A Selection Index for Organic Dairy Farms in Ontario

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1. Milk Production in Ontario Organic Farms

Milk production in Ontario organic farms has increased steadily in the last decade. In 2000 there were 25 organic dairy farms selling 5.4 million litres (Hemming, 2002), about 0.2% of the province total production; by 2004 their number had almost doubled to 46 (0.9% of total), producing about 0.4% of the province's milk. This is quite small compared to some European countries (Denmark, Germany, Switzerland), where the number of organic dairy farms is in the thousands, and their market share is up to 10%. However, there are another 60 farms in Ontario in the transition stage, and if they all became organic, it would bring the total number of organic dairy up to 100 or 2% of the total.

For this research a sample representative of organic dairy farming in Ontario was identified. It included eighteen farms, almost 50% of the total, and they are spread over the south, central and eastern regions of the province. All are certified organic, except for one still in transition. Of these farms, 18 were visited and an individual questionnaire was filled up, while 17 agreed to release their DHI data for research purposes.

1.1. Organic versus Provincial averages

To ensure that the effect of an unusual event (a barn fire or a drought) was minimized, six years of DHI data, from 1998 to 2003, were included. All the participating herds were enrolled in DHI over this period, except for one, that had four instead of six years of data. Average production and herd size for the sample are in Table 1.

Table 1. Herd averages of 17 organic dairy herds enrolled in DHI, from 1998 to 2003.

	Milking Cows #	BCA Milk kg/year *	Milk kg/day	Fat %	Protein %	Somatic Cell Count (000)	Cows left herd % **
Average	45	8069	22.0	3.93	3.23	309	28
Minimum	19	6536	13.8	3.45	3.04	201	17
Maximum	73	10575	28.8	4.88	3.66	457	39
SD	6	431	1.5	0.16	0.07	31	2.6

* Kg milk are converted from BCA, and are adjusted for age and stage of lactation
** Includes cows culled, dead or sold

Correlations (r) indicate an association between different variables and vary from +1 to –1; the closer the value to zero, the weaker the association. Correlations between herds' variables are given in Table 2. There is a definite tendency for higher producing herds to have lower SCC (r= -0.56). If we consider milk production per day, instead of BCA, there is a tendency for fat and protein content to be higher when milk is lower, (r=-0.52 and –0.39, respectively). Somatic cell count tends to increase in larger herds, and in herds with higher protein percent.

Table 2. Correlations between herd variables.

	Herd Size	SCC	Fat %	Protein %
Milk BCA	0.04	-0.56	-0.17	0.03
Milk kg/d	-0.22	-0.64	-0.52	-0.39
SCC	0.34	1.00	0.13	0.32

Organic farms were compared to all farms controlled in Ontario between 1998 and 2003. Compared to conventional, organic herds have lower BCA (Breed Class Average) for milk (-19%), fat (-15%) and protein yield (-16%), while they have higher fat percentage (+8%) and similar protein % (Table 4). In general, a lower milk production is associated with higher fat and protein content, and it is a little surprising to see so little difference in the protein content in favour of organic milk. The high fat content in organic milk may be due to the high content of forage in the ration, while the low protein content could depend on a lack of protein the ration.

Table 3. Ontario Organic and conventional farms DHI production records from 1998 to 2003

	Herds size	BCA* milk	BCA* fat	BCA* protein	Fat %	Prot %
Organic	45	153	158	159	3.93	3.23
Conventional	56	189	186	190	3.65	3.19

*BCA= Breed Class Average, production adjusted for age and month of calving.
For Holstein cows: 1 BCA= 53 kg milk, 1.96 kg fat and 1.68 kg protein; e.g.: 153 BCA= 8109 kg milk

1.2. Difference among organic farms

At the beginning of the research the question came out repeatedly if it was possible to find common grounds for organic farmers. Since each farm is unique, one could argue that there are no general guidelines to be given to farmers, because each one has specific needs. If this were true, then there would be little need for setting up selection programs, because there would not be a general direction that could benefit the whole sector. Selection would only be within each farm and its effectiveness greatly limited. On the other side, by focusing the research on similarities and by identifying common elements, we could find general guiding principles to help farmers in their selection decisions.

Farms were divided by level of average milk production over the 6 years considered. Milk production was based on BCA converted to kg milk by the appropriate factors and farms were divided in three groups: high (1.5 or more standard deviations above the average), average and low (1.5 or more standard deviations below the average). Averages by production level are given in Table 4. It seems that the longer a farmer has been organic, the less pressure he puts on production: the high producing group has been certified more recently, while the low group has been organic on average since 1987. This could be due to the fact that the longer one has been organic, the further away he gets from conventional methods.
In general, a higher volume of milk is associated with lower fat and protein content. While this occurs for fat %, it does not with protein %, again raising questions on the protein

content of the ration. Herd size increases slightly as production decreases. Overall replacement rate is rather constant across production levels, while there is a tendency to have more dry cows at low production levels.

Similarly to what was found in Ontario, a research in Norway, comparing 31 organic and 93 conventional dairy herds, found lower milk production (-20%), lower replacement rate and higher SCC in organic farms (Hardeng and Edge, 2001).

Table 4. Herd averages by milk production level

Milk Level	Farms #	Certif year	Cows	Milk BCA kg	Fat %	Prot %	SCC (000)	Cows Dry%	Cow left herd %
High	4	2000	44	9492	3.85	3.25	244	15	30
Medium	8	1992	48	8040	3.97	3.19	305	16	27
Low	6	1989	50	6980	3.94	3.27	368	17	30
SD	-	-	6	431	0.16	0.07	31	0.9	2.6

2. Crops and Feeding

2.1. Land, crops, and production constraints

A questionnaire aimed to identify areas of concern and interest in dairy selection for organic farms was prepared and tested. Eighteen farmers (40% of the whole industry) agreed to take part in this survey, which required on average about 2 hours to be completed. This is an extremely high participation rate, even more so, because of the time required to fill the forms.

In line with traditional Ontario family farms, tie stalls are the majority in this sample: twelve of the barns are tie stalls with milking pipeline, while 6 are free stalls with milking parlours.

Tillable land was 249 acres/farm, ranging from 600 to 90 acres, with hay, haylage and pasture on 68% of the land and corn grown only on 7% of the land (Table 5). Corn is not very popular in organic rotations because, due to its high Nitrogen requirements and sparse soil coverage, it needs more nutrients and is more prone to weed infestation. Also, due to the prevalent use of GM corn varieties, it is difficult to find GM-free corn seeds on the market. Compared to a sample of 169 conventional Ontario farms, pasture, hay and haylage is higher in organic: 68% instead of 55% of tillable land, while corn is lower: 7% instead of 14% (OMAFRA, 2003). Only 28% of the farms surveyed grow soybeans and 61% grow corn.

When discussing factors limiting milk production, farmers felt that the quota is by far the most important, followed by the size of the barn. Labour, together with on farm production of forage and grains are considered limiting only by few (Table 6).

Table 5. Land base and major crops in organic farms.

	Tillable land acres	Acres/cow		Major Crops as % of Land			
		Tillable	Pasture+ hay	Pasture + hay	Corn	Soya	Grains
Average	249	5.4	3.7	68	7	4	20
Maximum	600	11.1	9.4	100	19	24	33
Minimum	90	2.4	1.3	30	0	0	0

Table 6. Main factors limiting milk production: average score (1= unimportant, 5 =very important) and number of farms scoring it as the most important

Constraint	Milk Quota	Barn Size	Labour	Grain production	Forage Production
Average score	4.5	2.8	2.5	2.5	2.2
# Farms with score=5	12	4	2	1	2

2.2. Feeding

The amount of concentrate fed to cows varies from 2 to a maximum of 12 kg/cow/day and on average is 7 kg in winter (Table 7). Mixed grains are the most common high energy feed and about 40% of the farmers do not feed any corn and soybeans. Compared to conventional, organic producers rely less on corn as a source of high energy for cows: almost half of those surveyed did not use any corn in the ration. For protein, most rely on forages, since 55% of respondents do not use any soybeans in the ration. Again, as for corn, due to the prevalence of GM soy varieties and high prices of organic soy, only three farmers buy soybeans, and none buys corn. About half of the farmers must buy some or all the cereals they feed to the cows, but there is a good organic market for these. Seven farmers buy hay, but they all agree that price and availability of organic hay are quite good. On average organic farmers buy only a small amount of their feed: 9% of hay, 28% of grains, and grow very little cash crops. Instead, similar conventional farms buy 88% of their concentrates (Stonehouse et al, 2001). Since organic farmers rely heavily on their forage production and minimize feed imports to the farm, they may find it difficult at times to meet the feed requirements. Total Mixed Ration is used in four farms.

Table 7. Land available, pasture use and concentrate feeding.

	Pasture as % of forage	Purchased feed as % of requirements				Max kg grain/cow/day	
		Hay	Grains	Corn	Soy	Winter	Summer
Average	80%	9	27	0	17	7	5
Max	100%	57	100	0	100	12	8
Min (*)	50%	0	0	0	0	3	2

* The lowest value is 5%, but it refers to a transitional farmer, expected to become organic in 2005, feeding TMR, with hay, haylage and pasture on 61% of tillable land.

2.3. Differences among organic farms

Several researchers (Kearny et al, 2004; Weigel et al, 2001) have indicated that milk production under intensive and extensive production systems may be controlled by different genes. Studies in New Zealand (Harris and Kolver, 2001) and Ireland (Dillon and Veekamp, 2001), where dairy production is based on pasture, indicate that the most profitable cows for these environments are different from those selected under a high concentrate-feeding regime. Therefore, the amount of concentrate fed to milking cows was considered as a possible criterion to group organic farms. The correlation between milk production and maximum concentrate fed in winter is quite high, 0.76. After some discussion with several producers and given the high correlation between concentrate use and milk production, it was decided to use level of milk production, instead, as a criterion to group farms because it is more readily available and better defined than amount of concentrate feeding.

2.3.1. Land and Crops

One of the most interesting facts is that the amount of tillable land available per cow decreases from 6.2 acres in the high producing group, to 5.7 in the medium to 4.5 in the low group. The same is true for the land available per cow for pasture and hay. This could be a consequence of the quota: with decreasing milk production per cow, farmers are forced to increase the number of cows to fill their quota. Even though these differences may be not significant, because of the small number of observations, they show a gradient from high to low production level (Table 8). While there is no difference in the amount of land used for forages, more corn is grown by high producers, and more mixed grains by low producers.

Table 8. Average land and crops by production level

Milk Level	Tillable land acres	Total acres/cow	Pasture+hay acres/cow	Major crops as % of land			
				Pasture + hay	Corn	Soya	Grains
High	234	6.2	4.5	67	13	5	15
Medium	283	5.7	4.1	70	6	2	21
Low	213	4.5	2.9	66	5	5	23
SD	126	2.3	1.9	18	7	7	9

Farmers feel that several factors limit their milk production, but these factors have a different role in each farm. It is quite difficult to say how much we can generalize from these scores. Quota is instead the most limiting factor for high and medium producers. On farm grain production is quite limiting for high producers, while for low producers none of the factors is a serious limit on milk production, including milk quota, suggesting that in order to fill their quota they need to increase herd size, and have a higher stocking rate (Table 9).

Table 9. Average score (5= most important, 1= least important) for factors constraining milk production within a farm

Milk Level	Milk Quota	Barn Size	On farm forage production	On farm grain production	Labour
High	4	3	3	4	2
Medium	5	3	2	3	2
Low	3	3	2	1	3

2.3.2. Feeding

There is a close association between level of grain fed to cows and their production level. As expected, the level of grain fed to cows changed with average milk production per cow and the maximum amount of grain fed during winter was 4.2 kg/cow/day for low producing herds, 8.4 for medium herds and 10.5 for high herds (Table 10).

While rations in the high group included corn and soybean, in the low group only 2 farmers fed some corn and soybeans. None of the farmers purchased any corn and only three purchased soybeans. The high producing group was almost self-sufficient, while the rest of farms purchased about 1/3 of the grains needed. TMR was used in four farms out of 18 interviewed.

Table 10. Feeding system and major crops grown.

Milk Level	Pasture as % total forage	Max grains in winter Kg/cow/day	Purchased feed as %	
			Hay	Mixed Grains
High	83 *	10.5	3	7
Medium	90	8.4	12	30
Low	79	4.2	13	38

* does not includes one transition farm with only 5% of pasture fed as total forage

3. Health and Replacement

3.1. Somatic Cell Count (SCC)

Since in Canada and in many countries actual occurrence of mastitis is not recorded, the number of somatic cells in milk is used to measure the level of udder infection.

Ontario DHI uses two measures of somatic cells: the weighted mean of SCC, in order to measure the actual SCC of the bulk tank, and the SCS or Linear score, which is a log transformation of SCC. The latter is used for genetic evaluations: bull proofs are SCS and range from 2.30 to 3.70.

The maximum acceptable level of SCC in milk varies between countries: in Europe it is 400,000 cells/ml, in Canada is 500,000 and in the USA is 750,000. In Ontario, when SCC is above 499,000 for 3 out of 4 months, producers are penalized, and if this level continues for several months, the milk is not purchased. The connection between SCC and mastitis is not consistent at the lower level of SCC: while higher SCC level indicate a high frequency of subclinical mastitis, acute mastitis still occur at low SCC level. Some studies (Barkema et al, 1998) showed that herds with very low SCC, had a higher incidence of acute and environmental mastitis, while herds with higher SCC (250,000 to 400,000) have more contagious mastitis. However, most of the studies showed that SCC is indeed an indicator of udder health and a high SCC should be addressed because it also affects milk quality and flavour and it may cause milk losses and economic penalties. As a guideline, Ontario DHI suggests that cows above 200,000 SCC should be tested for mastitis.

In organic herds the use of antibiotics entails the loss of the organic status of an animal and therefore the use of these drugs is very limited. However, all of the farmers interviewed found that the need for allopathic medicine has consistently decreased since they became organic. They all observed a dramatic improvement in the health of animals and a sharp decrease or even disappearance of clinical and acute mastitis. However, in contrast with this observation, the average SCC and linear score for organic is higher than for conventional: average SCC is 309,000, more than 50,000 above the provincial average and their average SCS linear score is 3.4, like the average of the lower 20 % in the province, with only 3 organic farms above the 50% of conventional farms in the province (Table 11). This could be explained by the presence of subclinical mastitis and by a resistance to intervene with antibiotics.

Table 11. Herd averages of 17 organic dairy herds enrolled in DHI, from 1998 to 2003.

	Somatic Cell Count (000)	Linear Score
Average	309	3.4
Minimum	201	2.24
Maximum	457	4.00
SD	31	0.21

3.2. Culling and health problems

A measure of annual replacement rate was given by the DHI data and referred to all cows leaving the herd, including cows culled as well as sold for dairy. This overall replacement rate is 28% for organic (Table12), lower than the 32% provincial average for conventional herds, as expected, given the lower production pressure on these herds. However, when farmers were asked how many cows were culled last year, the actual culling rate turned out to be 21%, with cows having a 5 year productive life in organic herds (Table 10).

Table 12. Replacement and culling rates, and dairy animals (%) sold

	Replacement rate 1998-2003 (%)	Cows culled in 2003 (%)	Sold for in 2003*
Average	28	21	15
Range	17-39	5-44	0-37

*includes all animals, calves, heifers and bulls, as percent of the dairy herd

When asked to score reasons for culling, the most important was fertility, followed by mastitis, feet, production and age. Other factors, like conformation, calving problems, injuries or temperament were less important (Table 13). In Ontario conventional herds fertility is also the main reason for culling, followed by low production, mastitis, sickness, udder breakdown and feet problems (Canwest DHI, 2003). Therefore, there are differences between reasons for culling in organic and in conventional herds.

Table 13. Main culling reasons (5= most important, 1= least important)

	Fertility	Mastitis and SCC	Feet	Milk	Age	Others*
Average score	3.8	3.2	2.4	1.1	0.9	0.5
Farms (%) score=5	41	35	12	6	6	0

* Include: Conformation, Calving, Temperament and Injuries

Organic regulations allow the use of homeopathic and herbal remedies, while antibiotics and other allopathic drugs lead to the loss of the organic status of an animal. Therefore, health was expected to be an important area of concern for organic farmers. Most of the farmers found that after becoming organic the number of health problems greatly decreased, together with the vet bills. Previous research on Ontario organic and conventional dairy farms showed that veterinary costs, inclusive of breeding, were 20% lower in organic farms (Stonehouse et al, 2001). Fewer health problems in organic herds were also found by research in Norway (Hardeng and Edge, 2001).

From the questionnaire the most common health problems are mastitis, feet, difficult calving, milk fever and ketosis (Table 14). Mastitis and calving problems are the most widespread across farms, with some farms being more affected than others. Feet problems when present in a farm, affect a large number of animals (15% to 26%). Milk fever and ketosis happen in half of the farms and affect 3% of cows.

Table 14. Health problems, occurrence per year out of 866 cows

	Mastitis	Feet	Calving	Milk Fever and Ketosis	Injury and Sickness	Metritis and Retained Placenta	Bloat and Displaced Abomasum
# Farms affected	11	7	10	9	7	3	4
# Farms with >5% cows affected	6	6	2	3	0	1	0
% Cows affected	6.5	6.3	3.5	2.9	1.1	0.5	0.5

On average the veterinarian comes to an organic farm only 3-4 times per year for health reasons and visits 6% of the cows in a year (Table 15). The most common reason for calling the vet is difficult calving. However, one may wonder if this low reliance on the vets is partly due to the fact that training in veterinary medicine is based on allopathic medicine and not on alternative and homeopathic medicine.

Some health problems, particularly those related to feet, mastitis and calving, seem to be clustered in few herds and it could be useful to try and address the root causes of these problems directly with the farmers.

Table 13. Veterinary calls per year.

	Calving	Milk Fever Ketosis	Mastitis	Injury/ Sickness	Bloat/ Displaced Abomasum	Metritis/ Retained Placenta
Average/farm	1.3	0.8	0.4	0.4	0.2	0.1
Total # calls	21	12	6	6	4	1
Over all cows	2.4%	1.4%	0.7%	0.7%	0.5%	0.1%

3.3. Differences among organic farms

When farmers were grouped by production level, there were large differences in SCC and Linear Score, measuring the number of somatic cells in milk. As milk went down, SCC went up and the average load of SCC in milk for the low group was quite high, at 368,000. Differences between farms at different production levels were significant for Linear score. Replacement rate based on the total number of cows leaving the herd was quite similar across production level and was around 30%. However, this figure based on six years of data, includes also cows sold as breeding stock. When farmers were actually asked the actual number of cows culled last year, there were differences between production levels. However, given the small number of farms in each group and the fact that they were based on a single year, these differences could be due to chance alone. Interestingly, culling rate was highest in low producing herds (Table 16).

Table 16. Average of different variables by milk production level

Milk Level	SCC (000)	Linear Score	Cows Dry (%)	Cow left herd 1998-2003 (%)	Culled cows 2003 (%)
High	244	2.88±0.21	15	30	19±16
Medium	305	3.46±0.27	16	27	16±6
Low	368	3.76±0.29	17	30	35±9

When farmers were asked to rate reasons for disposal, fertility came first with the same score for all three groups, followed by mastitis and feet problems (Table 17). Production was mentioned by lower producing herds, and was a real concern for three farmers. All the other reasons were minor. Age was mentioned by all as a reason of disposal and came before type, injuries or temperament.

Table 17. Reasons for disposal in 2003 by milk production level

Milk Level	Reasons for disposal (1=least important, 5=most important)						
	Fertility	Mast/SCC	Feet	Milk	Age	Type	Injury
High	3.8	2.8	1.0	0.0	1.0	0.0	0.0
Medium	3.8	3.8	2.8	1.3	0.6	0.8	0.6
Low	3.8	2.7	3.0	1.5	1.3	0.5	0.3

The number of health problems was overall very low, and few farms with some specific problems greatly affected the group average (Table 18). The number of vet calls per herd slightly decreased with production, even though the average herd size increased. Difficult calving and milk fever were most frequent in the high production group. Clinical mastitis was more frequent in the medium group and feet problems occurred more often in the low producing group. The occurrence of metabolic problems, like milk fever and ketosis, decreased with milk production level.

Table 18. Veterinary calls, major health problems as percent of herd

Milk Level	Milk cows	Veterinary calls/herd	Difficult Calving %	Clinical Mastitis %	Feet %	Milk Fever and ketosis %
High	44	4	6	0	0	5
Medium	48	3	3	11	7	3
Low	50	2	3	4	10	1

4. Selection

4.1. Breeds and use of AI sires

While farmers with pure Brown Swiss and Jersey are very satisfied with the performance of these breeds, many with Holstein herds are less than satisfied. The general feeling is that Holstein cows have been selected for a different system of production and have problems getting adapted to a forage-based diet. There are also concerns about their health, fertility, longevity, grazing capacity, loss of body condition, general fitness and inbreeding. Crossbreeding can be very effective in eliminating inbreeding, and improving fitness traits through the hybrid vigour and decreased homozygosity. However, the choice of breed/breeds is critical, and there is little information available for dairy crossbreeding. In the organic sector, there is often the idea that going back to the “good, old breeds” is the way to go. But some of these minor breeds may not have a herd book and a selection program. Thus the farmer is the one doing the progeny testing on his own herd, with all the risks involved, and may find out that an improvement in fitness may be offset by a sharp decline in milk production and udder conformation.

The number of farmers that used some crossbreeding is much higher in the organic than in the conventional sector. In fact about 40% of the farmers in this research has crossbred some or all of their cows, compared to less than 1% among conventional producers.

The breeds used are quite different: while for conventional producers Jersey and Brown Swiss are the most common choice for crosses with Holstein, the organic producers have also experimented with other breeds, such as Dutch Belted, Milking Shorthorn and Simmental. Crosses with Dutch Belted were the most common (28 cows in 3 farms) and were undertaken to increase rusticity and capacity to produce from forage alone. However, some of these crosses have yielded conflicting results, because some of these breeds do not have any genetic evaluations and have lower production and udder conformation. Only in two herds crossbred cows make up all or most of the herd. Out of the remaining 16 herds, 11 are purebred: 9 Holstein, one Brown Swiss and one Jersey. In the other five herds crossbred cows are 17%. In many cases several breeds might have been tried (Table 19 and Table 20).

Table 19. Herds with purebred and crossbreed cows

	Purebred herds			Herds with Crossbred cows	
Breed	Holstein	Jersey	Brown	Most	Few
Herds #	9	1	1	2	5
Cows in herd	100%	100%	100%	95%	17%

Table 20. Crossbred herds and total number of cows by breed

Breed	Crosses Used *				
	HOxDB	HOxBS	HOxSI	HOxMS	HOxBSxJE
Herds #	3	2	1	1	1
Cows #	28	5	6	13	44

* HO=Holstein, DB=Dutch Belted, SI=Simmental, MS=Milking Shorthorn, BS=Brown Swiss, JE=Jersey

The use of AI sires is prevalent on cows, (96% in 13 farms), while natural service (NS) sires are used more often on heifers (Table 21). However, in eight farms natural service sires are bred in the farm and do 85% of the inseminations. This raises a concern regarding inbreeding. For some reasons, farmers that seem very concerned about it when referring to national selection programs, sound not as concerned when using their own bulls, even though the risk of inbreeding is higher, especially in small herds. This seems paradoxical, but may be due to the fact that they feel in control and know the animals.

Table 21. Use of AI and NS sires in organic herds

	AI on cows 80-100%	AI on cows 79-0%	NS only on heifers	Herds with NS sire	NS sires bred on farm
# herds	13	5	8	11	8
%inseminations	96	23	100	74	85

4.2. Different breeding strategies among organic herds

When organic farms are grouped by production level a pattern emerges regarding breeding choices. In the high producing group, Holstein is the breed of choice (Table 22) and there are no crosses, suggesting that producers are quite satisfied with the breed. At the medium production level there is some interest in crossing, but still 91% of the cows in this group are Holstein. Crosses are mostly with Brown Swiss, a dairy breed of large size, with productions similar to Holstein. It is in the low production group that the percentage of

Holstein cows decreases to only 57%. Farmers in this group have been organic for a long time and tend to manage their farms quite differently from conventional. They are very interested in increasing grazing ability, longevity, health, hardiness and muscling and often chose dual-purpose breeds, like Dutch Belted or Milking Shorthorn.

Also AI usage varies with production level, from 100% in the high production group, to 59 % in the low production, and this affects also the intensity of selection, since natural service sires are not proven. Using NS sires is also necessary when crossing with minor breeds, since semen from these breeds is rarely available from AI centres.
It is apparent that the level of production is an effective criterion to split organic farms in more homogeneous group also for breeding strategies.

Table 22. AI usage, breeds and crossbreeding by production level

Milk Level	All herds (18)	Holstein-based herds (16)		
	AI on cows (%)	Holstein cows (%)	Crossbred cows (%)	Breeds of crossbred cows*
High	100	100	0	none
Medium	76	91	9	BS (mostly) DB, JE (few)
Low	59	57	43	DB, MS(mostly) JE, BS (few)

*BS=Brown Swiss, DB=Dutch Belted, JE=Jersey, MS=Milking Shorthorn, JE=Jersey

4.3. Traits in selection indices

Selection objectives indicate the direction in which selection must go. They should be directed at selecting the animals best suited for a given production system. The traits to be included in a selection index are those directly influencing production and those affecting the overall fitness, also called functional traits (Table 23).

Ideally, we would like to select directly for all the traits of importance. However, this is not always possible, because a specific trait is not recorded and we must use other indicator traits. For example, while Skandinavian countries record actual mastitis and can therefore select animals that have fewer mastitis, in Canada, as in most countries, we do not collect these records and must use SCC instead. The same is true for forage intake: since it is hard to measure actual intake on a large scale, we may use other traits, like capacity.

In deciding which traits should be selected for, we should keep in mind that the more the traits to be selected, the slower the genetic progress for each of them. Therefore, the traits to be included in a selection program must bring a real benefit to the farms.

Table 23. Traits included in most selection indices.

Production traits		Functional traits	
Milk	Beef	Health and Reproduction	Durability
Milk Fat Protein	Growth rate Weight at ≠ages Muscling	Fertility Calving interval Days open Calving ease Stillbirth Mastitis SCC	Feet and legs Udder conformation Capacity* Type traits Lactation persistency** Milking speed Temperament Longevity

* Capacity is body capacity
** Lactation persistency is a measure of the drop in milk production after the peak

4.4. Traits important for organic

Organic farming requires different production practices such as high forage content in the ration, reliance on pasture, avoidance of antibiotics and allopathic drugs. Some of these requirements are expected to affect the relative emphasis of different traits, compared to conventional farms, and shift the emphasis from production to functional traits.

When farmers were asked to list the major areas of concerns that should be addressed by selection, they mentioned grazing capacity, fertility, longevity and health (Table 24). As expected, organic farmers see selection as a major tool to improve cows' fitness and longevity, rather than production alone. Only 3 farmers out of 18 mentioned milk, and only one mentioned fat and protein content. It is as if they felt that present level of production is high enough, for some it is even too high, and they would like more attention to be paid to other functional traits. The fact that grazing capacity was the most mentioned testify to a specific need for organic farmers to increase the ability of cows to produce on grass alone without adverse effects on fertility and health in general.

Table 24. Major areas of concern to be addressed by breeding

Trait	Grazing Traits*	Fertility	Health Longevity	Feet Milk	Udder	Fat% and Prot%
Farmers %	39%	28%	22%	17%	11%	6%
Farmers #	7	5	4	3	2	1

*Grazing traits included: keeping body condition on pasture, capacity to produce milk from forage alone, grazing capacity

4.4.1. Production traits

Researchers in several countries: UK (Hovi et al, 2002), Sweden (Jonsson, 2001) and Denmark (Kristensen and Pedersen, 2001) have shown that milk production in organic farms is similar or below production levels in similar conventional farms, because of the lower concentrate level in the ration. A lower production level in organic can be offset by lower costs of production (Stonehouse et al. 2001), but this is not always the case. Because of the constraints on organic dairy production, we can expect less emphasis on production than on functional traits, compared to conventional farms. Only three farmers mentioned milk as an area of concern, while some even said that they would like to have cows with lower production potential, because it was hard to meet the energy requirements at the peak of lactation with a diet high on roughage.

Selection for milk includes also fat and protein content. From this survey protein content in organic farms is lower than expected, and in five farms is below 3.10%. However, only one farmer mentioned protein and fat percent as areas of concern.

Research in other countries has also found that organic milk may have a lower protein content than conventional milk: 0.12% lower in Sweden (Jonsson, 2001) and 0.10% lower in the UK (Powell et al 2002). This low protein % could be caused by an energy unbalance in early lactation, more likely to happen when cows are on pasture and concentrate content in the ration is lower than for conventional production.

Since protein content is very hereditable (40%), it can be effectively improved by selection or by introduction of breeds with high protein content. In this sample Jersey and Brown Swiss herds had a protein at 3,54%, well above the average of the organic group at 3.23%.

In Ontario only few organic farmers have experimented with beef to increase their revenues, either by crossing to beef bulls, or using dual-purpose breeds. However, problems with marketing and the BSE crisis have forced most to reconsider this option and from this survey beef is a secondary source of income for only four farmers and it is not mentioned by any as an objective of selection. Thus, when talking about production traits in Ontario dairy herds, we refer only to milk, fat and protein, and beef is not included.

4.4.2. Grazing

Organic dairy production is usually less intensive than conventional and forages cover in organic production a larger amount of the energy intake. Organic farms rely more on homegrown feeds (Sholubi et al., 1997), and organic standards limit maximum concentrate allowance, in the EU to 40% of energy requirements at beginning of lactation (Knaus et al., 2001). Different studies were carried out under organic standards to see the effect of low concentrate feeding on milk production and health. Concentrate feeding in organic farms ranged from less than 1 kg/day to 7.7kg (Knaus et al, 2001), 3.6 to 6.6 kg/day flat rate (Kristensen and Pedersen, 2001), and 8, 3 and 0 kg /day in a Danish experiment (Sehested et al., 2003). Most studies showed a reduction in milk production with decreasing concentrate allowance and pointed to the importance of selection for feed intake to maximize the amount of forage consumed by a cow. However, none of these studies focused on specific grazing traits. An excellent paper discussed grazing and the effect of concentrate supplementation on feed intake and milk production (Bargo et al, 2002), and could be a starting point for considering which traits to include when referring to grazing. Comparisons between pasture based and intensive dairy production has shown that there is some genotype by environment interaction (Zwald et al, 2003; Boettcher et al, 2003). This means that the genes controlling milk production in these production systems may be somewhat different. Other research indicates that the Holstein breed, selected for intensive production systems, may not be the best for extensive dairy farming, as seen in Ireland (Dillon et al., 2003a) or in New Zealand (Harris and Kolver, 2001).

Grazing was the trait that most organic farmers would like improved by selection (Table 24). In summer pasture is the main source of forage for the organic dairy herd and it is difficult to feed a balanced ration, because of the changes in the composition and quality of grass during the growing season. Also, meeting the feed requirements of high producing cows on forage alone may be a challenge.

Grazing traits meant producing ability from forages alone, without adverse consequences on health, fertility and body condition. Are organic farmers justified in asking for specific traits, because they produce under more extensive conditions? Their direct experience agrees with research from Ireland and New Zealand, where the most productive animals for an intensive system may not prove to be the best under extensive conditions. Since dairy selection programs in Canada do not offer any information on grazing and the Holstein breed is considered not very well suited for a forage based production, several farmers have taken steps to improve their herds grazing ability by trying different breeds with contrasting results.

4.4.3. Fertility and health

There is strong association between a negative energy balance and fertility, as discussed by Veerkamp, 2002. Even though it may be challenging for some organic farmers to meet the energy requirements at the beginning of the lactation, health and fertility records are better in organic farms. A comparison between 31 organic and 94 conventional dairy farms showed that health problems were almost 50% lower in organic farms, including clinical mastitis, ketosis and milk fever, even though cows were on average older in the organic farms (Hardeng and Edge, 2001). In a Swedish study comparing organic and conventional dairy productions over 10 years at a University research station, they found that while health in the organic herd was worse, except for mastitis, in the first 5 years, while it was consistently better in the last 5 years (Jonsson, 2001).

In a Danish study comparing performances in organic dairy at different levels of concentrate, there was no indication that health problems increased or fertility worsened with lower concentrates (Sehested et al., 2003).

On the other hand, studies comparing performances at different levels of concentrate feeding in conventional dairy production found a negative impact of low concentrate on fertility and milk fever (Pryce et al., 1999).

An experiment in Ireland has shown that on a pasture-based production, cows of high genetic potential have lower fertility, lower body condition and a higher culling rate than cows of average genetic merit. It seems that it is more difficult to meet their energy requirement through grazing alone (Dilllon et al., 2003b). Also in a pastoral system like in New Zealand, Holstein cows, with high potential for milk production have also lower survival rate, poor fertility and body condition, so that at the end their lifetime profitability is greatly reduced (Harris and Kolver, 2001).

In organic farms low quality pasture together with low concentrates in the ration may make it difficult to meet the energy requirements of very productive cows. This may cause fertility, reproductive and metabolic disorders, and fertility is the first cause of involuntary culling (Table17). Even though many farmers surveyed have noticed an improvement in fertility since becoming organic, they still feel that it is an important trait to be improved by selection.

With regard to health, organic standards in Ontario impose severe restrictions on the drugs that farmers can use, without losing the organic status of the animals. Therefore it was expected that health would be one of the main traits considered for selection and it was mentioned by 22% of the farmers (Table 24). Even though switching to organic has generally decreased health problems, organic producers see selection as an important tool to improve the health of their herds.

4.4.4. Longevity

There are indications that cows last longer in organic farms. In the UK, culling rates in 13 organic farms were 4% lower than in conventional (Hovi et al., 2002). A Danish study based on 31 organic farms found that on average organic cows were 10 months older when culled, and lasted longer: 3.0 instead of 2.3 lactations (Hardeng and Edge, 2001). In a Swedish research culling for health reasons was lower for organic, while it was higher for milk (Jonsson, 2001).

Since organic relies on a more extensive production system, it may be also interesting to see the differences between intensive and extensive dairy production regarding longevity. In New Zealand Holstein cows of high genetic potential for production had a lower survival rate on a pasture system (Harris and Kolver, 2001). The same was true for Ireland, where North American Holstein cows had a much lower survival on pasture: only 21% lasted to 6.8 years, compared to 40%, 49% and 56% for Irish Friesian, Montbeliarde and Normande (Dillon et al., 2003b).

In Ontario the overall replacement rate over the last six years was 28%, a four percent lower in organic farms than in conventional (Table 10) and the actual culling rate in 2003 was 21%. This allows farmers room to sell some breeding stock. In spite of this, longevity is one of main traits that they would like to see improved by selection, together with health (Table 24).

4.4.5. Other traits

Other traits mentioned were smaller size, less dairyness, increased capacity, polledness, fitness and hardiness. Overall organic farmers have a different perspective on what should be improved by selection: they ask for novel traits, related to grazing, and do not see much need for extra improvement for milk production. All of them acknowledge the important role that selection plays in organic production and would like to see genetic improvement help them develop a dairy cow better suited for organic production.

It may be interesting to compare the opinions of Ontario organic farmers with those in Switzerland, where a survey was carried out in 2003. Out of 3595 Swiss organic dairy farmers, 1000 were sampled and 608 responded to a questionnaire, focused on breeding decisions and problems (Haas and Bapst, 2004). For these farmers, the most important traits were in the order: fertility (84%), SCC (81%), longevity (78%), milk performance from forage (77%), protein and fat content (72%).

5. Selection Indices

5.1. Genetic change: factors affecting it

Selection is based on the choice of the parents of the next generation and it can be very effective at changing the genetic makeup of animals. For example, dairy production has improved at a very fast pace in Canada, in the last 10 years, the genetic potential of Holstein cows has increased on average by 1350 kg for milk, that is 135 kg/year (CDN, genetic trends, February 2004).

How are these genetic changes brought about? There are several factors affecting them.
a) Intensity of selection: depends on how "difficult" we are and it depends on the percent selected. If we select the top 1% we can expect to find animals that are much better than if we select the top 30%.
b) Accuracy of evaluations: depends on the mistakes we make when choosing an animal. Since we cannot see its genetic make up, we rely on indicators: its genetic proofs, its production, or even just its appearance. The least accurate the criterion we use, the more mistakes we make when we choose.
c) Genetic variability: this is very important, because it determines the potential for change. Paradoxically, if we were to select all the animals with the best genes, so that they would all have the same genetic make up, there would be no room left for further progress, because they would be genetically all the same. The more different the genetic make up of animals, the more room there is for improvement.
d) Generation interval: this is the difference in age between generations. If there is an improvement between generations, then the shorter the time spans between them, the faster the progress. In general, generation interval and accuracy of evaluation work against each other: if we choose young animals as parents of the next generation, we shorten the interval, but we loose accuracy. On the other hand, if we choose older animals, their proofs are more accurate, but we lengthen the interval.

A formula shows how these factors interact to determine genetic progress:
Progress = (Intensity x Accuracy x Genetic Variance)/ Generation Interval
In dairy cattle, there are different intensity of selection, accuracy and generation interval, for cows and bulls. They may also vary if we consider parents of bulls and parents of cows. Thus, we split genetic progress in four components:

```
Sires         Dams                Sires         Dams
     \         /                       \         /
     Bulls                             Cows
```

The genetic progress can be calculated as shown in the example below (Table 25). The largest contribution (70%) to genetic progress in a dairy population using AI comes from the selection of sires and dams of bulls. This is the impact that AI centres have on the overall population. On the other hand, farmers are the ones selecting sires and dams for their cows, and the overall impact of their decisions on genetic progress is about 30%, mostly from sire selection. Why is the impact of selection of cow dams so small (3% to 5%)? After all a farmer knows his cows and cow families quite well, and sees first hand how they perform. However, he has to keep most of his cows for next generation, thus selection intensity is quite low. Also, the fact that a cow is really good does not necessarily mean that she will transmit these traits to her progeny. After all, genetics is only one of the factors determining a performance, and not the largest. To have a good measure of the genetic value of an animal, one should look at his progeny. But cows on average may have 3 to 4 calves and half of these are males. And by the time her daughters are producing, a cow may be already gone from the herd. That is why it can be helpful to consider whole families, but even so there are only few observations for each animal that can be used for selection decisions. Thus, at a farm level, cow selection intensity and accuracy is much lower than that for bull selection, and the selection of bulls determines most of genetic progress within the herd (85% to 90%), while that of cows determines only 15% to 10%.

Table 25. Genetic progress in dairy cattle kg milk: an example

	% Selected → Intensity	Accuracy	Genetic Variability	Genetic progress (kg milk)	Percent of genetic progress	Generation Interval (years)
Sires of bulls	5 → 2.06	0.95	600 kg	1174	43%	8
Dams of bulls	5 → 2.06	0.60	600 kg	742	27%	6
Sires of cows	20 → 1.40	0.88	600 kg	739	27%	6
Dams of cows	90 → 0.20	0.55	600 kg	66	3%	4

The overall genetic progress/year is given by the sum of genetic progress over the sum of generation intervals:

(1174+742+739+66)/(8+6+6+4) = 2721/24 = 113.4 kg/year

This is a theoretical situation. How much genetic progress has been really achieved? Based on the genetic value of cows born in different years we can estimate the actual progress for different traits. In many countries selection has been very effective and average change in genetic potential above 100 kg/year are not uncommon. Unlike environmental changes, such as feeding, genetic changes are there to stay and are cumulative.

In Canada the effectiveness of selection has been quite remarkable. In the last 10 years there has been a rapid genetic progress for production and other traits (Table 26). This means that cows born in 2001, compared to those born 10 years before, have a higher genetic value: 1200 kg milk, 3.5 kg fat, 3.9 kg protein and are 2 points higher for capacity and feet and legs, and 5 points higher for mammary system (Table 27).

This is the result of the AI centres selecting the bulls to be proven, and of the dairy farmers choosing the bulls actually used. The potential for selection of cows within a herd is limited because most of the culling is involuntary. If replacement rate is low, then there is some room for voluntary culling and therefore some selection of cows.

Table 26. Canadian genetic trends by birth year for Holstein cows

Year	Cows	Milk	SCS	Conf	Cap	F&L	MS	LPI
1991	67691	-914	2.98	-2.0	-0.5	-0.2	-2.5	-992
1992	91021	-827	2.97	-1.5	-0.2	-0.1	-2.0	-874
1993	111394	-707	2.97	-1.3	-0.1	-0.1	-1.9	-779
1994	129371	-609	2.98	-1.0	0.2	-0.3	-1.6	-710
1995	138154	-441	3.00	-0.8	0.3	-0.2	-1.5	-603
1996	131999	-296	3.03	-0.2	0.5	0.2	-0.9	-455
1997	137388	-103	3.00	0.9	0.6	0.9	0.3	-206
1998	139834	20	3.00	1.4	0.7	1.1	0.7	-77
1999	138746	124	3.00	2.0	1.1	1.3	1.4	35
2000	135549	217	3.00	2.8	1.6	1.6	2.1	165
2001	141435	290	2.99	3.5	1.9	2.2	2.6	277

(CDN, Feb 2005)

Table 27. Genetic change for Canadian Holstein over 10 years.

Years	Milk kg	Fat kg	Prot kg	Fat %	Protein %	SCS	Cap	F&L	MS
1991-2001	1200	36	39	-0.07	0.00	0.01	2	2	5

(CDN, Feb 2005)

5.2. Selection priorities for organic

Organic farmers were asked to score which traits were the most important for selection in their farm, among those available in 2003-2004. Based on the average score, feet and udder conformation came first, followed by fat, body capacity, protein and SCC (Table 28). Capacity is important because associated with forage intake and SCC because indicators of udder health and mastitis resistance. Longevity, milk persistency and calving ease had all similar scores. Milk production came a distant last, with only two farmers scoring it as the most important, and 12 ignoring it. Lifetime Profitability Index (LPI), the main index for breed selection in Canada, scored only 2.3, and was used extensively by only 2 farmers. During the interviews, several farmers felt that selection has pushed cows to produce enough or even too much milk, especially when forage fed, making it more difficult to meet their energy requirements at the peak of lactation.

Table 28. Average score of traits selected by all organic farmers (1=least important, 5= most important) and number of scores = 5

Traits*	Udder	Feet	Fat	Capac	Prot	SCC	Long	Pers	Calv	Milk	Conf
Avg score	3.9	4.1	3.3	3.2	3.0	2.6	2.4	2.2	2.2	1.5	1.2
#Scores=5	9	10	6	7	6	2	4	3	4	2	5

* Traits are: Udder= udder conformation, Capac= body capacity, Pers= milk persistency, Long= Longevity, Calv= Calving ease, Fat= Fat yield, Prot = protein yield, Conf = Conformation

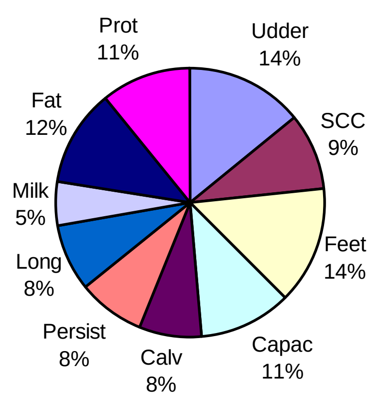
From the survey it appears that organic farmers do privilege functional traits relative to production traits, with udder conformation and feet ahead of any production trait, and milk being the last among eleven traits.

A selection index can be built based on the traits chosen by organic farmers and their relative scores. Such an index is not based on objective economic parameters, but on the preferences expressed by the farmers and should include the traits from Table 28.

All traits were pooled together, and their relative importance is shown in Figure 1: milk, fat and protein together make up 28% of the index, udder conformation and health (SCC) made up 23%, feet and capacity another 25%, and calving ease, persistency and longevity made up 24%. The relative weight of production to functional traits is about 28 to 72. For comparison, the relative weight of production to functional traits in the LPI index used in Canada in 2005 is very different: 54 to 46.

Udder, SCC, feet and capacity are the most important functional traits for organic farmers and alone have almost the same weight as all the other traits, production included.

Figure 1. Traits Selected - All farms



5.3. Different selection priorities among organic

First of all, when selection priorities were analyzed by herd milk level, the relative weights of production and functional traits were quite consistent across organic farms, with a very strong emphasis in favour of functional traits (Table 29). Even though there are large differences between organic farms and the way they are run, they all put most emphasis on functional traits; this is substantially different from LPI, with a 54% weight on production.

Table 29. Relative weights (%) of production to functional traits in organic farms

Milk Level	Production	Functional
High	30	70
Medium	22	78
Low	32	68

When we consider production traits alone (Table 30), milk is the most important for low producing herds, and the difference is substantial: while at the high and medium production levels 10% of the weight is on milk, at the low production level, this is three times as much. It seems that farmers in this group feel they have lost too much milk and would like to get some back. Fat is instead the most important traits for farmers in the medium production level and protein for those in the high production level. One farmer mentioned fat% and protein%.

Table 30. Relative weigh of production traits in organic farms

Milk Level	Milk	Fat	Protein
High	10	41	49
Medium	9	55	36
Low	33	33	34

Unlike production traits, whose prices are known, functional traits do not have a market value and it is quite difficult to give them an economic value. Therefore, it is remarkable to see that the relative weights of functional traits are quite consistent across organic farms (Table 31). Udder conformation and health (Udder + SCC) are together the most important at 32%, followed by feet and capacity. Their relative values are very similar for all farms and altogether make up about 65% to 70% of the weights of functional traits. Calving ease, milk persistency and longevity are less important and vary between production levels: longevity and calving ease are more important for low producing herds, while high producing herds pay more attention to persistency.

Table 31. Relative weight of functional traits in organic farms

Milk Level	Udder	SCC	Udd + SCC	Feet	Capac	Calv	Persist	Long
High	21	11	(32)	21	18	7	13	9
Medium	20	11	(31)	22	15	11	11	10
Low	16	15	(31)	17	15	13	9	15

In spite of all differences, there is a remarkable consistency among organic dairy producers regarding the relative emphasis of functional and production traits, and among functional traits. This consistency can support the feasibility of a selection index for Ontario organic dairy farms.

5.4. A Selection Index for organic dairy

A selection index for Ontario organic dairy was formulated, based on the priorities given by all organic farmers. The weights are for standardized traits:

Figure 2. Organic Index Formula

(Protein yield x 0.11) + (Fat yield x 0.12) + (Milk x 0.05) +
(Mammary system x 0.14) - (SCS x 0.09) +
(Feet and Legs x 0.14) + (Frame and Capacity x 0.11) +
(Calving ease x 0.08) + (Milk persistency x 0.08) + (Herd-life x 0.08)

(all traits must be standardized, that is divided by the specific standard deviation)

There is only one selection index used for organic dairy: this is the Ecological Breeding Index (EBI), currently available to Swiss organic breeders (Bapst, 2001). Compared to the one proposed by Ontario organic farmers, there is less emphasis on overall production, feet, capacity and calving ease and much more emphasis on longevity and persistency, within and across lactations (Table 32). However, out of 600 Swiss organic producers surveyed, 57% wanted more weight on SCC, 49% on fertility, 47% on longevity, 45% on protein and fat content, and 43% on forage intake.

Table 32. Relative weights of organic Ontario (ONT) and Swiss (EBI) selection indices

	Udder	SCC	Feet	Capac	Calving Ease	Persist	Long	Milk	Fat	Prot
EBI	12	9	8	5*	2*	18*	22	8	7	9
ONT	14	9	14	11	8	8	8	5	12	11

*In EBI some of the traits are different from those considered in Ontario:
Conformation instead of Capacity, Stillbirth instead of Calving ease
Persistency includes increase in milk production from 1rst to 3rd lactation,

5.5. Dairy Selection Indices worldwide

The majority of farmers want to improve both functional and production traits. What can be done when several traits are to be improved? One could select one trait at the time, starting from the most important, and choose only bulls above a certain value. The problem with this is that we could overlook some really interesting bulls just because they are below a given threshold. A more efficient way is to put all the important traits together in an index, and choose the best bulls based on this index. In this way traits are balanced against each other, the genetic progress is on a set of traits, recognized as important, and bulls are not overlooked just because they may be low for one trait.

Worldwide, emphasis on production traits ranges from 80% to 29% (Van Raden, 2002; Van Raden, 2004; Miglior et al., 2005). Most countries place at least 50% emphasis on production. Only Scandinavian countries have a much lower weight on production, around 30% (Table 33).

Table 33. Relative emphasis (%) between production and functional traits in Holstein selection indices in several major dairy countries

Country	Production Traits	Functional Traits
Israel PD01	80	20
Great Britain PLI	75	25
Japan NTP	75	25
Ireland EBI	69	31
Australia APR	67	33
New Zealand BW	66	34
Spain ICO	59	41
Italy PFT	59	41
The Netherlands	58	42
USA Net Merit	55	45
USA TPI	54	46
Canada LPI	54	46
Switzerland ISEL	53	47
Germany RZG	50	50
France ISU	50	50
Great Britain TOP	50	50
Denmark S-Index	34	66
Sweden TMI	29	71
Average	*58*	*42*

Within production traits, protein is by far the most important trait, with a 3 to 1 ratio relative to fat, and milk is ignored in almost half of the countries. At first production traits included mostly or only yield traits, but by 2004, out of 17 indices from 15 countries surveyed, only four did not push for protein content one way or another (Miglior et al., 2005).

Worldwide, the most important functional traits included in Holstein selection indices were in decreasing order: longevity, SCC, udder conformation, feet, fertility, type, calving ease and growth and temperament (Table 34).

The group of traits considered in the different selection indices varied noticeably between countries. Only longevity was included in all indices, followed by udder traits, SCC and feet. When compared to the preferences expressed by organic farmers, only longevity has the same weight, while udder and SCC, was much more important for organic, together with feet, calving ease and capacity. Functional traits and their weights in the selection indices of Skandinavian countries are the most similar to the preferences expressed by organic farmers, except they included also fertility as one of the most important traits.

Table 34. Relative weights (%) of functional traits in Selection Indices from different countries (VanRaden, 2002) and their averages across countries

Country	Index	Longevity	Body Size	Overall Udder	Feet & Legs	Final Score	Milking Temp.	Udder Health	Fertility	Calving Ease	Other
Australia	APR	8.5	-4				4	5.2	8.2		3.2[1]
Canada	LPI	6.6	3.8	13.2	9.9			5	5		
Switzerland	ISEL	7	3.3	9.6	4.8			10	6		4.8[2]
Germany	RZG	25	3	6	3.7			5	5		2.3[3]
Denmark	S-Index	6	-2	9	5		2	14	9	6	13[4]
Spain	ICO	3		16	10	9		3			
France	ISU	12.5	2.5	7.5	2.5			12.5	12.5		
Great Britain	PLI	15			5			5			
Great Britain	TOP	2	8	18	14			8			
Ireland	EBI	23							8		
Israel	PD01							11	9		
Italy	PFT	8		13	6	4		10			
Japan	NTP			21.3	3.7						
The Netherlands	DPS	26						4	4	8	
New Zealand	BW	5	-19						10		
Sweden	TMI	6		12	9		3	12	10	12	9[5]
United States	Net Merit	11	-3	7	4			9	7	4	
United States	TPI	11		10	5	15		5			

[1]Milking speed
[2]Overall rump (2.4%) and dairy character 2.4%
[3]Dairy character
[4]Meat quality (5%), Milking speed (6%) and other health traits (2%)
[5]Meat quality (6%) and other health traits (3%)

5.6. Organic index compared to LPI

Comparisons were made between the overall organic index (ORG-ALL) and LPI to see if they were significantly different. A new formula for LPI was implemented in February 2005 (LPI-2005), with less emphasis on production and more on health traits. It includes several new traits: fat % and protein %, together with fertility, which has became available for the first time on February 2005.

The overall organic index (ORG-ALL) was compared to the official index of selection in Canada, LPI. The relative importance of production traits is much lower in the organic index than in the LPI (28% versus 54%) as can be seen in table 35; on the other hand, health traits are much more important in the organic index than in the LPI (25 % rather than 10%). Such differences determine major changes in the ranking of bulls.

Table 35. Relative importance (%) of production, durability and health traits in organic and LPI indices

Index	Production	Durability	Health
ORG-ALL	28	47	25
LPI-2005	54	36	10

Bull proofs from February 2005 were used to calculate the organic index (ORG-ALL) and LPI based on the 2005 formula, using the weights in Table 36.

Table 36. Organic indices and LPI: weights as percentage of the total index

	PRODUCTION			DURABILITY				HEALTH				
Index	Milk	Fat	Protein	Herdlf	Feet	Capac	Mamm	CalvE/ Fertil	SCS*	Persist	Milk speed	Udd depth
ORG-ALL	5	12	11	8	14	11	14	8	9	8	0	0
LPI-2005	0	22	32	7	11	4	14	5	3	0	0.5	1.5

Traits are: Mamm= Mammary System, CalvE= Calving ease for organic and Fertility for LPI-2005, SCS=Somatic Cell Score, Persist= Persistency
LPI 2005: Fat

Correlations between the new LPI and the organic index were calculated for 6739 Holstein bulls officially proven in February 2005. Correlations were 0.823 for all bulls, were 0.753 for the top 1000 for organic index and 0.593 for the top 100. Among the best bulls for ORG-ALL and LPI-2005, there were14 in common in the top 30.

Compared to the top 30 bulls for LPI-2005, the top 30 bulls selected for organic have lower productions, fat and protein percentage and lower fertility. They are better for capacity, mammary system, feet and persistency, have also lower SCS and are easier calvers (Table 37).

The differences between the organic index and the new LPI indicate that there is a need for a specific index for organic farmers. Given that fertility proofs are now available and that organic farmers rank it as the first cause for involuntary culling, it could be advisable to include fertility in the selection index for organic farmers.

Table 37. Average proofs of top 30 bulls by different indices

	Milk	Fat	Prot	Fat %	Prot %	Herd life	Feet Legs	Cap	MS	Calv	SCS	Pers	Fertil
ORG-ALL	1256	49	41	0.05	0.00	3.16	6.8	5.7	10.4	89.2	2.78	68.9	65.8
LPI-2005	1414	64	53	0.15	0.05	3.14	5.2	3.2	8.6	88.2	2.87	67.8	67.0
ORG-LPI 05	-158	-16	-12	-0.10	-0.06	0.02	1.6	2.5	1.8	1.0	-0.08	1.1	-1.2

5.7. Differences between Organic Indices

The other main objective of the research was to see if there a need for several selection indexes for organic farmers. Four organic indexes were considered: a general one (ORG-ALL), based on the preferences expressed by all organic farmers, and three more (ORG-high, ORG-med and ORG-low), based on priorities specific to the different levels of production.

For all the organic indexes the weights of production, durability and health vary, but not substantially. In fact the relative importance of production traits in the organic indexes varies between 22% and 32%; that of durability between 41% and 53% while health is very similar, around 25% (Table 38).

Table 38. Relative importance (%) of production, durability and health traits in different selection indices

Index	Production	Durability	Health
ORG-ALL	28	47	25
ORG- high	30	49	21
ORG-med	22	53	25
ORG- Low	32	41	27

Bull proofs from February 2005 were used to calculate the four organic indexes using the weights shown in table 39. The correlations between the general organic index (ORG-ALL) and the others were very high: 0.98 to 0.99 with ORG-med and ORG-low, when all proven bulls (n=6739) were used. Correlations were also above 0.90 when top 50 to 1000 bulls were considered (Table 40), indicating that there would be very little difference in ranking bulls by one or the other of these indexes. Of the best bulls for all four organic indexes, there were 25 in common among the top 30. Thus, selecting bulls with one or the other organic index would be almost the same, since of the top 30 bulls only five would be different. The average proofs of the top 30 bulls for the different organic indexes were quite similar (Table 41).

Table 39. Organic indices: weights as percentage of the total index

	PRODUCTION			DURABILITY				HEALTH				
Index	Milk	Fat	Protein	Herdlf	Feet	Capac	Mamm	CalvE/ Fertil	SCS*	Persist	Milk speed	Udd depth
ORG-ALL	5	12	11	8	14	11	14	8	9	8	0	0
ORG- high	3	12	15	8	15	12	14	5	8	8	0	0
ORG-med	2	12	8	8	17	12	16	8	9	8	0	0
ORG- Low	10	11	11	6	12	11	12	10	11	6	0	0

Table 40. Correlations between organic indexes of Holstein bulls proven in February 2005

Correlation	All proven bulls	top 50	top 100	top 1000
ALL,high	0.981	0.983	0.982	0.986
ALL,med	0.994	0.935	0.933	0.960
ALL,low	0.991	0.923	0.925	0.959

Table 41. Average proofs of top 30 bulls by different organic indices

	Milk	Fat	Prot	Fat %	Prot %	Herd life	Feet Legs	Cap	MS	Calv	SCS	Pers	Fertil
ORG-ALL	1256	49	41	0.05	0.00	3.16	6.8	5.7	10.4	89.2	2.78	68.9	65.8
ORG high	1142	46	39	0.06	0.01	3.17	6.8	7.0	11.2	88.3	2.84	69.0	65.4
ORG-med	994	44	36	0.10	0.03	3.18	7.5	6.1	11.4	88.7	2.83	69.2	65.8
ORG-low	1465	51	45	0.00	-0.03	3.16	5.8	5.8	9.4	89.5	2.77	68.8	65.5

5.8. Organic Fertility Index

The indices above are based on the preferences expressed by organic producers among the traits with a genetic evaluation at the time of the survey. However, starting in February 2005, proofs for daughters' fertility were available. Since fertility is one of the main cause for culling also in organic farms and calving ease was the only fertility related trait at the time of the survey, it was decided to replace the latter with fertility. Moreover, rather than directly selecting for easy calvers, one should avoid the use of difficult calving bulls on heifers. Therefore, the organic indices (Organic-All, high, medium and low) were modified and calving ease was replaced by fertility, with the same weight (Table 9).This new index will be called ORGF.

From the correlations, there is a sizeable difference between the organic (ORGF) index and LPI. However, the differences among organic indices are very small, and do not warrant the use of separate indices for organic farms (Table 42).

When average proof of top 100 bulls were compared (Table 43), there were considerable differences in production: bulls selected for organic indices had a lower production for all traits, similar fat and protein percentage, and have higher linear traits (feet, capacity and mammary system). Differences for the other traits are much smaller (in SD?).

Table 42. Correlations between organic fertility indices and LPI of Holstein bulls proven in February 2005

Correlation	All proven bulls	top 1000	top 100	top 50
ORGF,LPI	0.878	0.700	0.652	0.640
ALL,high	0.995	0.977	0.965	0.959
ALL,med	0.992	0.972	0.947	0.956
ALL,low	0.995	0.979	0.954	0.964

Table 43. Average EBV of top 100 bulls for various index listings

	LPI	LPI-O	LPI-H	LPI-M	LPI-L
MILK	1301	917	904	772	1062
FAT	53	37	39	35	36
PROT	46	31	32	28	34
FATP	0.08	0.05	0.08	0.08	-0.01
PROTP	0.03	0.01	0.03	0.03	-0.01
HL	3.14	3.17	3.17	3.17	3.17
FL	4.6	6.0	6.5	6.8	5.5
CAP	1.7	4.8	4.8	5.0	4.7
MS	7.8	9.1	9.2	9.3	8.9
MCE	86.9	86.2	85.8	86.0	86.8
SCS	2.91	2.80	2.83	2.82	2.80
PERS	68.1	68.8	68.8	68.5	68.4
DF	67.0	66.9	66.3	66.9	67.5

6. Conclusions

The objectives of the research were to determine:
a) The priorities of selection for organic dairy in Ontario,
b) A selection index based on organic farmers' priorities,
c) The need for a unique or several indexes for organic.

The research has shown that based priorities of selection for organic dairy farms differ from conventional, because of a lower emphasis on production and much higher emphasis on health traits.

A selection index for organic can be developed based on these priorities. This index includes the following traits: fat, protein and milk yield (28%), udder health and conformation (23%), feet and legs (14%), capacity (11%), lactation persistency (8%), longevity (8%) and calving ease (8%). The major difference between the organic and the conventional index is the relative emphasis between functional and production traits. As a result, a different group of bulls would rise to the top when ranked by these two indexes. Among the top 30 bulls, only 11 are in common between the two indices, indicating the need for a specific selection index for organic dairy producers.

Organic farms at different level of milk production followed different breeding policies. However, their selection priorities did not differ much. They all wanted much more emphasis on functional (70% to 80%) relative to production traits (30% to 20%). There were some differences in the relative importance of some of the traits: lactation persistency and longevity were more important for high producers, while SCC, milk and calving ease were more important for low producers. Three different selection indexes were defined based on selection priorities expressed by farmers at different production levels. To verify if there was a need for separate indexes for different types of organic farms, bulls were ranked by these three indexes and then compared to the overall organic index. Across all these indexes, 25 of the top 30 bulls were the same, indicating that these different organic indices were equivalent.

In conclusion, the needs expressed by organic dairy farmers in Ontario should by met by a specific selection index and there is no need for separate indices. Such an index can be developed and a list of bulls ranked by it should be available to organic producers on a regular basis.

Organic farmers in Canada and in other countries would like to see selection used to improve grazing traits, and a cooperation between researchers in Canada, Germany and Switzerland should be encouraged to identify which traits can be used to improve the ability to produce milk from a high forage diet.

Moreover, some refinements could be made to the Ontario organic index, regarding the definition of body capacity, the inclusion of fertility, the main cause of involuntary culling, and the possible inclusion of fat and protein percentages

References

Bapst B, 2001
Swiss experience on practical cattle breeding strategies for organic dairy.
The 4th NAHWOA Workshop, Wageningen, 24-27 March 2001

Bargo F., Muller L.D., Kolver E.S. and Delahoy J.E., 2002
Production and Digestion of supplemented dairy cows on pasture: and invited review.
J. Dairy Sci. 86:1-42

Barkema HW, Schukken YH, Lam TJGM, Beibor ML, Wilmink H, Benedictus G, and Brand A, 1998
Incidence of Clinical mastitis in dairy herds grouped in 3 categories by bulk milk somatic cell counts
J Dairy Sci, 81:411-419

Boettcher P.J., Fatehi J. and Schutz M.M., 2003
Genotype by environment interaction in conventional versus pasture based dairies in Canada.
J. Dairy Sci.86:383-404

Canwest DHI 2003 Provincial Statistics.
http://www.canwestdhi.com/pdf_files/2003%20provincial%20statistics.pdf

CDN (Canadian Dairy Network), Feb 2005.
http://www.cdn.ca/Articles/0502/trends/gtrends.nat.0502.ho.EN.html

Dillon P, Veerkamp R F, 2001
Breeding strategies
Teagasc national breeding Conference, 2001

Dillon P, Buckley F, O'Connor P, Hegarty D, Rath M, 2003a
A comparison of different dairy cow breeds on a seasonal grass-based system of milk production. 1 Milk production, live weight, body condition score and DM intake.
Liv Prod. Sci., 83:21-33

Dilllon P, Snijders S, Buckley F, Harris B, O'Connor P,Mee JF, 2003b
A comparison of different dairy cow breeds on a seasonal grass-based system of milk production. 2. Reproduction and survival.
Liv Prod. Sci., 83:35:42

Haas E and Bapst B, 2004
Swiss organic Dairy farmer survey:Which path for the organic dairy cow in the future?
Proceeding fo 2nd SAFO Workshop, Witzenhausen, Germany, 25-26 march, 2004

Hardeng F. and V.L. Edge, 2001
Mastitis, chetosis and milk fever in 31 organic and 93 conventional Norwegian dairy herds.
J. Dairy Sci. 84: 2673-2679

Harris B.L., Kolver E.S., 2001
Review of Holsteinization on intensive pastoral dairy farming in New Zealand
J.Dairy Sci. 84:(Suppl)E56-E61

J. Hemming, “Carving out your niche”, Ontario Milk Producer, March 2002: 23-25.

Hovi M., Taylor N., Hanks J. and S. Roderick, 2002
Fertility and fertility management in 13 well established organic dairy farms.
Source ????

Jonsson B.S.E., 2001
Results from the Ojebyn-project. Eleven years of organic production.
The 4th NAHWOA Workshop, Wageningen, 24-27 March 2001

Kearny J.F., Schutz M.M., Boettcher PJ and Weigel K.A., 2004
Genotype by enviroment interaction for grazing versus confinement. I Production traits.
J Dairy Sci. 2004, 87:501-509

Knaus W.F., Steinwidder A. and W. Zollittsch, 2001
Energy and protein balance in organic dairy cow nutrition - model calculations based on EU regulations.
The 4th NAHWOA Workshop, Wageningen, 24-27 March 2001

Kristensen T., and S. Struck Pedersen, 2001
Organic dairy cow feeding with enphasis on Danish conditions.
The 4th NAHWOA Workshop, Wageningen, 24-27 March 2001

Miglior F., B. L. Muir and B. J. VanDoormaal, 2005
Selection indices in Holstein cattle of various countries
J. Dairy Sci. 88:1255-1263

OMAFRA, 2003: Ontario Dairy Summary.
www.gov.on.ca/OMAFRA/english/busdvc/download/ondai03.htm

Powell et al (eds), UK organic research 2002: Proceedings of the COR Conference . 26-28 March 2002, Aberystwyth, pp 179-184

Pryce J E, Nielsen B L, Veerkamp R F and Simm G, 1999
Genotype and feeding system effects and interactions for health and fertility traits in dairy cattle
Liv. Production Sci. 57:193-201

Sehested J, Kristensen T, Soegaard K, 2003
Effect of concentrate supplementation level on production, health and efficiency in an organic dairy herd
Liv. Prod. Sci., 80:153-165

Sholubi Y O, Stonehouse D P and Clark E A, 1997
Profile of organic dairy farming in Ontario
American Journal of Alternative Agriculture, 13, 3:133-139

Stonehouse DP, Clark EA and Ogini YA, 2001
Organic and conventional dairy farms comparisons in Ontario, Canada
Biological Agriculture and Horticolture, 2001, 19:115-125

Van Raden P M, 2002
Selection of dairy cattle for lifetime profit
Proceeding of the 7th Word Congress on genetics Applied to Livestock production. 29:127

Van Raden P M, 2004
Invited Review: Selection on Net Merit to improve lifetime profit
J. Dairy Sci. 87:3125-3131

Veerkamp RF, 2002
Feed Intake and energy balance in lactating animals
7th WCGALP, August 19-23, 2002, Montpellier, France.
Session 10: Feed Intake and efficiency

Weigel KA, Rekaya R, Zwald NR, Fikse WF, 2001

International genetic evaluation of dairy sires using a multiple-trait model with individual animal performance records.
J Dairy Sci 2001 Dec;84(12):2789-95

7th WCGALP, August 19-23, 2002, Montpellier, France.
Session 10: Feed Intake and efficiency

N. R. Zwald*, K. A. Weigel*, W. F. Fikse†, and R. Rekaya*, 2003
Identification of Factors That Cause Genotype by Environment Interaction Between Herds of Holstein Cattle in Seventeen Countries
2003 J. Dairy Sci. 86:1009-1018