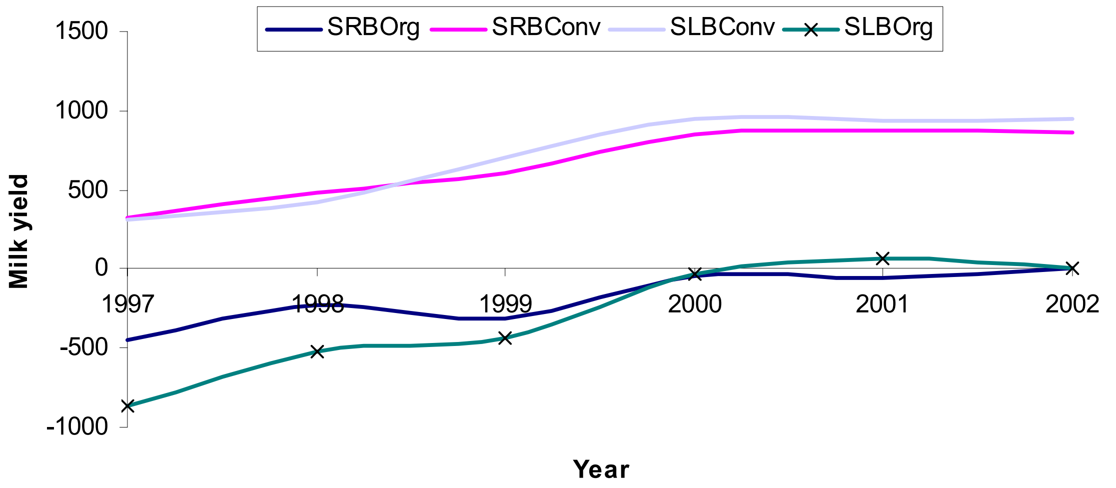

Figure 2. Development in milk yield (kg) over time.

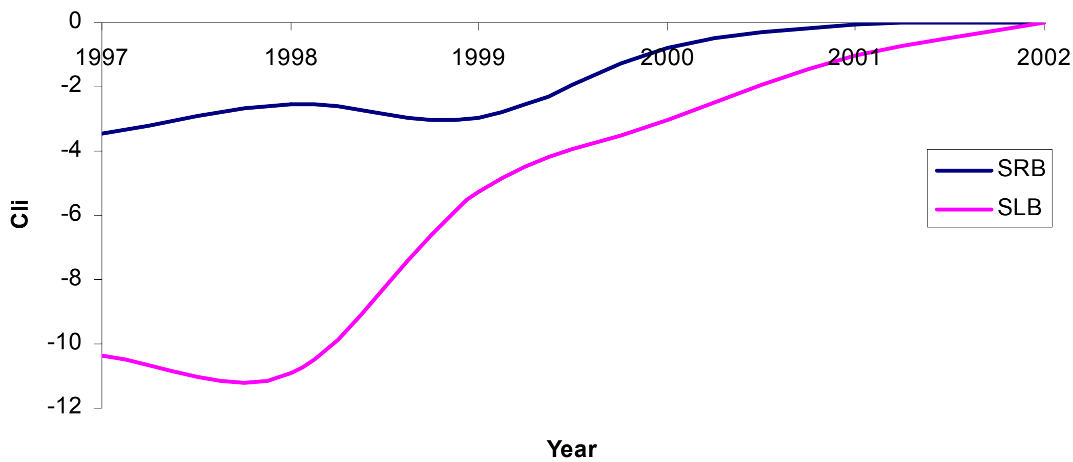

Figure 3. Trend over time for fertility (days from calving to last insemination) without adjustment for production.

Without adjustment for milk yield, system had a significant effect on all the fertility measures in SRB except for cfi. In SLB all three variables, system, year and herd-year size had a significant effect on fertility. The large change in fertility traits over time that was discovered (fig 3) can most likely be explained by the positive trend in production during the same time (fig 2). When adjustment for production was done, the effect of system was not significant for any fertility measures in SRB and only for cli and fli in SLB (fig 4). The rest of the variables, including milk yield were still significant for all four fertility measures in both breeds.

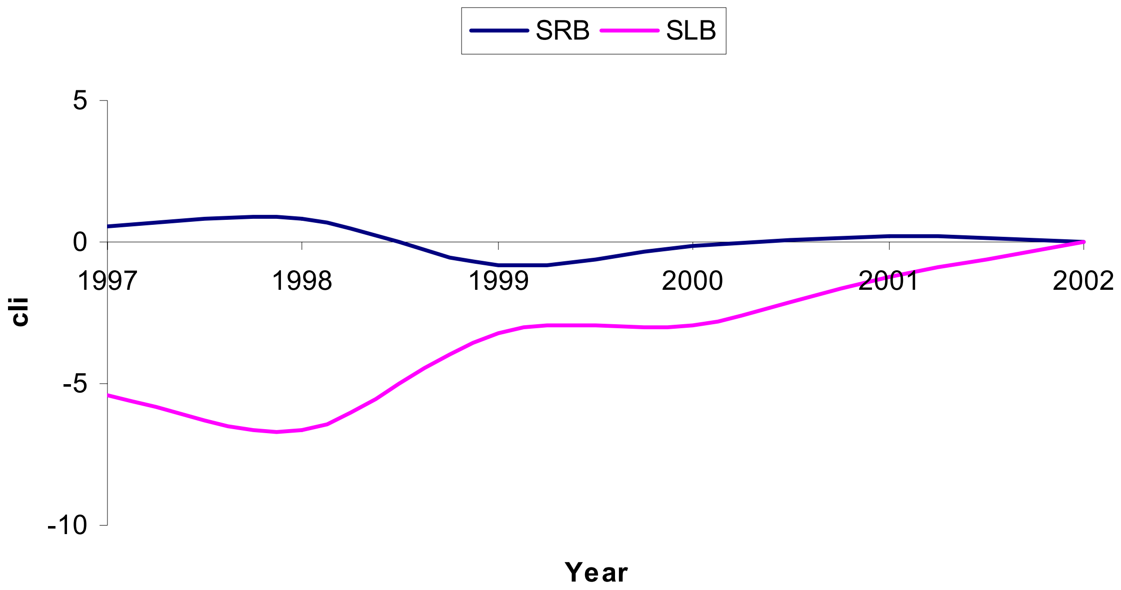

Figure 4. Trend over time for fertility (days from calving to last insemination) with adjustment for production.

Regardless of breed or system the fertility is deteriorating as the production is increasing. The exception is the first milk class that shows a worse fertility than the second and third class (fig 5). All fertility traits decreased with increasing herd size, i.e. bigger herds have shorter intervals and fewer inseminations (fig 6).

There was no interaction between effect of season and system. Cows calving in July-October had the fewest number of days between calving and first insemination (cfi) but the largest number of days between first and last insemination (fli) and number of inseminations per service period (nins) (fig 7). The combined effect, number of days between calving and last insemination (cli), was that cows calving in July-August had best fertility (shortest cli). For cows calving in March-April the result was the opposite, they had the longest cfi and the shortest fli and lowest number of nins. The combined effect, cli, showed that cows calving in this period had the worst fertility (longest cli).

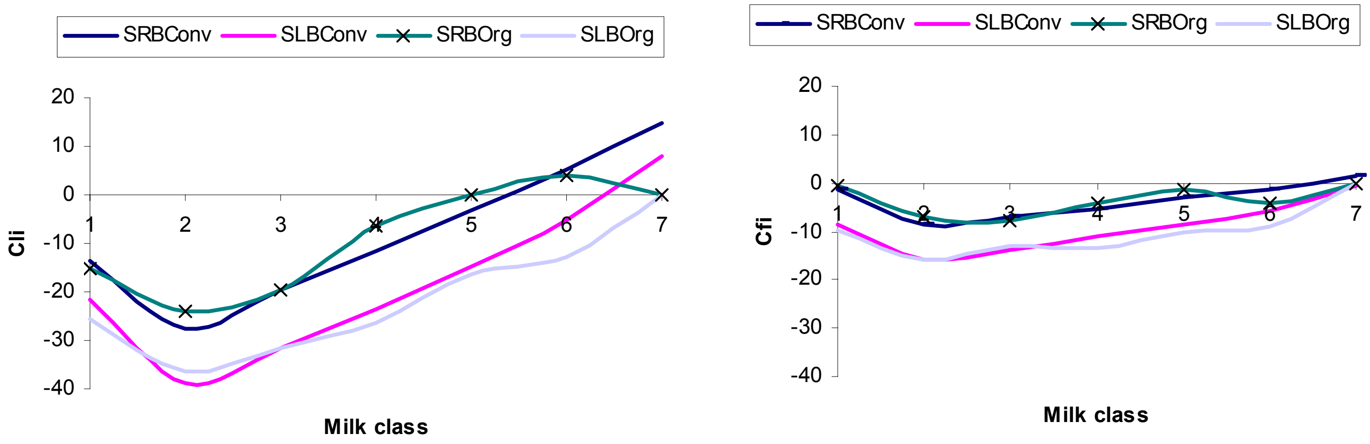

Figure 5. Trend of fertility (calving to last insemination and calving to first insemination) over milk class.

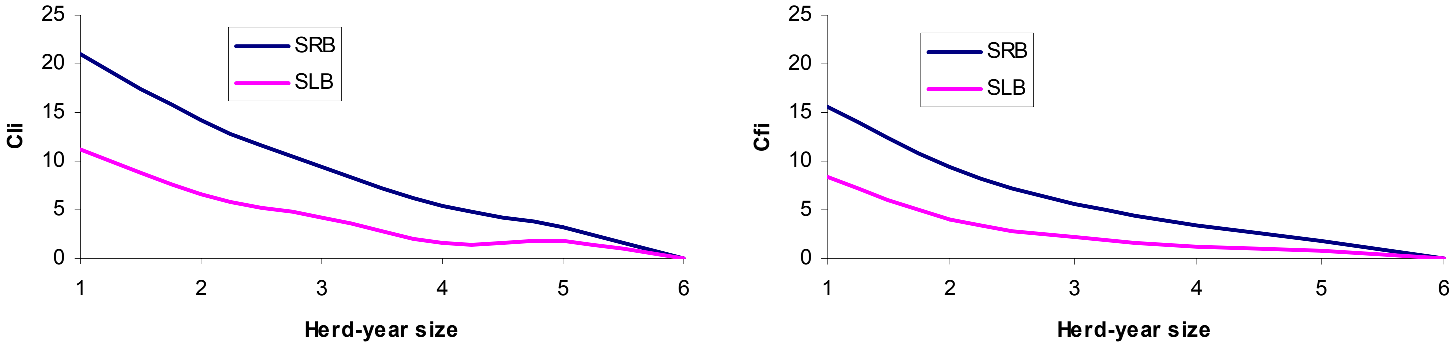

Figure 6. Trend of fertility (calving to last insemination and days between first and last insemination) over herd-year size.

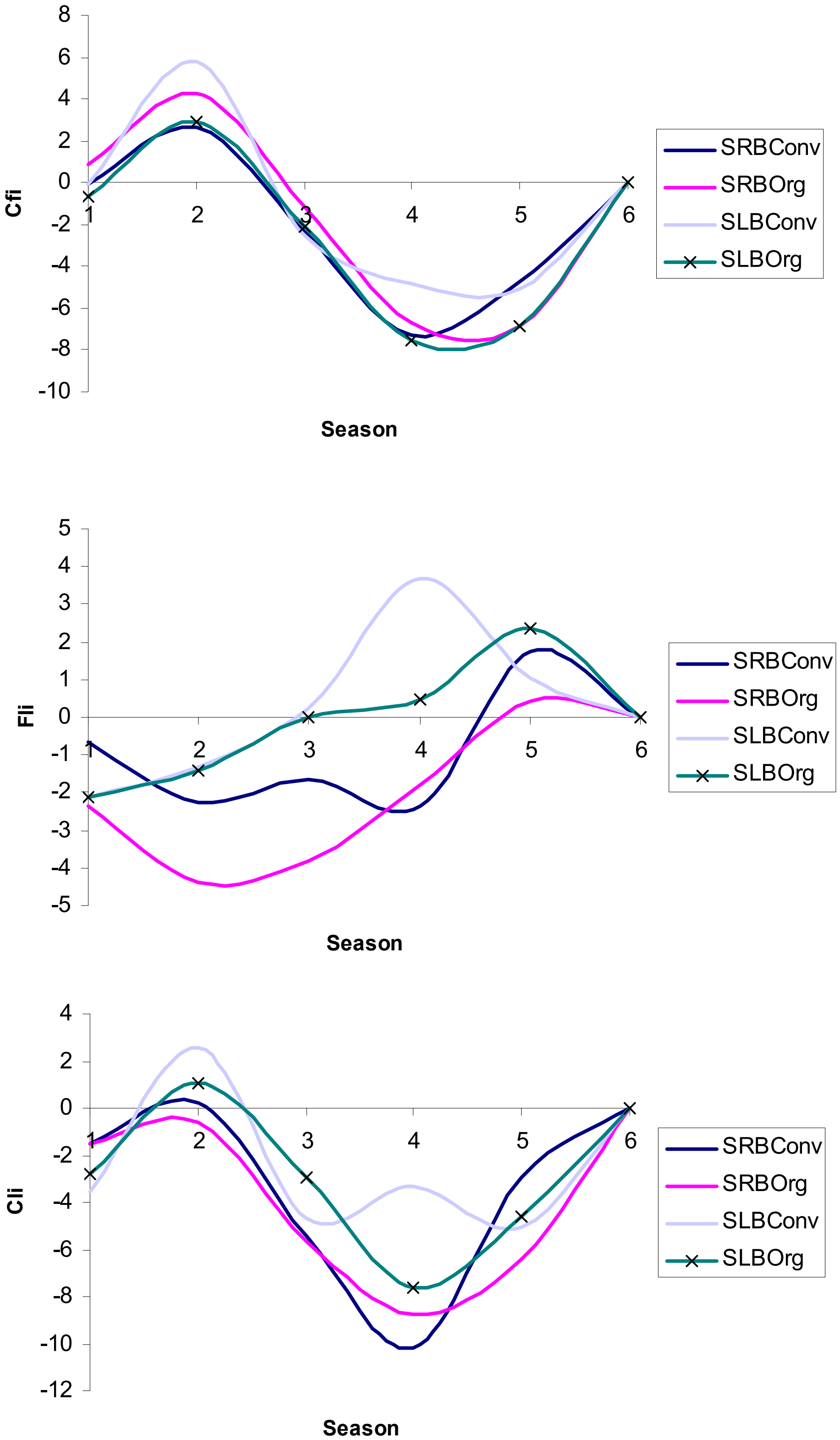

Figure 7. The effect of season on fertility (calving to first insemination, days between first and last insemination, calving to last insemination).

Discussion

In organic legislation it is stipulated that the animals in this production should be the ones most suitable for it. However without any comparative research on the subject, how would one know? This study is an important first step to create basic descriptive statistics on this subject. Based on facts about how the structure in conventional and organic systems are when it comes to distribution of cows over the different lactations, calving patterns, yield and time of first calving etc it is possible to study the differences between the two systems. The possibility of GxE can then be studied and in the end it might even be possible two find animals more suited to organic production than others. It is important to establish if the environments of the two systems differ so much that a re-ranking of bulls between the two may occur. If the difference is not large enough and GxE is of little importance, then a relevant question for the organic organizations would be if it is really necessary to have a separate breeding program for organic production.

In the future there may be a need of a separate organic index for bulls serving in organic breeding. There are several reasons for this, one is the fact that organic cows indeed produce in different conditions than conventional. The production level is lower in the organic system which might demand a different index even if cows were found to adjust equally well to organic environment. Another reason is the wish to keep organic production separate from conventional, this issue is a lot more complicated. Today organic farmers are indirectly making use of banned reproductive techniques such as ET when using conventional bulls. A separate organic index will not solve this ethical problem, it would require organically reared bulls with good breeding qualities, which at the moment are not available at all. This is mostly due to regulations on the feed but also because of the demand of 150 days of grazing per year. Even if it was possible to rear bulls organically the problem with keeping the genetic diversity at a reasonable level would remain.

In this study we distinguished between the two breeds, SRB and SLB. This can be an advantage because factors affecting production and fertility could be different between the two breeds. However, because of the missing herd effect in this study, the breeds are not compared in the same environment and therefore it can’t be concluded that one breed is better in one system then the other. If the effect of herd was included, and enough herds were represented in both systems, it would be possible to better determine if the result of a particular herd was due to good farming or to the system.

The production system had an effect on fertility which differed between the two breeds (table 3). Without adjustment for production the SRB cows were found to have better fertility in organic herds than those in conventional ones. When milk yield was taken into consideration the result was the opposite, the cows in conventional herds had then better fertility than organically producing SRB cows. SLB on the other hand had a better fertility in organic herds even when adjustment for production was done. This result indicates that milk yield indeed is affecting fertility and that including milk in the model affects the interpretation of the results. Furthermore, the improved fertility in organic SLB cows may be explained by the lower production stress. The difference in milk production between the two systems was larger for SLB than for SRB (fig 2). Therefore SLB cows might not be as physiologically stressed which in turn favors the fertility.

The results showed that SLB fertility has a deteriorating trend over time while SRB stayed on approximately the same levels. The deteriorating fertility in SLB can have many explanations, one could be the fact that the breed has a small genetic diversity which can have a negative affect on fertility. The influence of North American Holstein in SLB has in the last years been great and since the Americans have not selected for fertility it will have a negative affect on this trait also in SLB.

There was also a difference between the classes of herd size and the trend showed that fertility was better the larger the herd. This result may be explained by the greater possibilities a farmer with a larger herd has. Perhaps automatic milking is more common in larger herds and it gives the farmer more time for detecting reproductive behavior. This might be a reason why larger herds have shorter intervals between inseminations and fewer inseminations per service period.

All through this study the lowest milk class had a worse fertility, irrespective of system or breed, than the second and third class. The first milk class represents cows with very low production, possibly due to diseases or other problems, which may also have had an effect on fertility. Except for the first milk class there was a clear trend that fertility were deteriorating as the milk yield was increasing. More energy is needed for production which may lead to declining fertility.

The result of this study regarding the effect of season does not correspond all that well with the result of the Norwegian study on reproductive efficiency in organic cows (Reksen *et al*., 1999). In the study performed in Norway they had a maximum of 20% of concentrate in the feeding rations. KRAV rules allows up till 40% concentrate of the daily dry matter intake and for a short period of time during early lactation 50% (http://www.krav.se/regler.asp?ID=5,3). This might cause the difference between the results from the two studies. We could not find a difference in season effects between the two systems. The result that cows calving in July-October had the shortest cfi can be explained by the wish to concentrate the calving to the fall. Farmers often want their cows to have a 12 month calving interval on these cows and therefore they try to inseminate on the first heat. This results in a lower pregnancy rate and the number of days between first and last insemination and number of inseminations per insemination-period increases. However, altogether the farmers do succeed when the combined effect is shown to be better for these cows.

For the possibility of future studies on GxE interactions between the two systems there is a need to establish if there is a difference between them. If it is to be found that both conventional and organic systems has similar levels of fertility and production perhaps these levels have been reached in different ways. Is it the care of the farmer or is there a difference in the animals' ability to produce in different environments?

Conclusions

The production systems' effect on fertility differs between SRB and SLB cows. Without regard to production level of the cows both breeds has better fertility in organic system. With correction for production, to rule out the production levels impact on fertility, SLB cows still has better fertility in organic system whereas SRB are better in conventional production. The two breeds were not analyzed in the same environment in this study and therefore it cannot be concluded which breed is superior in an organic system.

The trends of the two-way interactions were similar for the two systems and both breeds. Fertility is better in larger herds but deteriorates as the production levels of the cows rises. Season has similar effect on the fertility in the two systems. Cows calving in late summer, July-October, have a better fertility than those calving in spring, March-April, independent of in which system they produce.

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