Breeding and feeding for animal health and welfare in organic livestock systems

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Introduction

Network for Animal Health and Welfare in Organic Agriculture (NAHWOA) is a Concerted Action Project funded by the European Commission. The main aim of the project is to provide a joint platform for research organisations and institutions involved in organic livestock production. The platform allows sharing of information and ideas along with development of new research priorities and the analysis of conventional research methodologies and their suitability to organic livestock research. It is hoped that the project will create a forum for an on-going discussion on animal health and welfare and their interrelationship within the framework of organic livestock production, and will be able to contribute to the development of organic regulations. The Network has 17 member organisations from 13 European countries.

The five thematic workshops planned for the years 2000–2001 are an important part of the project. The fourth one of these was held at the International Conference Centre in Wageningen, Holland, on 24-27 March, 2001. Over 60 delegates, from 13 European countries and from the USA participated in the proceedings, working groups and field visits in spite of the difficulties and cancellations caused by the then on-going foot and mouth disease outbreaks in boht Holland and the UK. The outbreak and its apparent consequences to livestock industry in Europe gave a poignant backgorund to the meeting.

The theme of the 4th NAHWOA Workshop was *"Breeding and feeding for animal health and welfare in organic livestock systems"*. According to most organic certification body standards and the current EU legislation, breeding and feeding are the two cornerstones of health and welfare in organic livestock systems. It is apparent form these proceedings that the concept of "organic breeds" or "organic breeding" is far from clear and that a lot of work needs to be carried out before 2005, when the current EU derogation allowing sourcing of livestock from conventional breeding systems to organic systems runs out. Similarly, the requirement to feed 100% organic feedstuffs from 2004 onwards makes heavy demands on the development of organic rations for monogastric livestock in particular. These proceedings show that a substantial amount of work is already being carried out to satisfy these requirements, and that some encouraging results are already there.

In addition to the thematic papers, these Proceedings also include a paper by Kat Bazeley *et al.*, presented at the third NAHWOA workshop in France in October 2000. Due to an editorial error this paper was left out form the appropriate proceedings. We would like to apologise for this and hope that those who have searched for this reference in the past will now be able to locate it. Also, abstracts of three posters presented both in Wageningen are presented.

Whilst farm visits could not take place during this Workshop as usual, the day dedicated for these visits was utilised by discussing the problematics of dealing with statutory disease control methods in organic livestock production. Approaches to vaccination and disease eradication and the growing concerns in regard to the spread of the bovine spongiform encephalitis (BSE) in Europe were of particular interest. – In the place of the cancelled farm visit to two organic dairy farms plus an organic poultry farm, a video was made at the farms of Dirk Endendijk and Frits Lozeman, both fundamental breeders within the Dutch Frisian herdbookTheir breeding system is described in detail further on in these proceedings, the delegates were able to see a video made on his farm. This video, "Power of the system", is now available both in English and Dutch versions from the Louis Bolk Institutes (address below).

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Acknowledgements

The Network for Animal Health and Welfare in Organic Agriculture would like to than thank Ton Baars and the members of staff of the Louis Bolk for making the Workshop a success. Because of the Foot and Mouth epidemic, it was impossible to invite farmers to the workshop or to visit any farms but we are particularly thankful to Dirk Endendijk and his colleagues who opened up their farms by allowing a video to be made of their dairy bereeding practices.

Many thanks also go to all the speakers and the delegates who participated actively and without whose contributions the Workshop would not have been a "workshop" and such a true exchange of knowledge and experience as it turned out to be.

Part A:

Breeding for animal health and welfare in organic livestock systems

Breeding strategies for organic animal production, an international discussion

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Introduction

In organic farming today, there is not a structural source of organically bred animals. In cattle, pig and poultry production, it is virtually impossible to find animals that have been bred specifically for organic production systems. Therefore, most farmers use animals from conventional breeding companies.

The suitability of these animals for organic environments, however, is questionable. Organic farming differs from conventional farming in many ways. Organic farming standards are laid down in European legislation. In general, these standards prohibit the use of chemical fertilisers, chemicals and pharmaceuticals. But organic farming systems differ also in aspects relating to natural/biological and economic, but primarily on ecological, sociological and ethical choices (COBL, 1977). Organic farming is based on the support of 'natural processes' in their production systems. Therefore, sustainability, diversity, renewability and integrity are important aspects.

Under these circumstances, it is not clear what the vision of the organic sector is in regard to livestock breeding. Neither has it been established whether the conventional breeding goals and selection techniques are suitable for organic farming. Further, it is not clear what possibilities there are for organic breeding, and what the consequences are of such breeding schemes would be.

Vision project

To answer these questions, we have started a vision project called "Organic Breeding, a long way to go". The aim of the project is to launch a debate on the approach to breeding in the organic sector. The main topics to be discussed are: reproduction techniques, production traits, breeding goals and programmes, efficiency and environment, agro-biodiversity, socio-economic aspects, animal welfare and the consequences of certain breeding restrictions for the sector. The debate should guide the organic sector towards a vision for organic breeding for the Netherlands and rest of Europe. A second aim is to formulate an action plan for realising an organic breeding system in practice.

Inventory

The project started with a survey of organic dairy farmers in the Netherlands. The study revealed that 63 % of the Dutch organic dairy herd are Holsteins, and that many organic farmers tend to use the same conventionally bred Holstein sires as their conventional colleagues (Elbers and Nauta, 1999). This suggests that breeding is not a primary consideration, when farmers convert to organic production. Mean production on the 153 participating farms was 6900 kg milk per cow per lactation while mean intensity of production was 8200 kg milk per hectare. These figures were considerably higher for newly converted farms (converted after 1995): 7100 kg milk per cow per lactation and a production intensity of 9030 kg milk per hectare. However, 41% of these farmers indicated that they were not satisfied with the current selection for breeding.

A second group of farmers, who have consciously chosen to use a different breed of cows, was identified among the majority of organic dairy farmers. In particular, crosses with breeds such as Montbéliarde (13%) and Swiss Brown (11%) were used on the organic farms in the study. Farmers using these breeds claimed that they are better suited for organic farming conditions. Twenty per cent of the total herds were local Dutch breeds; Dutch Friesians (8%), MRIJ (11%) and Groninger Blaarkop (1%).

In a second study, we visited farmers to ask them about their breeding strategies. We found that most farmers were not aware of the techniques used in modern breeding, and that they did not have many answers in regard to potential alternative breeding strategies for organic farming. Most farmer did not feel that there was a need for a stronger organic basis for breeding to support the future development of organic farming. Furthermore, most farmers had confidence in the big breeding companies and liked a high production yield per cow. They were concerned that an organic breeding programme would be too small and lack genetic value. In general, farmers would prefer more "robust" animals that maintain high yields but have few health problems.

Information obtained in several other projects indicates that pig and poultry farmers also use conventional breeding products. Where a dairy farmer still selects his own cows/female animals, pig and poultry farmers use F1 and F2 animals for production. However, some pig farmers have started selecting their own sows for rotational crossing.

Future questions

EU legislation prohibits embryo transfer and other reproduction techniques, apart from artificial insemination, in organic farming. However, these techniques are commonly used by breeding companies, especially in Holstein breeding, and by using sires from such breeding, organic farmers are indirectly making use of these techniques. It is uncertain whether this situation is being condoned or has simply been overlooked until now. The situation leaves us with many questions:

1. Which reproduction techniques would be acceptable under organic management?
2. What breeds do we need under organic management?
3. What type of animal do we need?
4. Which traits are important?
5. How do we select?
6. On which grounds do we need to select?
7. Do we need an organic breeding scheme?

The origin of the animals is important. The used breeds and strains must have the capacity to adapt to local conditions concerning their vitality and their resistance to disease (EU, 2000). Many dairy farmers don't use local breeds anymore, preferring Holstein Friesians. Pig farmers use crossbreds from the Dutch Landrace, and poultry farmers use lines which are based on very few previous lines.

There is some disagreement about whether these animals are 'local' or not, after years of local breeding. Using local breeds, however, also precludes the loss of variety in species. Such breeds can be saved for future generations of farmers by reintroducing them into the organic farming system.

The preferred type is strongly linked to the system to which the animals are tied. In organic farming, this should be a mixed, land-based system (EU, 2000). It is however, important to know, in which direction(s) organic farming will develop. At the moment, organic systems can differ strongly. In the Netherlands, some farmers keep animals in a mixed farming system, where they have to produce milk and meat on a diet of roughage and arable surpluses. Most farmers, however, keep animals in highly specialized systems, where ruminants are fed roughage and concentrates and pigs and poultry are fed only imported concentrates. Production levels in dairy cattle vary from 4,000 kg to 10,000 kg milk per lactation. Specialized organic pig and poultry production systems also lead to greater differences in production levels. Sows produce 15 to 22 piglets per year, and the production of laying hens can vary from 200 to 300 eggs per year on highly specialized farms.

Another important aspect is genotype-environment (GE) interaction. Until now, it is believed that the selection of breeding animals based on conventional data is appropriate for organic circumstances as well. The ranking of animals on the basis of production traits should be the same for organic farmers. Correlations between production indices of sires based on different countries range from 0.7 to 0.97 (Interbull, 2000). However, in a purely organic system, GE interactions may play a more important role for durability traits. For production traits, the differences in environment and system mean that we do not look at the same traits anymore. For example, milk production on an exclusive diet of roughage is not the same as milk production on a diet of 50% roughage and 50% concentrates (in energy equivalents).

In general, we have to ask ourselves what place animals should have in organic farming. Haiger stated that ruminants should be used to produce human food from mainly roughage with a maximum of 20% concentrates, so that they do not compete with humans for the same food (Haiger *et al*., 1988). This type of a system would need cattle that can cope with milk production from roughage.

In the Netherlands, organic farmers import to the farm about 20% to 30% of the feed-energy in concentrates, i.e. they use about 20% more (arable) land space for cereal production, mainly outside the country. This clashes with the organic principle that states that production should be soil dependent at farm level. However, when Dutch farmers exchange manure for concentrate with a local arable farm, a soil dependent system is created. Trials with this Partner Farm-concept are described by Nauta *et al*. (1999).

In the Netherlands, 33% of the total organic arable area would be needed in order to produce the total amount of concentrates required by organic dairy farming. This would be possible in an arable crop rotation when only fodder grain would be grown. Many arable farmers, however, grow bread wheat, which should be preferred on ecological basis. There is also the further question of organic pig and poultry production. For these sectors, all concentrates would have to be imported. Otherwise cattle could only be fed roughage, so that the feed requirements of the pig and poultry sectors could also be satisfied.

Organic breeding strategies

On the basis of the aspects described above, there are numerous possibilities for organic breeding. The exclusion of indirect use of embryo transfer (ET) and other reproductive manipulations will possibly be the first step to be taken. In consideration of animal welfare and naturalness of organic farming, the indirect use of these techniques may be banned in the near future. In Switzerland, organic farmers are already prohibited from using breeding bulls from ET. The consequences for cattle breeding can be considerable, as the breeding of bulls (especially in Holstein breeding) is mainly based on ET techniques. In Holland, such a measure would cut the number of breeding bulls for organic farming to about 55 bulls of different breeds at the moment. The more theoretical questions deal with GE interactions and the different breeding strategies.

Two extreme breeding strategies available for organic farmers are 'on-farm breeding' and quantitative genetics. On-farm breeding, as described by Endendijk and Baars (2001), leads to animals which are, after many years, highly adapted to the farm environment. Cattle breeding based on quantitative genetics always results in average information in a national or world-wide population. The value of traits can be estimated in a relatively short time. However, the value for individual organic farms is also average. There are alternatives that combine aspects of both these extremes, such as line breeding described by Bakels, Foundation Breeding for Dutch Friesians (Endendijk and Baars, 2001) and Lifetime production breeding (Postler, 1999).

The basis of foundation breeding is formed by a group of farmers who breed purebred animals through 'on-farm breeding'. In this way, each farm creates a unique population within the total population of this breed. Users can choose bulls from different "foundation farms" and create their own rotational crosses with different populations or lines. In this way, the producer gets the maximum effect of heterosis within the breed.

Line breeding as described by Bakels and Postler (1986) is based on three different Holstein lines with different types of animals. Through rotational breeding, user can create a balance between the different types.

Lifetime production breeding as described by Postler (1999) is based on a real life production profile of ancestors and a different contribution of conventional breeding data. The ancestors of a bull have to have produced more than 150,000 kg milk in combination with a progressively higher production in the first three lactations. Of the daughters, data of the second and third lactations are included for 30% and 50%, respectively, in the index. In this way, lifetime production and milk production persistency are based on real numbers.

Future scenarios

For the future, the following scenarios are possible for organic farmers:

1. Using conventional breeding products;
2. Using conventional breeding products with restrictions and/or modifications;
3. Using organic breeding on the basis of the national organic population; or
4. Using organic breeding on farm.

The first scenario allows the use of animals of a high genetic level and a fast genetic gain. However, the genetic value is still questionable, and this strategy might harm the sector's image because of the wide-scale manipulation of reproduction in these breeding schemes. However, these breeding schemes are more and more focussed on durability traits (Vollema, 1998; Olesen *et al.,* 2000; Koenen *et al.*, 2000).

In the second scenario, the objections to conventional breeding schemes could be resolved by placing some restrictions and modifications on the background and pedigree of bulls, e.g. no ET allowed and data required for at least three lactations of a bull's daughters in the index. However, these data are still based on conventionally managed milking cows. It is important to find out what the effect of GE interaction is on the genetic value of the different traits.

In the third scenario, breeding is based only on data of organically held cattle. This is only possible when there are enough daughters of bulls available on different farms. In the Netherlands, a dozen Holstein Friesian bulls now have enough daughters so that a production or durability index can be estimated. Interestingly, this situation has developed, as so many organic farmers use the same top pedigree bulls.

The last scenario is based on the technique described by Endendijk and Baars (2001). Dirk Endendijk's farm is part of a system called 'Foundation Breeding'. Eighteen farmers in Holland are breeding purebred Dutch Friesian dairy cows according to this system. The populations of cows on these farms become more and more adapted to their own farm system and the breeding goals of each individual farmer. In this way, variations between farms develop within the breed. Other farmers can use bulls from different farms in a rotational crossing system to profit from heterosis within the breed. This kind of breeding can be used for different breeds and crossing systems. However, the breeding skills of farmers play a very important role in this type of breeding. Some form of professional support might need to be developed for this type of on-farm breeding.

Conclusions

At the moment, it appears that a “vicious circle” has developed in organic farming with respect to animal breeding. Farmers do not know what type of animal they need and take refuge in "tried and trusted" conventional animals. At the same time, an organic alternative is missing. In view of new EU legislation and developments on the organic market, it is essential that the organic dairy sector starts discussing livestock breeding and the sector's position with respect to breeding principles and goals, and the possibilities for developing an organic breeding system.

As GE interactions seem to be more important for durability traits and basic information on this is not available, there is a need to initiate studies on the subject. There is also a need to study the several alternative breeding strategies and future scenarios available for organic farming.

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Ecological total merit index for an Austrian dual purpose cattle breed

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Introduction

In breeding objectives, traits should be included according to their economic importance. Miesenberger (1997) estimated such economic weights for production traits and functional traits using a herd model for Austrian cattle breeds. The economic weights of several functional traits (e.g. longevity) turned out to be high (Miesenberger *et al.*, 1998). An improvement in one of those traits increases the efficiency of an animal, not by higher output of products, but mainly by reduced input of costs (Groen *et al.*, 1996, Miesenberger, 1997). Some authors (Dempfle, 1992; Groen *et al.*, 1996) point out that in addition to economic reasons for including functional traits in the breeding programmes there are several other reasons, for example ethical reasons and consumer concern, which become more and more important. For this reason and because of the fact that organic farming plays a considerable role in Austrian agriculture, it seems worthwhile to make suggestions about a more ecological breeding goal for cattle breeds.

In the following “ecology” is defined in a broad sense. 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, an ecological total merit index has to deal with characters which are indicators for the inner balance of an organism, like health and fertility traits.

This study shows different possibilities of how to create a more ecologically orientated total merit index for the dual purpose Simmental population, which is the most frequent cattle breed in Austria. Furthermore, the effect on the expected selection response in milk production, beef production and functional traits under selection with the current economic total merit index and more ecological index variants, e.g. with higher economic weights of the functional traits, is shown. The efficiency of different indices is compared to get a basis for future decisions.

Materials and methods

To estimate the economic weights and calculate a total merit index a herd model and methods described by Miesenberger *et al*. (1998) and Miesenberger (1997) were used.

Estimation of the economic weights

A herd including milk production, bull fattening and heifer rearing was simulated in a steady state over an infinite planning term. A computer program developed by Amer *et al.* (1994), which was adapted by Miesenberger *et al.* (1998) was used to compute the economic weights for the various traits by calculating herd profit per year before and after a genetic change. The resulting difference in herd profit was divided by the number of cows per herd. All costs were treated as variable. For a more detailed description see Miesenberger *et al.* (1998).

All economic weights presented in this study were calculated under the assumption of a quota on fat and protein yield. A reference situation was defined with respect to the Simmental population in Austria. The average milk yield per cow place and year was 5,321 kg milk, 223 kg fat and 180 kg protein. The age structure of the herd modelled approximated the situation in the present Austrian Simmental population (see Miesenberger *et al.*, 1998). Prices and costs in the basis situation were average prices in Austria in 1996. Some of the prices considered are given in Table 1 (scenario I).

Modelling of the breeding programme

The program ZPLAN (Karras e*t al.*, 1994) was used to describe the Austrian Simmental breeding programme. For predicting the annual genetic gain, a pure deterministic approach is employed. One round of selection is considered with its impact on a given time horizon with specific discount rates. All selection groups in the whole population are to be defined, each with a specific selection intensity and with particular sources of information (type and number of relatives) for index selection. The ZPLAN method applies the gene flow method described by McClintock and Cunningham (1974), Hill (1974) and Elsen and Mocquot (1974) to calculate a number of criteria such as annual monetary genetic gain for the aggregate genotype, annual genetic gain for single traits, discounted return and discounted profit over the given investment period. These criteria allow the evaluation of the genetic and economic efficiency of breeding programmes. Using this program, different genetic improvement schemes have been evaluated by Graser *et al.* (1994), Riedl (1996), Mueller (1995), Kominakis *et al*. (1997), Wünsch *et al.* (1999) and Sölkner *et al.* (2000). In the following, some of the most important input parameters for the Austrian Simmental population are given.

Total population size	650,000
Proportion of recorded cows	0.35
Proportion of AI	0.88
No. of young bulls tested per year	130
No. of proven bulls selected per year	16
No. of selected bull dams per year (elite-matings)	2,000
Use of young bulls (years)	0.4
Use of proven bulls (years)	2.0
Use of natural service bulls (years)	2.2
Use of bull dams (years)	3.0
Use of dams (years)	3.8
Mean generation interval in years (all selection groups)	5.65
Milk recording costs per cow (EURO)	47
Investment period (years)	20

Development of an ecological total merit index

There are several possibilities to alter an index in direction of a more ecological breeding goal. Different traits can be included in the total merit index and the economic weights of these traits can be changed. Both possibilities are discussed subsequently.

Choice of traits

Which traits should be taken into account in an ecological total merit index has to be clarified when the breeding goal is defined. In case of a meaningful ecological breeding goal, one supposition should be to include traits for health and fertility into the index. Miesenberger *et al.* (1998) showed that functional traits should be included in the aggregate genotype also from an economic point of view. Selection for such a total merit index will result in a higher economic efficiency than selection for production traits only (see also Sölkner *et al.,* 2000). In the total merit index in Austria, the following traits are incorporated: fat and protein yields, daily gain, dressing percentage, EUROP grading score, longevity, persistency, paternal and maternal fertility, paternal and maternal calving ease, paternal and maternal stillbirth and somatic cell count. Fat and protein yields are combined in the subindex “milk value”, daily gain, carcass percentage and EUROP-grading score give the “beef value”, and the combination of all other traits, the functional traits, results in the “fitness value”. Because of the consideration of the functional traits the current economic total merit index in Austria can be judged positively with regard to an ecological orientated choice of traits.

The scenarios considered subsequently include only traits currently used in the total merit index in Austria. Feed intake and capacity and efficiency of feed utilisation are not included in these indices although improvement of such traits may lead to a reduction of environmental costs, e.g. due to less nitrogen secretion per unit of product. Groen *et al.* (1996) point out that feed intake is a very complex trait, which cannot be treated separately but should always be considered in relation to milk production and body weight. The question whether a reduction or an increase in (residual) feed intake (capacity) should be considered, is not solved yet.

Relative economic weight of the traits

The calculation of economic weights with the herd model requires assumptions with regard to the costs of input. Under ecological aspects costs for the environmental pollution and consumption of fossil energy have to be taken into account. It is assumed that the consideration of such external costs leads to higher prices for feedstuffs such as concentrate and corn silage. From a social standpoint, the value of agricultural products (milk, beef) has to be higher. Therefore economic weights were calculated under different scenarios with regard to costs and returns (Table 1). The resulting weights were used to construct four different selection indices. The following scenarios were assumed:

Scenario I: Costs and returns used by Miesenberger e*t al.* (1998) were assumed. The economic weights correspond to those assumed for the current total merit index in Austria.

Scenario II: Costs of 1 kg of dry matter of concentrate (barley and soya) were 50 percent higher than under scenario I (see Table 1)

Scenario III: The same assumptions as in scenario II, but the costs of corn silage are increased additionally. One energy unit (MJ NEL) of corn silage is as expensive as one energy unit of grass silage (Table 1)

Scenario IV: The same costs as in scenario III were assumed, but no corn silage was used in cattle feeding.

To take social aspects into consideration, returns of agricultural products were increased in scenario III and IV (see Table 1). The milk price per kg was increased by 0.015 EUR and beef price per kg carcass weight by 0.360 EUR. These are typical differences between prices paid to organic farmers in comparison to conventional farmers.

Table 1: Some returns and costs in the six different index scenarios in Euro

	Scenario			
	I, V, VI	II	III	IV
Returns per kg				
Milk carrier	0.04	0.04	0.05	0.05
Milk fat	3.37	3.37	3.37	3.37
Milk protein	4.20	4.20	4.20	4.20
Bull (carcass weight)	3.02	3.02	3.38	3.38
Costs / kg dry matter				
Barley	0.18	0.27	0.27	0.27
Soya	0.28	0.42	0.42	0.42
Grass silage	0.12	0.12	0.12	0.12
Corn silage	0.11	0.11	0.13	-

In deriving economic weights for functional traits, especially reproductive and health traits related to animal welfare, it is important to consider public opinion and consumer attitude towards animal production (Groen *et al*., 1996). To provide some indication of the effects of selection according to a total merit index where ethical aspects with regard to animal welfare are taken into consideration, two further index variants were investigated. The weights of the traits, which constitute the subindex "Fitness value" in the current Austrian total merit index were increased arbitrarily.

Scenario V: Economic weights for all traits of the "Fitness value" 50 percent higher than in scenario I
Scenario VI: Economic weights for all traits of the "Fitness value" 100 percent higher than in scenario I

Table 2 gives an overview of the economic weights of the traits included in the 6 indices.

Table 2: Genetic standard deviation (s_A) and economic weights per genetic standard deviation for the six scenarios.

Trait	s_A	Unit	Economic weight in scenario					
			I	II	III	IV	V	VI
Fat yield	15.60	kg	26.05	20.41	22.67	21.54	26.05	26.05
Protein yield	10.50	kg	27.51	24.42	26.71	28.23	27.51	27.51
Daily gain	47.00	g	11.28	9.22	9.56	9.56	11.28	11.28
Dressing percentage	1.14	%	11.26	11.26	11.26	11.26	11.26	11.26
EUROP grading score	0.25	class	4.22	4.07	4.07	4.07	4.22	4.22
Longevity	180	day	21.60	22.76	21.60	21.60	32.40	43.20
Persistency	1	s_A	2.91	4.87	3.92	2.54	4.37	5.82
Fertility paternal	5	%	7.25	6.54	6.54	6.90	10.88	14.50
Fertility maternal	5	%	7.25	6.54	6.54	6.90	10.88	14.50
Calving ease paternal	0.22	class	1.71	1.71	1.71	1.71	2.57	3.42
Calving ease maternal	0.22	class	1.71	1.71	1.71	1.71	2.57	3.42
Stillbirth paternal	2.5	%	4.00	2.91	3.82	3.63	6.00	8.00
Stillbirth maternal	2.5	%	4.00	2.91	3.82	3.63	6.00	8.00
Somatic cell count	1	s_A	14.53	14.53	14.53	14.53	21.80	29.06

Results and discussion

Relative economic importance of subindices

Table 3 shows that the consideration of external costs leads only to a marginal shift of the relative importance of the three subindices “Milk Value”, “Beef Value” and “Fitness Value”, favouring the “Fitness value” (scenario II to IV in comparison with scenario I). The reason for this shift was a higher economic weight of the functional trait persistency under scenario II and III. The weight of persistency increases due to higher concentrate costs. This confirms the results of Miesenberger (1997), who showed an increase of the economic weight of persistency under increasing costs for concentrate. Generally higher feeding costs lead to lower economic weights of functional traits, where an improvement is coupled with increased feedstuff consumption.

The arbitrary increase of the weights of the functional traits caused a stronger shift of the relative importance of the subindices towards the traits combined in the ”Fitness value” (scenario V and VI compared to scenario I).

Table 3: Relative economic importance of the 3 subindices “Milk Value”, “Beef Value” and “Fitness Value” under the six scenarios.

Scenario	Milk Value	Beef Value	Fitness Value
I	37	18	45
II	32	19	49
III	36	18	46
IV	36	18	46
V	30	15	55
VI	25	13	62

Expected selection response under selection with different total merit indices

The results given in this chapter are intended to provide some indication of the effects of selection according to the six scenarios presented. When interpreting the expected selection responses, one should be aware of the assumptions. Table 4 contains the selection response per year in genetic standard deviations for each trait under the six different scenarios. Selection with the current total selection index in Austria (scenario I) lead to an improvement of all considered traits except four functional traits. Small negative responses were observed for paternal and maternal fertility, paternal calving ease and paternal stillbirth. Selection with indices where external costs were considered (scenario II, III and IV) yielded similar results, though there is less deterioration in the functional traits mentioned above. The picture changed under scenario V and VI where a higher economic weight is put on the functional traits, but even under scenario VI, a small negative response of paternal calving ease and paternal stillbirth was observed. The application of the indices under scenario V and VI allowed no improvement of the trait dressing percentage. Table 4 also illustrates that with higher weights for the functional traits the selection response for traits combined in the “milk value” decreased by 19 and 38 percent, respectively.

Table 4: Natural selection response per year in genetic standard deviations under the six scenarios.

Trait	Natural selection response under scenario					
	I	II	III	IV	V	VI
Fat yield	0.180	0.161	0.174	0.174	0.146	0.111
Protein yield	0.179	0.162	0.174	0.176	0.145	0.111
Daily gain	0.083	0.078	0.078	0.079	0.076	0.066
Dressing percentage	0.003	0.011	0.007	0.007	-0.004	-0.009
EUROP grading score	0.017	0.021	0.019	0.019	0.010	0.004
Longevity	0.051	0.068	0.057	0.056	0.088	0.114
Persistency	0.046	0.061	0.052	0.048	0.065	0.077
Fertility paternal	-0.009	-0.004	-0.007	-0.008	0.002	0.010
Fertility maternal	-0.023	-0.015	-0.020	-0.021	-0.001	0.014
Calving ease paternal	-0.031	-0.030	-0.030	-0.031	-0.027	-0.022
Calving ease maternal	0.069	0.069	0.070	0.069	0.079	0.084
Stillbirth paternal	-0.008	-0.009	-0.008	-0.008	-0.007	-0.005
Stillbirth maternal	0.039	0.040	0.041	0.040	0.052	0.061
Somatic cell count	0.001	0.015	0.007	0.006	0.033	0.058

Economic efficiency of the different total merit indices

The economic efficiency expresses the robustness and efficiency of a certain set of economic weights used in a total merit index with regard to the monetary total selection response (Gibson, 1995). The economic efficiency is calculated by multiplying the natural selection response of the single traits under selection with the “used” total merit index with the corresponding economic weights of the “true” total merit index. These products are summed up and divided by the expected monetary total selection response with the “true” total merit index. Table 5 shows the proportion of the monetary total selection response, which can be achieved by use of an index with the economic weights of the index for the scenario in the respective line under the assumption that the weights of the index in the respective column are “true”.

In the first line of Table 5, the economic weights used in the current Austrian total selection index are assumed to be “true”. From an economic point of view, the indices under scenario II to IV were of the same value. A selection index with 50% higher economic weights (scenario V) lead to marginally reduced economic efficiency (3% less efficiency). Doubling the economic weights of functional traits in the selection index under scenario I reduces the efficiency by 11%. Irrespective of the assumed “true” scenario the economic efficiency of the index under scenario V is about 97 to 98%.

Table 5: Economic efficiency with regard to the monetary total selection response per year of the used index scenario relative to the "true" index scenario (bold) in the respective line.

Scenario	I	II	III	IV	V	VI
I	**1.00**	1.00	1.00	1.00	0.97	0.89
II	0.98	**1.00**	0.99	0.99	0.98	0.93
III	1.00	1.00	**1.00**	1.00	0.98	0.91
IV	1.00	1.00	1.00	**1.00**	0.98	0.91
V	0.97	1.00	0.98	0.97	**1.00**	0.98
VI	0.89	0.95	0.92	0.91	0.98	**1.00**

Conclusions

The derivation of economic traits with a herd model, with and without consideration of external costs, leads to almost identical economic weights for the single traits. Selection responses under selection with indices based on such economic weights did not differ very much. Recording of external costs and a subsequent calculation of economic weights is not the most effective way to construct a more ecological total merit index, because the economic weights turned out to be relatively insensitive to the assumed external costs.

Interpreting the calculated expected selection responses for the single traits one should be aware of the fact that the assumed correlations between the traits play a considerable role. Under the assumed genetic and phenotypic correlations it could be shown that increasing the economic weights of functional traits directly is a reasonable possibility to take some ecological values into account. To alter economic weights this way pays regard to external costs indirectly. Sundrum (1997) showed that increasing the average age of cows from 5.1 to 5.6 years was more effective with regard to methane emission than increasing the mean milk performance by 1.000 kg per year.

From an economic point of view, there is no great risk in increasing the economic weights of functional traits by 50%. The economic efficiency of such a selection is reduced marginally compared to a selection using an index with currently used economic weights of the single traits. The lower selection response of milk traits is nearly compensated by the higher response of functional traits. Nevertheless, due to the high subjective value of the milk traits in practice such an ecological total merit index may be at a competitive disadvantage beyond economic reasons.

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Breeding strategies for organic dairy cows

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Introduction

For thousands of years humans have attempted to make livestock species more suitable for production of food, fibre, transport and draught power. The rate of genetic improvement in recent years has been accelerated through developments in genetics, computing power, statistics, reproductive biology, molecular biology etc. To date, most of the selection pressure, regardless of species, has been on commercial traits or output, with rates of genetic change in targeted traits being greater than 3% per annum for poultry and around 2% for dairy cattle (Smith, 1984). Genetic selection can therefore partly be seen as responsible for the availability of cheap products in large quantities, but increasingly this is seen as being at a cost. With increases in production traits, regardless of what they are, come associated animal welfare issues, in particular unfavourable correlated responses in health and fertility traits. There is growing recognition that additional selection goals should be considered, and this is especially true for organic production.

In this paper, we review strategies for breeding organic dairy cattle, including:

1) The organic environment, and whether bulls that are progeny tested in intensive systems are also appropriate for organic systems;

2) Selection within breeds using broader breeding goals that include health and fertility traits and give some indication of how welfare can be included in the breeding goal;

3) Selection between breeds and whether the Holstein breed, which dominates in most countries, is the most appropriate breed for organic production;

4) The role of crossbreeding and the possibilities of introducing cross-breeding to dairy cattle breeding where straight-bred animals dominate; and finally

5) The prospect of using genetic marker technology as a tool for genetic progress.

The UK project

A research project was started at SAC in April 2000 to review breed differences and heterosis in animal characteristics that are potentially important to organic production. This project also aims to model the outcome of different selection strategies within organic systems. A major objective is to define the appropriate economic weight for important breeding traits. For instance, breeding for disease resistance (e.g. mastitis) is potentially far more valuable in an organic system. The study is desk based, but involves an active group of stakeholders to guide the research. The stakeholders include representatives of organic farmers, industry, certification bodies, consumers, researchers, veterinarians etc.

Genotype by environment interactions

Simm *et al.* (2001) suggested that farming is polarising into three distinct areas: (i) intensive systems that are high-input and high-output and buy in feeds etc.; (ii) extensive low input systems that rely on home-grown forage based diets; and (iii) niche markets, such as organic systems.

Organic systems will inevitably feed high proportions of home-grown foodstuffs, both because organic standards stipulate a minimum proportion of forage in diets (e.g. 60%; UKROFS), and because purchased organic concentrates are expensive. The stringency of the Organic certification bodies' rules may make it inevitable that organic farms will be more homogeneous than conventional systems. Organic farms are more likely to be more integrated systems of production than conventional dairy units; "Organic farming works most successfully where a diversity of livestock species and a diversity of crops are produced"; Younie (2000).

A relevant question, is whether we need to breed cows to suit systems, or alter systems, where possible to suit the animals? In other words, are sire rankings likely to alter dramatically when a different system such as organic farming, is used. So called genotype by environment interactions (GxE) are generally thought to be of little importance where the environments are broadly similar (for production traits), but of greater importance where environments or genotypes are very different or extreme. 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. Of relevance in terms of breeding strategies, is whether the difference between organic and conventional farming systems is enough to allow sire rankings to differ. One way of partially resolving this problem is to alter the relative economic weights of traits in the breeding goal. The breeding goal includes traits which selection is intended to improve, so for dairy cattle, economically important traits might include production, health, fertility, longevity etc.

It is likely that weights would differ between conventional and organic systems; and we will return to this issue later in the paper.

To date, genotype by environment interactions have not been investigated for conventional versus organic farms. Furthermore if differences were to be seen in sire rankings, perhaps they would be more important for health and fertility traits than production traits, and there may be subsequent implications for animal welfare. From a welfare perspective, the interaction between the animal and its environment can be thought of as a critical determinant of welfare (e.g. Fraser *et al*., 1997), and it follows that welfare will tend to be higher the better the match between G and E (Lawrence *et al.,* 2001). Furthermore, modern animal breeding may be shifting the animals' genetically based adaptations such that 'traditional' environments, are no longer appropriate for the changed genotype. Future breeding programmes need to consider more fully the consequences of selection programmes. A synergy of economics, genetics and ethology is needed to tackle this area.

Selection within breeds

One of the fundamental problems in dairy cattle breeding is that most of the traits of interest are only expressed in females. In dairy cattle populations, which depend on progeny testing for genetic improvement, progress can be attributed to four 'pathways'. These are selection of: (i) bulls to breed bulls – selection of top AI bulls to be sires of the next generation of AI bulls; (ii) cows to breed bulls – the selection of top cows to breed the next generation of AI bulls; (iii) bulls to breed cows – the choice of bulls to breed cows in herd; and (iv) cows to breed cows – the choice of cows to breed replacement heifers in herds which contribute bulls for testing. The contribution of each of these pathways is approximately 30%, 29%, 28% and 3% (Woolliams and Smith, 1988). So, for the individual breeder, the choice of AI bulls has the greatest impact by far.

We have already mentioned that there are likely to be at least three groups of production systems in future. A key question for organic farmers (or those falling into the other two groups) is whether or not they need to have different breeding policies. To formally answer this question we need to know details of the costs and returns in each of the systems, and the genetic correlations between the most important animal characteristics in the systems (e.g. to know whether protein yield is controlled by the same genes in the two production systems). If the economics are sufficiently different, or the genetic correlations are substantially below 1, then we probably do need different breeding policies. At the simplest level, this might mean weighting nationally or internationally available predictions of the genetic merit of bulls or cows (predicted transmitting abilities or PTAs) differently for different systems, or basing selection on a wider number of traits. However, if animals rank very differently in different systems, it may require separate evaluations. In this paper, we describe how bull rankings might differ between a very preliminary investigation of a future version of the UK national selection index, £PLI, that includes somatic cell count (SCC) to predict mastitis and describe the tools which are available now, or could be developed, to allow more tailored selection policies in the future.

Genetic selection for mastitis resistance is one preventative management strategy that can be implemented in conjunction with other steps. It may be argued that breeding for disease resistance is important regardless of whether the farm is organic or conventional, but it is likely that the relative economic value of mastitis would be greater in organic than conventional systems. Research at SAC has shown that the economic value of mastitis is also dependent on the incidence of mastitis in the herd (Kadarmideen and Pryce, 2001), and that the value of mastitis is greater in herds with high incidences of mastitis. As part of SAC's organic breeding project, a generic economic weight for mastitis predicted by SCC will be derived, which will enable several alternative selection strategies to be modelled.

Selection indexes

In many countries, PTAs on individual traits are combined using selection indexes. These are of three main types: (i) economic indexes based on milk production traits only, accounting for expected differences in market values of milk, fat and protein, and possibly for different costs of production, (ii) indexes which use arbitrary weightings to combine PTAs for milk production and type traits, and (iii) broader economic selection indexes including direct measures or predictors of traits such as longevity, fertility, disease resistance or live weight as well as milk production (Simm, 1998). Adding a welfare value to traits associated with perceived animal welfare is a subsequent development, although this is difficult, in that peoples' perceptions of the value of welfare vary enormously. The 'value' of welfare is an area of considerable debate, it goes without saying that the amount of money people are willing to pay for welfare will vary greatly. If a single figure for the value of welfare could be arrived at, the result could be an arbitrary and uneconomically driven index (an area we will return to later). As the array of information available on AI bulls worldwide increases, it is becoming more important to have these different pieces of information combined into indexes which give each of them appropriate emphasis within the index. The development and wider use of indexes of overall economic merit should simplify selection, and help to breed cows that are both healthier and more profitable.

In the UK, an index driven by economics (the third type in the list above) has been available for the last few years (Veerkamp *et al.*, 1995). The breeding goal of the current version (£PLI) includes milk, fat and protein yields plus lifespan predicted from actual daughter survival records and four linear type traits (Brotherstone *et al.*, 1998). Likely future extensions to this index include the use of PTAs for somatic cell count as a predictor of resistance to mastitis, and PTAs for calving interval as a measure of fertility. Preliminary calculations suggest that expansion of £PLI to include mastitis resistance (M) and calving interval (CI) could increase economic response to selection by 78%, compared to selection for production alone (Pryce *et al.,* 2000). Selection on such an index could also halt or greatly slow the decline in fertility and mastitis resistance, compared to selection for production alone. Table 1 shows expected annual responses in terms of net returns and correlated responses in production, lifespan, health and fertility, when selection is on production only (£PIN), production plus lifespan (£PLI) and a hypothetical index, where it is assumed that PTAs are available for mastitis and calving interval (£PLI+M+C).

Because there are high genetic correlations between yields of milk, fat and protein, it is unlikely to be cost effective to breed for ratios of milk constituents, which exactly match market requirements, and it is probably much more cost effective for processors to do any fine tuning required. However, customised indexes are likely to be of particular interest to groups of farmers on milk payment schemes, which differ substantially from assumed average schemes. Their use will ensure economically optimal emphasis on altering composition at the level of the cow. These indexes are also likely to be of interest where other costs or returns differ substantially from assumed average values. For example, in organic milk production systems there is likely to be a higher economic value on resistance to disease. Customised indexes may also allow more targeted selection of animals for forage-based systems e.g. by including predictors of intake capacity, if this appears to be a limitation.

Table 1 Expected annual responses to selection per cow

Index	PIN	£PLI	£PLI+M+CI
Net response/year/100 cows (Euros)	805	1084	1582
Milk (kg)	94	89	42
Fat (kg)	4.5	4.2	1.6
Protein (kg)	3.1	3.0	1.7
Mastitis (/lactation/100 cows)	0.3	0.24	-0.02
Calving interval (d)	0.84	0.56	-0.81
Lifespan (lactations)	0	0.04	0.08

From a list of 28 breeding goal traits, the traits in Table 2 were consistently chosen as high priority traits to include as breeding goal traits (unpublished results from the SAC Participatory Research Group on Organic Breeding).

Table 2 The top 10 traits in Dairy Organic Breeding as ranked by SAC's Participatory Research Group in Organic Dairy Breeding Strategies and Soil Association volunteers

Rank	Trait
1	General disease resistance
2	Mastitis resistance
3	Longevity/lifespan
4	Somatic cell count (sub-clinical mastitis resistance)
5	Female Fertility
6	Feed characteristics (e.g. forage intake capacity)
7	Feet and legs
8	Lameness
9	Resistance to parasite infection
10	Robustness/hardiness

The weighting applied to traits will have a significant impact on the response to selection. Normally the weights applied to traits are derived through optimising their monetary value to the producer (e.g. Weller, 1994). In the examples presented so far, all weights are derived using economic models that account for the expected cost or return of a 1% change in genetic merit in the trait in question. However, this may not be an adequate framework for dealing with welfare traits, because these traits have an additional ethical value, which cannot be assumed to be the same as weights derived on the basis of optimising producers' profits. Therefore we need to consider what alternative approach could replace the conventional economic framework for estimating weights. Oleson *et al.* (2000) describe a framework where each trait is considered to have both a market and a non-market value; individual traits may differ in whether they have only one or both types of value.

In the absence of information to derive an ethical weight for welfare, we considered expanding the emphasis on lifespan in the £PLI example. Lifespan was chosen as it is genetically correlated to health and fertility problems (Pryce and Brotherstone, 1999), so an improvement in longevity might indirectly lead to an improvement in welfare. As the weight attributable to welfare is likely to vary with peoples' perceptions of its value, we varied the emphasis from the economic optimum to between 1 and 6 times of this value. As expected, the economic response, calculated as returns in production and lifespan only, diminishes with increasing the economic weight of lifespan from its estimated economic optimum (1x). Yet genetic progress in lifespan increases as greater emphasis is placed on this trait. As a correlated response, the number of cases of mastitis is expected to increase with the current version of £PLI (Figure 1). Increasing the emphasis on lifespan slows down the rate of increase in mastitis, yet the breakeven point to an improvement in mastitis is not reached until 4 or 5 times the current economic emphasis on lifespan.

Figure 1. Response in lifespan after 10 years of selection on £PLI, where the economic value of lifespan is inflated by 0 to 6 times its direct estimated value

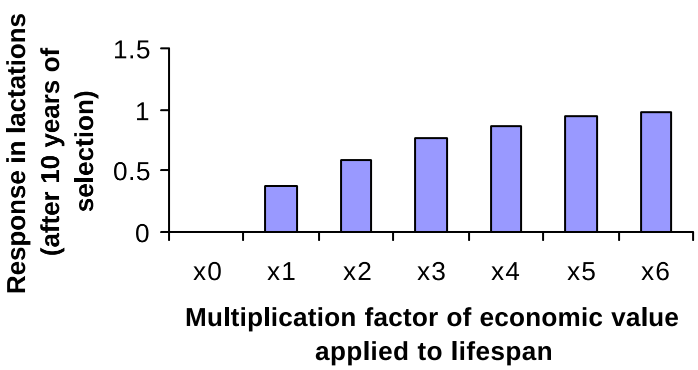


Figure 2. Mastitis cases per 100 cows after 10 years of selection on £PLI, where the economic value of lifespan is inflated by 0 to 6 times its direct estimated value

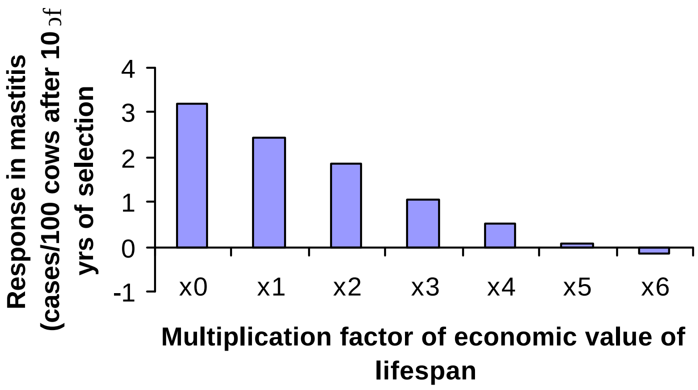
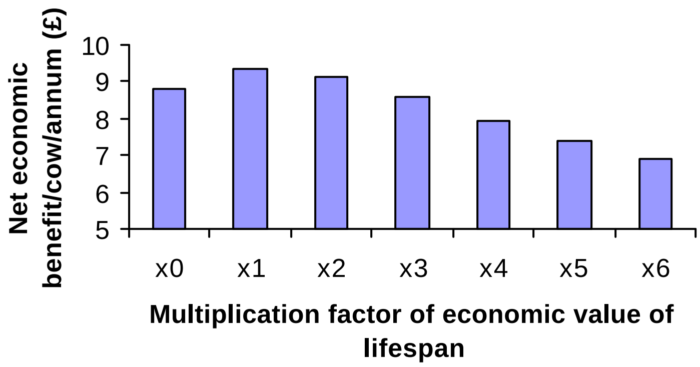


Figure 3. Annual economic response of selection on £PLI, where the economic value of lifespan is inflated by 0 to 6 times its direct estimated value



Crossbreeding

The genetic control of crossbreeding effects can be split into two main parts: additive and non-additive. The additive part is the average of the two breeds (in a simple two breed cross), and the non-additive part is heterosis. This is where the phenotypic performance of the crossbreds (M_{F1}) deviates from the mean performance of the parents (M_P).

$$Heterosis = \frac{M_{F1} - M_P}{M_P} \times 100$$

F1 crossing systems (the first cross between two breeds), maintain 100% of the direct heterosis in the crossbred part of the herd (Table 3). What to do after the first cross is a dilemma. One strategy would be production of F1s (first crosses), which would involve maintaining a proportion of the herd as purebred and mating the best ones to maintain the purebred population, while mating the rest of the purebreds to the desired crossing bull to provide replacements for the crossbred part of the herd. Reducing the number of purebred animals necessary can be reduced by using sexed semen, which is currently permissible in organics as long as separation is by physical rather than chemical means. Alternatively, continuous rotational crossbreeding strategies could be used instead, or even producing a composite breed. A two breed rotational cross maintains 67% of the direct heterosis, while three breed and four breed crosses maintain 86% and 94% of the direct heterosis, respectively. The problem is to find several breeds of suitable merit that the crossbred population is better (economically) than the purebred population.

Table 3. Levels of individual heterosis expected in continuous and discontinuous systems of crossing

Crossing system		Direct heterosis
Discontinuous		
F1	AxB	100
F2	(A.B)x(A.B)	50
Backcross	Ax(A.B)	50
3-way cross	Ax(B.C)	100
Continuous		
Purebred	A	0
2-breed rotation	Ax(B(A(B(A.B)etc	67
3-breed rotation	AxC(B(A(C(B.A) etc	86
4-breed rotation	AxD(C(B.A) etc	94

After Simm (1998).

There are some estimates of heterosis effects for milk production traits and rather fewer published estimates for other traits, such as health, fertility and survival. Heterosis estimates from the review of Lopez-Villalobos (1998) are presented in Table 4. Averaged over six studies, the advantage in milk yield for a Friesian-Jersey cross is 5.1% greater than the expected average parent performance.

There are very few published estimates on heterosis effects for health and fertility traits. Most diseases and measures of reproductive performance have low heritability estimates (e.g. Pryce *et al.*, 1997; Kadarmideen *et al.*, 2000). The low heritability could indicate that the trait is under the control of largely non-additive genetic effects, e.g. dominance plays a major role. In the review of Lopez-Villalobos (1998), the average estimate of heterosis for days open is –5.8% (11 studies), so days open is shorter in the crossbred population than the parent average. There is evidence that Jersey–HF crossbred cows survive better than the parental breeds with the crossbred cows exhibiting up to 5% heterosis in survival from one lactation to the next (Harris *et al.*, 1996).

Table 4. Heterosis estimates for production traits

		Lactation yield % heterosis			Composition	
Breeds crossed	Number of studies	Milk	Fat	Protein	Fat %	Protein %
Hol x J	6	5.1	7.8	6.3	1.3	
Hol x A	9	4.2	3.1	4.0	0.2	-3.3
Hol x G	3	8.1	8.5	4.7		
Hol x BS	4	5.6	6.55	7.8	-0.7	0.3
J x A	3	6.0	6.4	6.1	0	
J x BS	1	5.6	10.1		2.8	
A x BS	2	1.7	1.65	0	-0.6	1

Hol: Holstein; J: Jersey; A: Ayrshire; G: Guernsey; BS: Brown Swiss
After Lopez-Villalobos (1998).

Introducing new genes by crossbreeding

Recent advances in molecular biology allow the identification and location of individual genes, or other sequences of DNA, on the chromosomes. In the short to medium term, the main benefit of these new techniques is likely to be in assisting conventional selection programmes. Genetic markers for the gene of interest can be used to aid selection programmes as it is possible to select animals that have a desired gene controlling a characteristic of importance, this gene can be deliberately selected for and hence passed down from generation to generation. These techniques are likely to enhance conventional selection, especially for traits that are difficult, expensive or time consuming to measure (e.g. sex-limited traits, disease resistance traits). Examples of a single gene that affects all of, or part of, a trait of interest in cattle are polledness, resistance to a disease, or casein type and thus milk processing characteristics. However, the breed that is being used may not have a particular gene.

The EU Regulation on Organic Livestock Production allows dehorning and disbudding on animal welfare and safety grounds. Currently, all the biodynamic organisations (in German speaking countries) prohibit de-horning and disbudding. But in most other European countries the interpretation of this regulation has been that disbudding is acceptable. Asingle gene controlling polledness does not occur (in normal circumstances) in the commercial Holstein breed. It does, however, exist in the British Friesian. Introducing the polled gene to the Holstein would mean that calves would not have to be dehorned or disbudded, thereby removing a stressful procedure. The polled gene is a dominant gene to the horned gene and therefore carriers of the gene will be polled. The British Friesian is said to be (PP) for the polled locus and the Holstein is assumed to be (pp). The polled gene in cattle located on chromosome one (Brenneman *et al.,* 1996). Georges *et al.* (1993) have mapped microsatellite markers for this gene.

Table 5 illustrates a breeding programme whereby a polled gene is introduced into a horned cattle population. First, the donor line containing the gene to be introgressed (polled) is crossed with the recipient line (horned). This demonstrates how the donor parental contribution is reduced by 50% in each successive generation of backcrossing.

Table 5. The use of introgression to introduce a polled gene to a horned breed (Nicholas, 1996)

Generation	Mating program		Average proportion of genes from HF in polled offspring
0	Polled	× Horned	
1 (Backcross 1)	Polled offspring	× Horned	$1/2 = 1 - (1/2)^1$
2 (Backcross 2)	Polled offspring	× Horned	$3/4 = 1 - (1/2)^2$
3 (Backcross 3)	Polled offspring	× Horned	$7/8 = 1 - (1/2)^3$
T			$1-(1/2)^t$

Assuming an initial breed difference of 1,000kg of milk between the two breeds and a 1.5% rate of genetic progress, the introgression procedure to introduce the polled gene into the Holstein population would be completed after 16 years (4 years per generation, 3 backcross generation plus intercross). Homozygous bulls would be produced, so all offspring would be polled. The predicted genetic merit of bulls would be around ~ 7,240 kg at the end of the introgression scheme. The genetic merit of the rest of the commercial Holstein population of bulls would be estimated to be ~ 8,060 kg at this point. Based on the difference in milk yield between the commercial and polled population, the introgression population is just over 11% (for kg of milk) behind the commercial population. This genetic lag estimate does not account for the substitution effect of the polled gene (Wall *et al.,* 2000). The genetic lag with an introgression scheme that has two backcross generations is slightly higher at 12% (7,670 kg in the commercial population versus 6,840 kg for the introgression population). Assuming a rate of genetic gain per annum of 1.5% in the pure-bred British Friesian bulls, it would take 21.5 years of selection on milk yield to get to the 7,240 kg (equal to that of homozygous bulls post introgression). Although still lagging behind the commercial population the substitution effect of the polled gene may out weigh this difference. Ultimately introducing the polled gene into a population is a "welfare-friendly" strategy.

Conclusions

The size of the Holstein population around the World means that this breed will continue to be dominant and make the greatest genetic progress in terms of milk yield than any other breed. Yet, the growing importance of hidden costs, such as increasing health and fertility problems with rising milk yields may make a niche for other breeds and cross-breeds. This is particularly true in organic systems, where the cost of disease is expected to be greater than conventional systems. However, even for organic systems, remaining competitive in terms of production is still important, so selection will still need to include milk yield. The 'right' choice of breed or cross for an organic farm is virtually impossible to determine as a lot depends on individual farm circumstances. But regardless of the choice of breed or cross using selection tools, such as selection indices that consider a broader range of traits will make the selection decision easier. Adding in an ethical value for welfare traits is a major challenge, but should not be overlooked. Neither should modern methods of gene tracking as a means of introducing otherwise difficult to select for genes into a population. The cost of introducing the polled gene into a population may appear to be unsustainable, but will the organic consumer accept de-horning in the future?

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Family breeding at Rivelinohoeve

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Introduction

With the growing influence of the experimental sciences, breeding has largely become a technical, numerical assessment of a cow. This (limited) method of observation and study has had both positive and negative breeding results. The introduction of artificial insemination, for example, has resulted in a genetic erosion of available breeding stock. The large-scale adoption of embryo transfer (ET) by breeders will further accelerate this process. Before long, the abbreviation ET will be appended to the names of most breeding sires. Moral objections also exist against these developments.

Organic farmers are interested in breeding programs, which are better adapted to the main goals of organic dairy farming, such as animal feeding without concentrates and good lifetime production. Therefore, professor Bakels developed another breeding scheme, which integrated these goals (Bakels and Postler, 1986; Postler, 1990). Organic farmers are also interested in a more natural way of breeding without the use of artificial techniques, such as deep freezing of sperm and embryos or the use of hormones for synchronised ovulation. Organic farmers are also interested in a breeding techniques that take into consideration the interaction of genotype and environment.

In the mid 1980's, Ton Baars met the breeder of Dutch-Friesian cows Dirk Endendijk (Baars, 1990). Endendijk was famous as a cow breeder with a specific personal opinion about breeding goals and breeding strategies. During several years he was the top milk producer according to the milking records in the Netherlands, with cows producing over 10,000 kg milk per lactation. However, Endendijk did not follow the system of Holstein breeding, as most Dutch dairy farmers, but reached this production with the original Dutch Friesian cattle that was almost wiped out by the introduction of the Holsteins.

Another point of interest was that Endendijk had a system of breeding based on natural service in stead of artificial insemination.

Biodynamic farmers have shown interest in the breeding system of the conventional breeder Endendijk, because of the closed system of breeding. The handling of this breeding system does fit very well in the spiritual concept of biodynamic farming. Biodynamic farmers realised that the system of breeding practised by Endendijk could be a translation of the concept of 'farm-individuality'.

Endendijk's breeding system is centred around the unique characteristics of the individual farm. His method of observing and breeding may therefore be particularly interesting for organic farmers, who ideally should formulate their own breeding goals. Currently, most organic farmers still buy breeding stock from conventional AI organisations, simply because there does not seem to be an alternative. The authors of this paper argue that the reason for this apparent lack of alternatives is rather a lack of clear vision on 'organic breeding', and therefore an alternative breeding system can not be established. In this paper, the authors review the literature for categorisation of breeding strategies and describe the system of family breeding on Endendijk's farm as a potential alternative for organic dairy producers.

Background on breeding strategies

Hagedoorn (1927 and 1934) distinguishes three categories of breeders and users per breed of animal. In practice, the distinction between the categories is not always clear. The first category is a fairly small group of breeders, who know the breed they use very well and constantly work to maintain or improve the quality of the breed through continuing breeding selections and family breeding. The quality and consistence of the breed depends on these 'elite breeders'. They are breeders in the true sense of the word. They have an ongoing but exclusive supply of top-grade male breeding stock, and so their influence on the quality of the breed is much greater than one would expect solely on the basis of the number of animals bred by them. In other words, their influence bears no relation to the number of animals, which they provide for the breeding programme.

The second category of breeders is much larger than the first. These breeders produce herdbook animals, using male breeding stock produced by the first group of breeders. Continued use of these sires ultimately results in a very high overall quality of the breed. Some herdbook breeders might, after a time, feel confident enough to start making their own selections and to breed with their own male breeding stock, effectively moving up to the category of elite breeders. The role of breeders in this second category, the 'herdbook breeders', is to provide a large number of good male breeding stock for the third category in the breeding cycle, namely the 'users' of the breed.

Anema (1950) described three different breeding methods:

1. Pure breeding: this occurs when male and female animals from the same breed are paired.
2. Family breeding: in this method, the breeding animals are related to each other in some degree. They have one or more fairly closely related predecessors.

3. Crossbreeding: this occurs when animals from different breeds are paired.

Family breeding is a broad concept referring to a method, which, in essence, perfects the method of pure breeding. Anema made a further distinction based on the degree of kinship:

a. Inbreeding, in which parent animals are paired with their own offspring, brothers with sisters, or half-brothers with half-sisters.
b. Next-of-kin breeding, in which parent animals are paired with second generation offspring: uncles with nieces, aunts with nephews, nieces and nephews.
c. Moderate family breeding or kin breeding, in which the paired animals are more distantly related.

In his thesis about breeding in small populations, De Roo (1988) also concluded that a system with a larger amount of male animals could overcome a high level of inbreeding.

Data collection on Endendij's system

The breeding strategy of the farmer was analysed in a retrospective way by means of in depth interviewing. The interviews were recorded on tape and analysed afterwards. During the analysis, new questions about choices, breeding goals, etc. were raised and in the next interview the farmer was asked again about these issues. Facts were written down out of the memory of the farmer and the farmer was treated as an authority. The farmer's experience was gathered first and literature about family breeding was used as a reference.

For the farmer the way of breeding had become a system, which he applied every day. For the researchers, the system was unclear, because we did not understand the farmer's daily choices. In the interviews the farmer was repeatedly asked about his motives in his breeding choices.

The pedigrees of all animals on Endendijk's farm were known. The researchers attempted to understand the farmer's thinking by the analysis of several pedigree lines. However, the researchers' knowledge on breeding was based on "conventional" breeding practice and the role of mainly male animals (Sires indices). At the beginning of the study, this led to a misunderstanding of the fundamental principles of the family breeding system. A new thinking was necessary to understand this way of breeding based on the interaction of genetics and environment.

Endendijk's breeding system

The vision of an experienced cow breeder: appearance of the cow

An (elite) breeder must have an idea, a conviction, of what the ideal cow should look like. Endendijk's ideal dairy cow belongs to the Kate family bred by Meekma Jr. (Anonymous, 1967).

"I found out what my ideal cow looks like at Meekma's in 1962. This image is continually in my mind. The Kate family had unusually many good characteristics. At the time, they were the best, most efficient cows in the Netherlands. Many of their characteristics were already pure-bred. Their pure breeding stemmed from the sire Leentjes Adema, who also sired Kate 47. Leentjes Adema was an inbred bull that almost always produced excellent cows. Kate 47 was a linchpin in the breeding process: she was strong, yielded a lot of milk, and aged well. It was Meekma Sr. who bought her."

Endendijk also values a cow with a balanced build and good character.

"A balanced build is important in breeding. The different parts of the body should be in proportion with each other. Many Holstein cows are not harmonious. Often, they're too pinched behind the forelegs; they're too slim up front. This often goes hand in hand with a poor positioning of the forelegs and feet. I firmly believe in harmony. It's important to strive for a harmonious build, because one shortcoming is linked to another. And of course, like every farmer I want cows with good udders. I want well-tempered cows that grow easily, calve easily, cows that are fertile. In short, I want smart, lively cows. It is hard to distinguish this from other breeding goals. I want a cow that I can work well with in practice; it should be tame, shouldn't kick, have healthy feet and a good appetite. Every farmer knows about the importance of these good, practical characteristics, but you won't find them in any book, let alone a sire list. Of course milk yield is a primary goal, we all milk cows for a living. So yes, they should milk easily, too."

The vision of an experienced cow breeder: high milk yield

Endendijk has a clear idea of how a high yielding cows looks like.

"You can tell a high-yielding cow by its suppleness; a good dairy cow has a very thin hide. The hide is wrinkled on the forehead, with skin hanging over the eyes. The cow also has thick milk veins. A high-yielding dairy cow has small veins running from the point where the milk vein leaves the belly to its forelegs. A cow that enjoys being milked will give more than a grumpy cow. That, too, is a genetic quality. There are at least ten characteristics which impact on milk production. The best dairy cow will have all these characteristics. It will be a good eater, persistent and keen to give milk. This is related to the size of the pituitary gland, the amount of growth hormone produced by the cow. In short, milk production is not a sum of indices. Pairing a cow and a bull that both have a negative index could still result in a daughter that gives 10,000 litres per lactation."

The vision of an experienced cow breeder: lifetime production breeding

Endendijk has a clear vision of the significance of lifetime yield.

"The idea of breeding on the basis of lifetime production is not a bad one at all. You'd be including all the good characteristics such as high fertility, good udder, strong feet, manageability, simply because a farmer wouldn't put up with a cow for twelve years if it didn't have these characteristics. Animals bred for a high lifetime production have to be tough and strong in their legs and bodies. However, lifetime production should not become a goal in itself, it should be seen as a means of assessing vitality."

Endendijk assesses whether cows are early or late maturing by looking at what the cows do between their second and their fifth year.

“Are they still growing and developing, both in height and bulk? A cow that stops growing soon starts collecting fat. That has nothing to do with having a dairy build or beef build. A heifer should be a heifer. It's wrong for animals to mature early. But don't get me wrong: muscle bulk is not necessarily related to early maturity. And a big, dairy type cow is not necessarily late to mature.”

The vision of an experienced cow breeder: positive and negative selection
Endendijk wants to be able to make positive choices in his breeding strategy.

“The art of breeding is selecting animals yourself. On many farms, particularly those with free housing, selections are decided by the housing. That's a form of negative selection. I have a housing system that enables me to do the selecting myself. All female calves are kept on until they're heifers. The selection process is concentrated in the heifer stage, after one or two recorded lactations.”

The vision of an experienced cow breeder: direct and indirect characteristics
In his choice and selection of cows, Endendijk focuses on direct characteristics as opposed to derived or indirect characteristics.

“You should breed directly towards your goal, avoid detours. It is stupid to reason that a large cow gives more milk, therefore we must breed for size. If your goal is a cow with a large appetite, then you shouldn't be surprised if you end up with large cows. Why breed long cows? Because they score well at shows. But a cow's length is not related to milk yield. A short cow gives just as much milk. In the Netherlands, breeders have wasted too much time breeding for useless characteristics, a certain straight line or height, generally fairly unimportant (show) characteristics.”

Selection for indirect characteristics is partly due to show judges having a wrong ideal image of the cow. This has resulted in breeding programmes being dominated by unimportant characteristics. On the other hand, there is often insufficient knowledge to determine which characteristics really are important for selection and shows.

Towards a farm-specific breeding system
A closer look at breeding reveals that breeding consists of two phases. The difference between the two phases is related to two of the three types of breeders as distinguished by Anema, the users and the elite breeders. In the start-up phase (phase 1), Endendijk uses elite breeders' sires. In his case, he almost exclusively used descendants of Meekma Jr.'s herd, the Kate family. After five to seven years, Endendijk gradually started using the Rivelino sires that he bred himself, and he too started providing bulls to other breeders. In this second phase, his breeding efforts are focused on maintaining and improving the breed. Endendijk has thus become an elite breeder himself.

Phase 1: user
Endendijk describes how he got started.

“You don't necessarily have to start with the best breeding stock. The way I started, by introducing Kate blood, just gives faster results. It's a way of benefiting from all the work that those before us have done. Pure-bred animals are not an essential precondition, but results come a lot faster by taking a sire from a good family and from a farm with livestock that appeals to you. On the female side, choose a good, old family with a breeding history going back at least 100 years: cow families from the old herdbooks. Then buy one or two sires and have all your cows served by them. And have your heifers served by a bull from that family or at least a closely related relative. After two generations your farm will boast progeny from two strong lines, on both the mother's and father's side. Some of these will perform especially well in the conditions and system of your farm. Of this generation, keep one bull calf which you can later use to serve some of your cows. Not all of them, just five or ten. If that yields good results, take another one of those bull calves. Before you know it, you've got four lines. That's when you can start expecting more stability in the quality of cows produced by your breeding programme."

Phase 2: the elite breeder

The transition from phase 1 to phase 2 is not always distinct. A phase 2 breeder becomes increasingly focused on using his own bulls. Many of Rivella 24's sons and grandsons (progeny) have been used in Endendijk's programme. Endendijk describes this process:

"After Rivella 69 I also used sons of Rivella 24, so that crosses between half-siblings do occur, though not as a rule. One such cross, with heifers for example, won't have really dramatic consequences."

The result of this is that Rivella 24 can be traced back 1-2 times or even 10-15 times in the lineage of almost all 60 dairy cows and heifers on the farm in March 1987.

Each year, Endendijk uses five to ten own-bred Rivelino sires:

"I have the lineage in my head right from the start: five to six generations of my own-bred animals. It's not really all that important; the further removed the lines, the less their influence. Parent animals have the greatest influence, the rest is just indulging in a hobby. It's enough to select the cows that perform best on your farm and select your bulls from these cows."

Bulls are taken from several cow families. All in all, there are about 15 different cow families on Endendijk's farm. The bloodlines are not all proportionately represented, as lactation data collected in March 1987 revealed. The animals are related because of pairings between the different lines.

The art of painting

Endendijk sharply condemns the large-scale use of some AI bulls:

"If you have a really good bull, you should kill it young. It doesn't matter because if a bull is truly outstanding, his daughters will be, too. And those daughters will produce more good bulls. Breeding is like painting. It makes no sense to fertilise 300,000 cows with the semen of one bull. No matter how good the bull is, you should never do that. A few thousand cows at the most. By producing more daughters, you're just reproducing more of what you already have. It's like making a copy of Rembrandt's Nightwatch.

It might be beautiful to look at, but it doesn't add anything to what's already there. You have to use a lot of bulls. Bulls are a breeder's paints. If you stop using bulls, you stop making art. You have to breed so that your herd has all possible qualities, then you'll be able to go on breeding forever."

Blood refreshment and improvement

Endendijk emphasises the need to introduce new blood into family breeding systems.

"A breeder like me is always bringing in fresh blood. Breeding is the practice of consolidating good qualities and introducing new ones. Of course, there comes a time when it is hard to achieve more improvement. At this stage, my lines are so good that I'm not introducing a whole lot anymore."

Endendijk's method to improve his breeding stock is to buy new animals - usually female - which bear all the characteristics of his cow type. He describes his choices:

"I prefer to introduce fresh blood through cows. It enables me to test the cow, to see whether she really is good. By buying an unknown cow, you bring in characteristics which you didn't yet have. It gives you an opportunity to compensate for weaker characteristics."

In March 1987, Endendijk bought a six-year old cow from a farm in Friesland:

"That animal has an enormous barrel. I mated her with one of my own bulls, then mated her daughter with one of my own bulls again, so that there's own blood in both parent lines. If I can introduce the original cow's fantastic body structure into the herd, well then I've managed to get a new characteristic that my herd didn't yet have."

Endendijk will only use a bull from a new family if the descendants of the bull have double Kate blood:

"I've always followed this principle, and it has done me well. If the bull is good, then I'll use it for mating."

Rivelino 37 and 148 are good examples of 'double' bulls bred by Endendijk himself from bought cows. Meekma Jr.'s Rivella bulls are characterised as pure-bred Kate bulls, meaning that they have at least double Kate blood.

Young bulls for breeding

When the breeding records were studied, it was noted that yearling bulls crop up regularly in the different pedigrees. The qualities of these animals have not been established beforehand. Endendijk clearly prefers to use yearlings:

"In my breeding programme, and in breeding in general, using yearling bulls is the fastest way to get ahead. I don't know why young bulls work better than older bulls. Of course, some older bulls do produce really good daughters, it's never as straightforward as all that. Klaas Meekma was well aware of young bulls' quality too. Rivella 24 and Rivella 39 were outstanding animals, and both yearlings. This rule doesn't only apply to bulls, but to heifers as well. Rivella 24 and 39 were both produced by heifers. In hindsight, heifers always give the best results."

The best cow, dams of bulls

Endendijk describes his method of choosing the dams of bulls.

"You shouldn't take a cow who just happens to be good, a cow with nothing special in her pedigree. You have to use cows from a good cow family. The definition of 'best' encompasses a lot more than milk yield alone. There are all the other characteristics too. You should focus all your efforts on that one supposed peak, since we don't even know if it is the ultimate peak. You have to see the animal as a whole, in all its facets. Not one cow or bull is perfect on all scores. The goal of breeding is to get the animals you want. The best animal is that animal with the most good characteristics. In effect, it's an all-round animal. I have no trouble using a bull from a cow with a lactation value of 100, if she calves easily, is easy to manage and so on. To keep things practical, imagine having to select the five best animals of your herd. The best milking cow may not be among them, since she might be such a bitch that you don't want to breed with her. And you wouldn't want her either if her udder was bad, or her legs, or if something else was wrong with her. It's about a tolerance threshold, and it's different for every cow. You have to pick those cows you'd keep longest if you had to reduce your herd from, say, 50 cows to 5 cows. You'd keep the cows you're fondest of: good milking cows, strong legs, healthy tame cows who never ail anything... They'll always have a good milk yield, otherwise you wouldn't be that fond of them, but they might not be the best milking cows. If a cow is a natural milkier, you tend to be more patient with them. The ability to let down milk, to want to give milk, is an important factor."

"A really fertile cow with a low milk yield is not going to be your favourite cow. And you won't be wild about a cow who gives a lot of milk but always has some problem or other. So, take your bulls from the five dairy cows that you'd keep if you had to do away with the rest of your herd. Those cows will have a good yield, though not necessarily the best yield. But they will be the best all-round cows. Farm individuality and differentiation is a result of my neighbour making different choices than me."

Choice for the right system

When studying different pedigrees in Endendijk's breeding records, one always wonders why a particular cow was mated with a particular bull. The answer is rarely profound. The match usually concerns a yearling bull that had just come of age to serve a cow. It's rarely a match based on careful selection:

"The system is of primary importance. The bulls are only part of the system. Many farmers think that breeding is all about finding that one special bull. It's not. You study pedigrees retrospectively. You don't go planning it. It's important to figure out which are good families and then you go and breed with them. You can sit down and write out the genealogical line sometime, sure. And there's bound to be bulls in that line that didn't live up to expectations. But success is created by the system, a system that is hundreds of years old. Bulls aren't successful, their families are. People have forgotten that. Everyone's focused on that one bull now: that unique, excellent special bull. But if you choose a good family, good progeny follows automatically. Breeding is really so simple, but it's been made into a science. You just have to stick with good families, use the bulls from those families."

Endendijk's breeding system is ultimately about perfecting the Kate cow:

"In theory, I have all my cows served by double Kate bulls. The more Kate blood in both parents' lineage, the more the cows will look like each other. Improvement is realised by introducing Kate blood in new cows, so that they can pass on the desired qualities. I'm always trying to reach a higher level of pure-breeding in a new line. I try to get cows pure-bred for more and more qualities, while omitting undesirable traits."

The advantage of this system is that the animals are selected for outstanding performance in a particular farming system. The qualities of the animals are reinforced by the system:

"I like to have cows who do well on my farm. It's great, of course, if they do well on other farms too, but my primary concern is that I have to make my living with them. I have to have efficient cows that are easy to work with, cows with a good yield, a good appetite, a good food to milk ratio, tame, obedient cows."

Farmer group as the gene pool for Dutch Friesian breed

As other farmers in the area have modelled their farms on Endendijk's housing and breeding system, his farm has become a prototype or a model farm. At least eight other farmers built the same cow housing and decided to keep the animals indoors the year round. Family breeding on closed farms has today become the basis of maintaining the original Dutch Friesian breed (Fries-Hollands) by some 17 farms, who more or less maintain the principal of family breeding within their own herd. Together they function as a gene pool for the FH-breed. This farmer group meets twice a year and discusses their choices and the strong and weak points in their herds.

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Swiss experiences on practical cattle breeding strategies for organic dairy herds

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Introduction

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. This paper will give an overview over the situation of organic cattle breeding in Switzerland for the last twenty years.

Background to the organic dairy breeding project in Switzerland

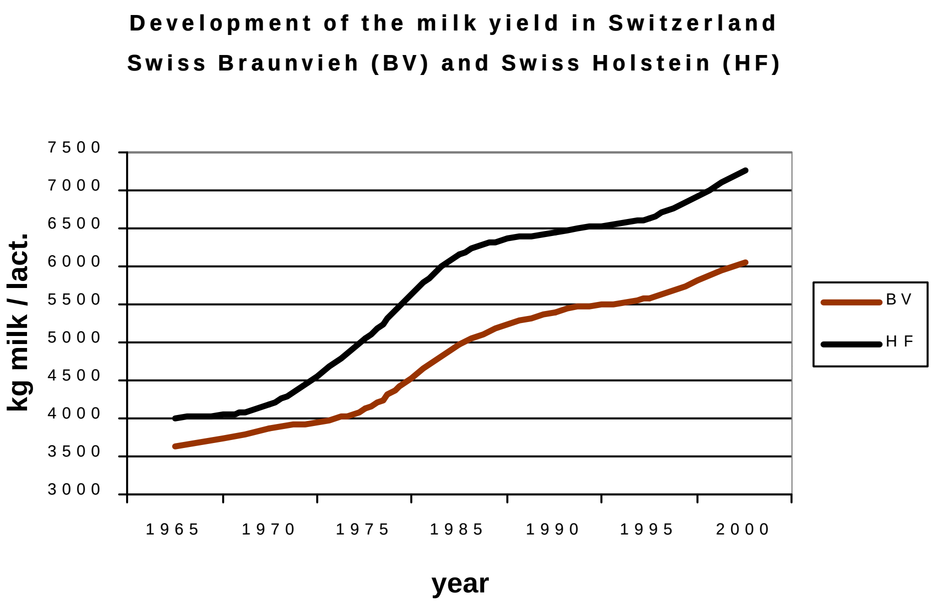
In the middle of the eighties, an adviser for organic farmers founded a federation with the aim to develop a line breed for dairy herds according to the model of Professor Bakels. A few farmers and other interested people were members of this organisation. They wanted to realise this program with Swiss Braunvieh. They chose several unrelated lines with high longevities and good milk performances and started pairing the lines in a strict rotation.

The project had little success as breeding organisation gave inadequate support to the effort. Another reason for this failure was the poor organisation of the pressure group. The group was dissolved in the early 1990's.

No further developments for orgnaic breeding programme took place, and each organic farmer had to find his own solutions to breeding strategy. During this period, the conventional breedin aims became increasingly one-sided. The singular aim was to increase milk yileds and, fat and, especially, protein content of milk. Functional traits according to the definition of an EAAP-working group (Groen et al., 1997) were considered, but had very little real impact.

In Figure 1, the development of the milk yield of Swiss Braunvieh (BV) and Swiss Holstein (HF) in Switzerland is demonstrated. Figure 2 shows the decrease of the length of productive life of cows in Switzerland from 1965 to 1989 as a mesasure of the development of the functional traits. Today, the length of cows'productive live is at approximately teh same evel: between 3 and 3.5 lactations.

Figure 1:

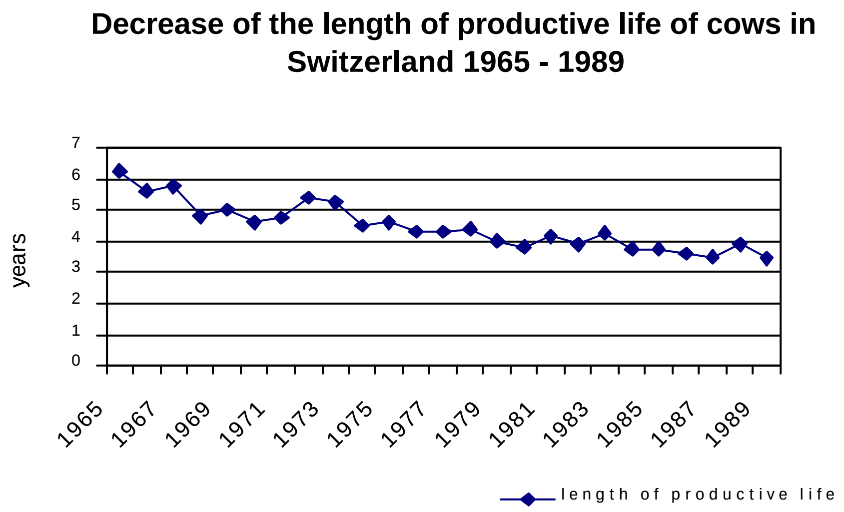


Schweiz. Braunviehzuchtverband, 2001
Schweiz. Holsteinzuchtverband, 2001

In 1995, a rapid growth of orgnic farming began in in Switzerland. The Swiss government started to pay special subsidies for organic farmers. and two big supermarket chains introduced organic food lines, including a lot of milk products, to the market. The number of organic farmers and organic dairy herds increased markedly (Figure 3). Simultaneously, the problems of high yielding, high genetic merit cows under organic conditions became obvious.

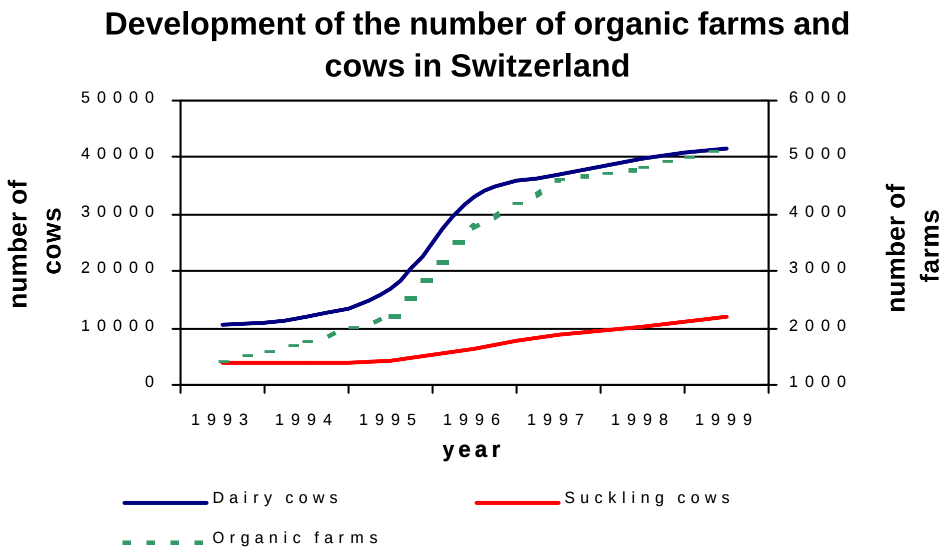
These was the reason for the Bio Suisse (association of Swiss organisations of organic farming) to put the official cattle breeding organisations under pressure to support the growing number of organic breeders. After long discussions, the initiative succeeded. The umbrella organisation of all cattle breeders in Switzerland (Arbeitsgemeinschaft Schweizerischer Rinderzüchter), Bio Suisse and FiBL (Research Institute of Organic Agriculture) decided to fund the introduction of a total global breeding value that was to be developed especially for organic breeding. A working-group was established for each breed (Swiss Braunvieh, Red and Whites and Swiss Holstein). This group is responsible for the development of the ecological total breeding value.

Figure 2:



Gazzarin, 1990

Figure 3:



FiBL and bio.inspecta, 2001

Ecological total breeding value of Swiss Braunvieh

Ecological total breeding value is a total global value for sires. In the conventional breeding systems, the main part of a total breeding value is made up of performance traits. Table 1 shows the difference between a conventional and an ecological total breeding value. It shows the current models of Swiss Braunvieh in Switzerland

Table 1: Opposition of conventional total breeding value and ecological total breeding value by the example Swiss Braunvieh (Schweiz. Braunviehzuchtverband, 2001)

	Conventional	Ecological
Performance traits	57 %	24 %
Functional traits	43 %	76 %
Total	100 %	100 %

Table 2 demonstrates the breakdown of the performance and functional traits of the ecological total breeding value. The model is designed after a similar index model of the South of Germany (BLT Grub, 1996).

Table 2: Ecological total breeding value of Swiss Braunvieh in Switzerland (Postler and Bapst, 2000)

Position	Weight in %
Breeding value milk (quantity)	8
Breeding value fat (quantity)	7
Breeding value protein (quantity)	6
Breeding value protein (content)	3
Breeding value persistence	8
Increase of the milk performance (1.-3. Lactation)	8
Breeding value longevity	20
Breeding value of the rate of living calves at the birth	2.25
Breeding value of the period from calving to the next successful insemination (service period)	3.75
Breeding value cell count	9
Breeding value type traits	25
Total	100

In the index, the persistence of lactation is considered important for organic dairy production. 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.

Another new position, taken into consideration when creating the index, is the increase of the milk yield from first to third lactation. It is considered that a cow in the first lactation should not produce high yields because it is still growing and needs to get in calf for the second time. Some older studies show that cows with good longevity have not low in the first and second lactations (Essl, 1982). This value isn’t yet thoroughly researched and needs further investigation.

The position type traits consider the positions of bull in relation to a good influence on health and longevity (type 20%, legs 35%, udder 30% and teats 15%).

This total breeding value was introduced in the autumn of 2000 for the Swiss Braunvieh in Switzerland. For the first time, bulls with an ecological total breeding value were included in the bull catalogue of the largest Swiss breeding company. Currently, this company offers a selection of 57 sires with ecological total breeding value. Twenty three of these bulls have a value that is above the average ecological total breeding value (SVKB, 2000). However, as the current organic regulations of Bio Suisse forbid the use of sires from embryo transfer lines (Bio Suisse, 2001), only 13 of the 23 top bulls are eligible for organic producers.

For the other breeds, Swiss Red and White and Swiss Holstein the introduction of the ecological total breeding value is planned during the next year. Of course the models must be adapted to the particular characteristics of the breed.

The Swiss ecological total breeding value is a good aid to preselect the current sires of the genetic companies. When pairing the farmer of course has to consider strengths and weaknesses of the particular cow and bull and has to pay attention to the corresponding positions.

Future

It is envisaged that this introduction is only a first step in the development of organic breeding strategies for Swiss dairy farmers. Currently, the suitable sires were all selected from conventional stock of breeding companies, and the choice is only partly adapted to organic farming. In the future, this anomaly should be eliminated by special pairing according to organic husbandry.

In the South of Germany, a project for the White and Red cattle has now been initiated (Enzler, 2001). Such projects are only successful when a great number of breeders are ready to use the test bulls in order to obtain reliable result of the progeny test (about 70 daughters of one sire are needed). The requirement for adequate test numbers mean that these tests are very expensive, especially for small breeding companies. A solution for this problem could be a collaboration with breeding companies in other countries. This would obviously be appropriate for organic farmers with similar extensive milk production systems as in Switzerland, Germany and Austria.

The development and the introduction of this ecological total breeding is dependent on the acceptance of the service among farmers and the demand for sires with good ecological total value breeding values.

In Switzerland, four main issues for development to guarantee the success of the project have been identified:

- Breeding is a long term process. Success and failure is evident only after years. Therefore, it's difficult to win farmers trust to a new breeding strategy. Monitoring and documentation of the results of the project in needed to produce data that will convince farmers of the advantages of the system.

- Conventional dairy cattle breeding aims at high yields, and functional traits appear to have little importance. Cattle shows, newspaper articles and discussions of the farmers themselves emphasise this view. The support of breeding companies and associations is important as a lot of organic farmers are also breeders. The support of organic certification bodies is also needed. It's also important to organise events for breeders with organic breeding ideas, where they have the possibility to present their success.

- Until recently, the market for organic cattle has been small, and organic farmers have had problems to sell animals with low potential for milk yields. With the new Swiss organic regulations (BioV, 2000), organic farmers have to buy their animals from other organic farms. This will open new markets for organic breeders. At the moment in Switzerland, there are several attempts to build networks for selling organic animals.

- In general, breeders are very interested in following new genetic trends and taking on new sires recently introduced in the catalogue. Sires with a high ecological total breeding value are not new sires in the catalogues, as several traits (longevity and increase of milk performance) need evaluation during two or three years. Educational effort is needed to change the practices the organic breeders in regard to new sires, that have not acquired the ecological total breeding value yet.

The Swiss experience shows that it is possible to develop a good breeding programme for organic dairy breeders. The experience also shows that acceptance of such a programme by farmers is complicated by many factors. For breeders to embrace breeding programmes that address organic objectives, it is important that there is a strong collaboration between farmers, breeding companies and organic sector bodies, aiming at development and adoption of such programmes.

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Breeding strategies in poultry for genetic adaptation to the organic environment

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Introduction

Organic table bird producers have to rely on many of the production factors also used by the conventional egg producers. One of these factors is the breeding stock, and this is not unproblematic. Unlike other farm animals, the laying stock is bred almost entirely in large trans-national commercial companies. There are only a few of them left (<5), and they operate in all regions of the world.

Similarly, world wide, the majority of farm based egg production takes place in battery cage system, and, therefore, the breeding goals of these trans-national breeding companies are aimed at hens that are able to produce high numbers of eggs in cages. Although half of these poultry breeding companies have some of their activities in Europe, they have so far paid little attention to the special needs of hens for organic egg production, mainly because it is a small part of their business. These cage-adapted hens may be able to produce many eggs in the organic system. However, only a few disturbances, often out of the control of the farmer, may lead to disastrous events, like feather pecking and subsequent cannibalism with unacceptably high mortality rates. In addition, the fact that organic diet is less concentrated and is not routinely balanced at factory level, may cause stress for the cage-adapted, small and efficient hens. Further problems are caused by a high number of mislaid eggs on floor, as cage-adapted birds are not good at nesting. If the management and husbandry is not optimised, high levels of infectious or parasitic diseases, not seen in cage systems may hit organic free-range flocks.

The aim of this paper is to discuss these problems and to make suggestions on how to develop breeding stock that is better suited for egg production under organic conditions.

The high yielding hen

Hammond's (1947) proposal that "the character required is best selected under environmental conditions which favour its fullest expression", has to a great extend been followed by the breeders ever since. The statement of Hammond means that the test environment of e.g. laying hens, candidates for being chosen as parents for the next generation of layers, should be the one that maximises the egg production of the individual hen. The most important environmental elements that are usually considered are that:

- the hens should be kept free of infectious diseases;
- the hens should be kept under circumstances in which stress is reduced to a minimum; and
- the hens should be supplied with a sufficient amount of balanced feed.

It is the impression from visits to breeding companies and discussions with their geneticists that the hygienic standard is very high in elite birds, mainly as a requirement from their customer. Also it is clear that the hen has been kept in individual cages for many generations, which implies that their laying pattern has not been disturbed by a social engagement to establish the ranking order.

The consequence of all this in terms of genetic capacity is a high egg yielding hen, when conditions are optimal. This means that the hen should be kept in a well-equipped cage system, have free access to a balanced diet, and have a high hygienic standard supplied with a good vaccination program. If these conditions are not met, we must recognise the risk involved in using these hens whose ancestors have:

- not been exposed to infection pressure for many generations and therefore no direct selection for disease resistance has taken place;
- been selected for a high number of eggs laid in individual cages, hence no drive exist for the hen to go to a particular nest for laying her eggs;
- not been disturbed by interplay with other hens during the period they were recorded for egg laying, and, therefore the ability to perform an appropriate social handling of the other hen in the flock has not been selected for at all;
- had free access to a balanced diet; therefore the laying performance is easily affected by non-optimal diet.

We also know that:

- native and local breeds that have not used in selection and the Red Jungle Fowl (the original ancestor of all domesticated hens) seem to have a better genetic resistance against infection, and often they also demonstrate a better defence and escape from predators (experiences from rural area of developing countries);
- the floor laying rate of cage-adapted breeds of laying hens was reduced to half over five generations of selection for laying rate in a floor system with trap-nest (see following section of this paper); and

- when keeping hens of the high yielding breeds from international companies under floor condition in houses or in free-range systems, there are too many cases in which the cannibalism and feather pecking get out of control (see a later section of this paper).

Indication of a G ´ E interaction

The Hammond thesis presupposes that no genotype × environment (G × E) interaction exists. Going through the literature on the subject, there are many different findings, and the main conclusions are that the chance for a G × E interaction increases as the difference between the environments grows and the genetic distance between the breeds is large.

Until 1980, hens were not allowed to be kept in cages in Denmark. Up to that time, some Danish breeding companies used floor systems with trap-nests to record the individual laying of hens as a criterion for selection, one of these was the Skalborg Hen. Already at that time, the large international breeding companies had some parent stock in Denmark, and these hybrids went into the Random Sample Test for laying stock at Favrholm in 1978, when they were still tested in floor systems. In 1980, the ban against hens in cages was lifted, and at a trial at the Random Sample Test at Favrholm, in 1982 the same breeds/hybrids were compared in a newly established cage system (Table 1).

Table 1. Comparison of the Danish Skalborg hen with international hybrids in 1978 in a floor system and in 1982 in a cage system. All breeds of White Leghorn type. (Neergaard, 1978; Neergaard, 1982)

Hybrids	Test in floor system, 1978		Test in cage system, 1982	
	Eggs in 365 days per hen placed	Eggs in 365 days per hen day	Eggs in 365 days per hen placed	Eggs in 365 days per hen day
Shaver	265	274	278	298
Babcock	259	264		
Hisex	264	267		
Lohmann	259	268	276	285
Dekalb			264	292
Average of international hybrids	262	268	273	292
Skalborg	262	267	240	266

In comparing Shaver and Lehman with the Danish Skalborg it is obvious that, in the floor system, the Skalborg is equal to the international breeds. When tested in cages, the international breeds have expressed their full capacity for laying which is 8% higher than on floor, whereas the Skalborg produces at the same rate in both environments.

Looking at the relative difference between the two expressions for laying rate, it was observed that Skalborg had a 5 times higher mortality in cages compared to the floor, while the international breeds had a mortality rate which was 1.5 times higher in the cages. The conclusion is that, although there is no statistical significance in Hybrid × Management interaction, it is obvious that the Skalborg breed is genetically adapted to the floor system, whereas the international breeds are genetically adapted to cage systems.

Yet another comparison of a hybrid (Lohmann Brown) with various breed combinations at a further deviating environment demonstrated that the local adapted breed combination (Sonali) was considerable better than the highly improved hybrid (Table 2). This comparison took place at the Smalholder Livestock Development Project in Bangladesh under semi-scavenging conditions. It is noted that the hens were kept under a free range system, in which they were supplied with about half of the food they needed, while they had to scavenge the rest in the surrounding area.

Table 2. Summary of performance of 8 different breed combinations (Rahman *et al.*, 1997)

Perfor-mance	**Lohmann Brown**	**(A´ R) ´Fa**	**Fa´ AB**	**R´ AB**	**Sonali (Fa´ R)**	**R´ WL**	**(R´ Fa) ´AB**	**WL´ AB**
Age at 1st egg, w.	35	32	32	34	33	32	33	35
Egg/hen Actual	86^{b}	104^{ab}	86^{b}	105^{ab}	119^{a}	97^{b}	86^{b}	99^{ab}
Eggs/hen 12 month	140^{ab}	137^{b}	125^{b}	139^{ab}	156^{a}	128^{b}	141^{ab}	139^{ab}
Mortality %	22.1^{ab}	35.0^{b}	27.6^{ab}	32.6^{b}	16.0^{a}	25.2^{ab}	21.2^{ab}	22.9^{ab}
Supplem. feed, kcal	146^{b}	122^{a}	136^{ab}	144^{b}	130^{a}	134^{ab}	146^{b}	135^{ab}

Figures with same or no superscript in a row are not significantly different
Abbreviations for breed: AB = Lohmann Brown; Fa = Fayomi, R = RIR; WL = White Leghorn; A = Female of the Lohmann Brown.

It can be observed that the Sonali hen is the best or as good as any of the other breed combinations compared. Of particular interest is that the Lohmann Brown seems poorer on laying and mortality and needed more supplementary feed than the Sonali hen.

Laying stock sold by the international breeding companies has a capacity to produce above 300 eggs in 12 months, under optimal conditions placed in cages, fed a balanced diet and using optimal vaccination programmes under high hygienic standards. Results from the German Random Sample tests (Sørensen, 1997a) showed that e.g. Lohmann Brown laid 303 eggs in 12 months.

The production capacity of Sonali tested in an optimal environment like the German Random Sample Test, is unknown, but it will be far below 300 eggs per hen - a bit above 200 eggs is the most likely result. Thus there is a considerable Hybrid × Management interaction or a genetic adaptation to the environment.

Behaviour traits of importance in free range/organic production

When trying to create a production system, which allow hens to move around in large flocks, the following three traits seem important:

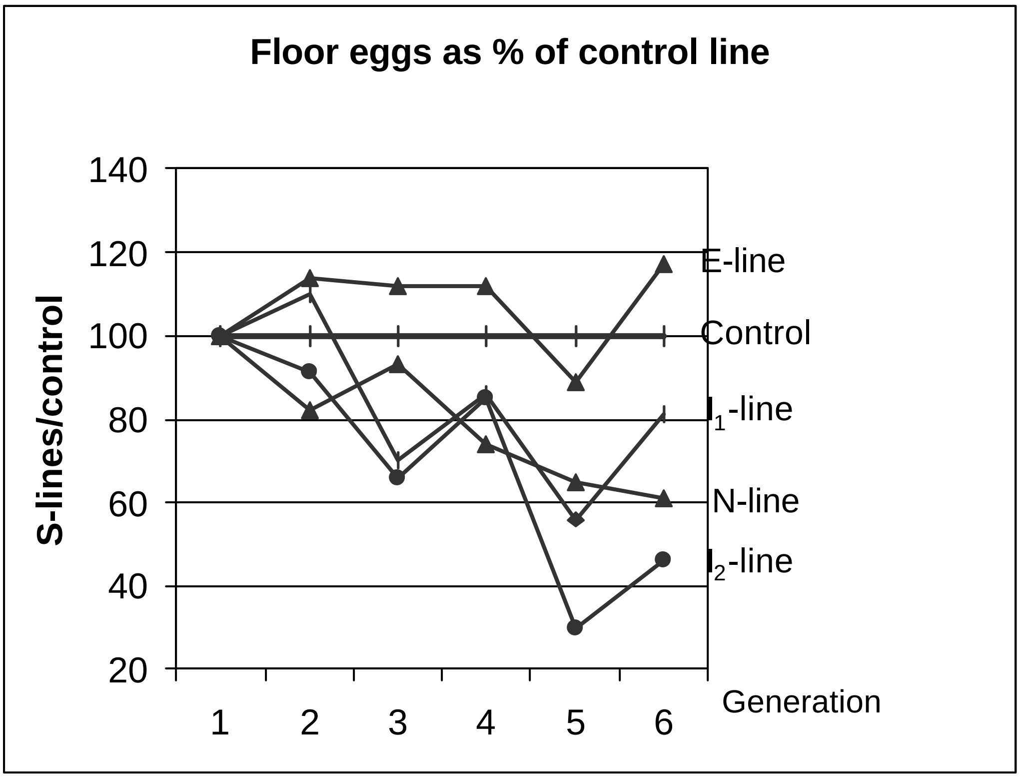
1. Ability to go to a nest before the oviposition;
2. tendency to perform feather pecking against other hens; and
3. tendency to perform aggressive pecks sometimes ending with cannibalism.

These are all behaviour characteristics, which the hens are not exposed to in an individual cage and, therefore, will not influence her egg laying record. However, these three items will always be of importance for a hen in a floor/free range system with many hens and will influence her egg laying record and her chance to be selected as a parent.

In regard to nesting behaviour, some results and experiences from a selection experiment with laying hens in Denmark are presented here. The base population was created in 1969 by a cross of seven international commercially bred laying stock. After four generations of systematic crossing, the base population was divided into five experimental lines, which for the following six generations were selected as

- C-line: control with complete random mating;
- N-line: selected for high egg number to 42 weeks of age;
- E-line: selected for high egg weight at the age of 38-40 weeks;
- I_1-line: selected for an index of high egg number and high egg weight; and
- I_2-line: selected as I_1-line.

Figure 1. Proportion of mislaid eggs (Floor eggs) of the Selected lines as percentage of the Control line, for each generation. Lines N, I_1 and I_2 were selected for high number of eggs laid on the trap nest, while Line E was selected for large eggs.



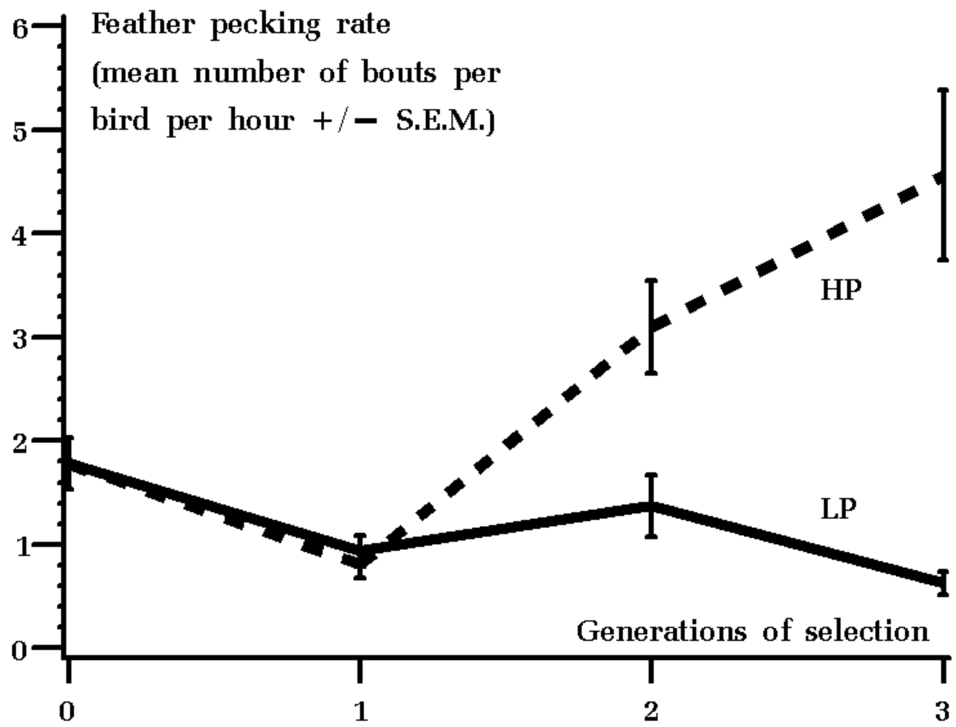
In each of the lines, 400-500 hens were tested for egg laying traits. The hens were kept in floor pens with 30 to 200 hens, and the eggs from the individual hens were recorded on the basis of those laid in the trap nest. (Sørensen *et al.,* 1980; Sørensen, 1992). Figure 1 illustrates the change in frequency of eggs laid on floor for the various selected lines in relation to the control line. The decrease in the curves for lines N, I_1 and I_2 are substantial and could be interpreted that these lines have got a better ability or willingness to go to the nest when laying their eggs and this effect is genetic in origin as these lines has been selected for high number of eggs laid in the nest, while the selection in the E-line was based on egg weight. It was not possible to estimate the heritability, but it is not negligible, as the selected lines have reduced the frequency of floor eggs by 9% per generation compared to the control line. It has to be pointed out that the 7 international laying stock that were the basis for the control line are supposed to have been selected for high laying capacity in a cage system through several generations. The frequency of floor eggs in the control line fluctuated between 10% and 2% during the experiment. The conclusion was that a certain degree of inheritance exists for the nesting behaviour.

In regard to feather pecking, there has been no reports demonstrating that selection for laying performance in individual cages has any correlated effect on feather pecking or cannibalism. On the other hand, there has been so many observations of defeathered flocks of hens and also so many reports of flocks of hens in which cannibalism has been serious in floor/free range systems, that these observations are beyond anecdotal.

In Western Europe, much concern has been expressed about the gentle feather pecking that leads to defeathered hens, but not necessarily to cannibalism. At Hohenheim University in Germany, Dr Bessei has developed an equipment that can be used in large scale to measure the bird's tendency to perform feather pecking. He has recently published this tool (Bessei *et al.,* 1997). At Research Centre Foulum in Denmark, intensive studies have shown that the degree of inheritance for feather pecking is low (h^2 = 0.15), but there is prospect for genetic improvement through breeding and selection (Kjær and Sørensen, 1997). This has been illustrated by a divergent selection experiment showing a considerable effect of selection direct for the tendency to feather pecking over 3 generations (Kjær et al, 2001) (Figure 2).

During the last few years there has been a growing interest in trying to test if there are any genetic variabilities that can be used to reduce cannibalistic behaviour. Among those should be mentioned the work by Craig and co-workers at Purdue University. They have worked with problems related to aggressive peck among hens or as they term it "Beak-inflicted injuries" (BI). They ran a selection experiment based on seven generations (Muir, 1996), in which the birds were kept in group cages with up to nine halfsib related hens in each cage, the criteria for selection was a family based index, which included survival rate. After seven generations of selection, mortality due to cannibalism was reduced to a third of that in the non-selected control line or 17% versus 48%, when tested in 12 bird cages and without beak trimming of the hens (Craig and Muir, 1996). There is obviously a considerable genetic potential in reducing the hens disposition for performing cannibalistic behaviour - though it has not yet been tested if this change in genetic disposition also is in effect when the hens are tested under floor/free range condition. Another remaining question is whether the cannibalistic behaviour, defined by Craig and Muir, is genetically correlated with feather pecking behaviour, as defined by several groups in Europe?

Figure 2. Effect of three generations of divergent selection for tendency to feather peck (HP line for high tendency, LP line for low tendency). Bouts per birds is series of gentle pecks performed without interruption. (Kjaer *et al.*, 2001)



Test of various breeds and breed combination

At Research Centre Foulum, a test of four breeds/breed combinations were performed using: ISA Brown (ISA), New Hampshire (NH), White Leghorn (WL) and the cross between NH and WL (C). The ISA is a hybrid widely used for commercial brown shelled egg production, while NH and WL are pure lines of the respective breeds selected moderately for production characteristics under free range conditions. The combination C is their two-line cross, applying WL as the father, used in small-scale extensive egg production in Denmark. In the laying period, from 113 days of age to the end of the experiment at 300 days of age, the hens were fed an organic diet. Hatching eggs of all genotypes were received from different parent stock farms and incubated and hatched at Research Centre Foulum. Chickens were reared from day old to 16 weeks of age in a conventional stable without access to any outdoor area.

Pullets were transferred to the laying houses at 16 weeks of age. Pullets from several rearing pens were mixed so as to balance out effects of rearing pen. Eight pens were stocked with 30 ISA, 7 pens with 30 NH, 3 pens with 25 WL and 6 pens with 30 C, each. Access to a range area was given at 16 weeks of age. The first 7 days, access was limited to 6 hours in the middle of the day. Thereafter, unlimited access was given. Feed was available *ad libitum*. Water was available *ad libitum* from a water tower provided with an electrical heater in case of frost. Light intensity was approximately 20 lx. Perches, 23-28 cm per bird, 95 cm above the floor, were available and each pen was equipped with 6 single nests (28 cm wide).

The results of laying and mortality are shown in Table 3. They illustrate that the high yielding ISA-Brown performs better than anyone of the other breeds for the first part of the production period. But the birds had an unacceptable behaviour that, in this case, resulted in a high mortality due to feather pecking. The plumage condition at 35 week shown in Table 4 underlines the finding that ISA Brown also had the worst behaviour as was seen from Table 3. Interestingly, the cross of the two breeds seems to perform more feather pecking than the pure line, which indicates a negative crossing effect.

Table 3. Egg production (given as rate of lay, Nos. of eggs, egg weight and mortality), as affected by genotype.

Traits	NH	WL	WL × NH	ISA-Brown	P<[1]
Rate of Lay, %	63.2[c]	72.4[b]	69.2[b]	84.6[a]	0.0001
Rate of lay, during January	54,2[c]	67,2[b]	61.4[bc]	81.4[a]	0.0001
Nos. of eggs, Hen placed 18-43 weeks	88.8 [c]	103.4[b]	105.5[bc]	127.2[a]	0.0001
Nos. of eggs, Hen placed 40-43 weeks	11.3[b]	14.9[ab]	14.2[ab]	16.0[a]	0.0156
Age at first egg, weeks	22.2[a]	22.9[a]	21.4[b]	19.8[c]	0.0001
Egg weight, g	54.7[c]	58.3[ab]	57.0[b]	59.3[a]	0.0001
Total Mortality, %	13.8[a]	6.7[b]	3.9[b]	19.9[a]	0.0199
Mortality- cannibalism, % 18-43 weeks	1.4[b]	0.0[b]	1.1[b]	16.0 [c]	0.0001

[a-c] Estimates in a row with no common superscript differs significantly (P<0.05)
[1]Probability for F-values for effects of lines in the ANOVA.

At the Swedish Agricultural University at Uppsala two lines (A RIR line and a WL line) has been bred for better egg production based on a diet prepared from "home grown cereals" or a low protein level (13%). This may be an advantage for organic production and there is at the moment an interest for testing that in the organic environment. This Swedish hen also termed **SLU-1329** (RIR ×WL) so far has been tested in aviary system and in free range system in Sweden against conventional hybrids. In the Aviary system it was compared with Lohmann LSL feeding a 15% crude protein diet (Abrahamsen and Tausen, 1998) and SLU-1329 showed a significant less rate of lay (75% versus 83

%). Under floor condition the SLU-1329 was compared to Lohmann LSL and Hisex white and Hisex brown using the low protein diet (13.5 % crude protein) and had rate of lay of 75% and 78% up to 78 weeks of age in two investigation while the international hybrids had a rate of lay of the same or significant lower. In both test the SLU-1329 had a significant better feed efficiency (Wilhelmson & Carlgren, 1996; Wilhelmson et al. 1996). Thus its seems that the Swedish Hen is a good alternative when egg production takes place with a low protein diet in floor condition. It remains to be tested in an organic condition, and in particular the problems that the two lines have been selected in cages has to be looked carefully at.

Table 4. Condition of plumage at 35 weeks of age[1] in the comparison of four breeds/breed combinations.

Treatment	Genotypes				
Traits	NH	WL	WL × NH	ISA-Brown	P<[1]
Rate of Lay, %	63.2[c]	72.4[b]	69.2[b]	84.6[a]	0.0001
Rate of lay, during January	54,2[c]	67,2[b]	61.4[bc]	81.4[a]	0.0001
Nos. of eggs, Hen placed 18-43 weeks	88.8 [c]	103.4[b]	105.5[bc]	127.2[a]	0.0001
Nos. of eggs, Hen placed 40-43 weeks	11.3[b]	14.9[ab]	14.2[ab]	16.0[a]	0.0156
Age at first egg, weeks	22.2[a]	22.9[a]	21.4[b]	19.8[c]	0.0001
Egg weight, g	54.7[c]	58.3[ab]	57.0[b]	59.3[a]	0.0001
Total Mortality, %	13.8[a]	6.7[b]	3.9[b]	19.9[a]	0.0199
Mortality- cannibalism, % 18-43 weeks	1.4[b]	0.0[b]	1.1[b]	16.0 [c]	0.0001

[a-c] Estimates in a row with no common superscript differs significantly (P<0.05)
[1]Probability for F-values for effects of lines in the ANOVA.

In Germany test is being performed at Neu-Ulrichstein in free range /organic systems of various hybrids. Among these the Lohmann traditional seems to be of particular interest.

Conclusions

Regarding access to breeding material for laying hens to organic egg production the following can be concluded:

- The breeding material available is genetically adapted to the cage systems.
- This cage-adapted material has a shortcoming in terms of behaviour in larger flocks. This manifests in too high tendency to feather pecking and cannibalism, and, independent of flock size, also in many mislaid eggs.
- Experiments have shown that feather pecking, cannibalism and nesting behaviour can be improved by selection.

- A search for alternative breeds/hybrids has not yet produced the ideal "Organic hen".
- There appears to be a possibility for adaptation of laying bird to diets with lower crude protein that makes a production possible based on "home grown" crops even in the northern parts of Europe.

Future perspectives

- There appears to be two strategies that should be set in action as soon as possible: a) a continuos search for breeds or lines that shows to be suitable for organic egg production; and b) initiation of a breeding programme for laying hens that takes into consideration the specific requirements for organic egg and meat production.
- There has been and still are in progress, small national projects dealing with item a), but little has been done to address item b). There is a need to identify who is going to do the job and get on with it before organic poultry production is faced with a crisis when the Regulation EC 1804/99 enforces sourcing of organically bred stock.

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Animal welfare and genetics in organic farming of layers: the example of cannibalism

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Introduction and summary

During the last 40 years, breeding programmes were directed at intensive husbandry systems and changed markedly the genotypes of the animals involved. Apart from the question whether these animals have been adapted adequately to these intensive systems, the question arises as to how far the potential to adapt to extensive systems was maintained. Should animals be selected anew for these extensive systems, or can we just go on with the strains available now?

Cannibalism frequently occurs in organic poultry farming. Literature shows that a wealth of factors - ontogenetical, environmental and genetical - might play a. role in the development of cannibalism. However, none of these factors stands out as the main cause of the observed problems. A survey in the Netherlands among 11 farms in 1995 showed the severity of the problem. In this paper, new data are presented from a. survey in 1997, using a questionnaire, an animal welfare index (Animal Needs Index), behavioural observations and plumage scores. Results obtained by factor analysis show that still no clear cause for the occurrence of cannibalism is found. Differences between organic poultry farms with roosters and farms without roosters, together with some experimental data, indicate the possible importance of roosters on poultry farms. Furthermore, changes in the use of different breeds between 1995 and 1997 by farmers show the effects, especially on mortality due to cannibalism. Thus, one of the most promising ways to reach a solution seems to be to adapt the animal to its ecological environment by genetic selection.

Heritability estimates of cannibalism are lacking; the only one available indicates high heritability. Based on this single estimate, genetic selection against cannibalism appears feasible. A tentative model of the process of genetic selection for organically farmed poultry is given, emphasising genotype-environment interactions. Because of the latter, basic genetic studies have to be followed by measurement in the practice of farming. This will then adapt the environment to the animal and the animal to the environment. Furthermore, it is noted that the molecular genetic analysis together with ethological analysis can show the genetic background, i.e. markers or even genes that are responsible for the cannibalism. With such information a Darwinian 'natural selection', using genetic information of layers that are good producers and survivors, appears to be within the reach of organic poultry farming.

Aim of the study

In this paper, the status concerning breeds and management in relation to cannibalism in organic poultry farming in the Netherlands is explored. Furthermore, the objective of the study is to determine the best way to diminish feather pecking and cannibalism in organic poultry farming by adapting the bird to the ecological environment. In 1995, a survey was done, of which data are published elsewhere (Koene, 1997a). New data concerning cannibalism and management variables from the survey in organic poultry farming in 1997 are presented. In this survey four methods of measuring farm parameters are used, i.e. a questionnaire, an animal welfare index (AN-index), behavioural observations and a plumage index. Using factor analysis main factors distilled by each method are extracted, and factor scores are correlated to reveal their relationships. Subsequently, a model of genetic selection is presented, that integrates classic selection procedures and new molecular genetic methods to integrate selection in practice with selection on the level of off-line breeding. Different breeding and selection strategies will be presented dependent on welfare criteria, rather than on production criteria alone.

Intensive layers in extensive systems

Part of the goal of extensifying farming is to improve the housing conditions of animals with respect to their welfare. During the last 40 years, breeding programs were directed at intensive farming systems and changed markedly the genotypes of the animals involved. Apart from the question whether these animals have been adapted adequately to these intensive systems, the question arises whether the potential to adapt to extensive systems was maintained. If we return to these extensive systems should animals be selected anew or can we just go on with the strains available now? If the question is whether we adapt the animal to the environment or the environment to the animal (Faure, 1980), it is obvious that the process of selection is guided by animal-environment interaction, i.e. differences between animals can be attributed to genetic and environmental differences.

There are *a priori* no convincing arguments either pro or against selection of domestic animals for more extensive systems (Koene, 1997a). However, problem behaviour may appear in more extensive systems differently from that observed in intensive systems. For instance, in alternative systems for laying hens with larger groups and more space, more animals have the possibility to interact and thus increase the possible number of interactions and decrease the controllability of behaviour from the farmer's point of view. Selection for egg production in intensive systems seems to have caused a loss of genes for social interaction, causing increased cannibalism in floor systems (Sorensen and Christensen, 1997). Because of production loss some other authors state that non-genetic solutions should be pursued whenever possible (for instance, Hocking, 1994). Problems that occur are aggression, feather pecking and cannibalism, which still may necessitate beak trimming. Of these the most serious and damaging is cannibalism, which is the primary subject of this paper.

Cannibalism: cause and cure

The causes of cannibalism are not well understood, but the onset of cannibalism has been attributed to a number of causes that are outlined below. Generally, in cannibalistic species most incidences of cannibalism are related to feeding behaviour (Dong and Polis, 1992). The main theories of causation of cannibalism in chicken concentrate on an early phase during ontogeny of pecking behaviour. Blokhuis (1986) proposed the theory that feather pecking was redirected ground pecking and thus a part of the feeding behaviour system. Recently the relationship between dustbathing and feather pecking was explored and partly substantiated (Vestergaard, 1994). Vestergaard and Lisborg (1993) showed that the results concerning dustbathing are not in contradiction with Blokhuis' theory. Feather pecking is redirected pecking but according to Vestergaard as part of the dustbathing behaviour system.

However, Koene (1998) showed that the relation between feather pecking and cannibalism is unclear. For instance, evidence showed that vent pecking often starts after the start of laying and is an indication that cannibalism is influenced by changes in the hormonal system (Hughes, 1973). Furthermore, due to genetic selection, layers have a strong motivation to peck (Sorensen and Christensen, 1997). The pecking objects will be determined by the level of motivation and probably a learning process that acts especially during the early days (imprinting) but can also operate during later life. As an example, the quality of laying nests may be of essential influence in the development of cannibalism. Thus, the motivational and learning components need more attention in future research (and is currently under investigation in the Ethology group in Wageningen). In summary, cannibalism can have different causes, e.g. feather pecking and vent pecking.

Management and cannibalism

Cannibalism itself has not been the subject of much research. Part of the relevant information is available through experience, for instance by scientific experiments stopped by cannibalism. The practical experience is to be found in handbooks, in which presumed causes, consequences and solutions are mentioned. Suggested causes in a selection of 12 handbooks (table 1) are food composition (11), bright light (9), stocking density (6), too much corn meal (3), climate (3), distraction (2), feeding too late (1) and floor eggs (1). Solutions suggested are red light (5), removal of cannibals (3), tar on the wounds (3), oats (2), salt (2), music (1), and removal of sick hens (1). More suggestions are given in the scientific literature (Hughes and Duncan, 1972). But results are mainly very diverse and often contradictory. More information from practice is needed, and therefore surveys were done in the Netherlands in organic poultry farming.

Table 1. Causes of and cures for cannibalism in poultry husbandry as extracted from A. selection of handbooks on poultry keeping. Items are separated in causes and cures and sorted in descending order according to their occurrence in the total of twelve books.

	Item Book	1	2	3	4	5	6	7	8	9	10	11	12	Total
cause	food composition	*	*	*	*	*	*	*		*	*	*	*	11
cause	bright light			*	*	*		*	*	*	*	*	*	9
cause	density			*		*		*		*	*		*	6
cause	too much corn meal		*			*	*							3
cause	methionine/arginine	*				*								2
cause	red cloaca										*		*	2
cause	too few distraction					*							*	2
cause	feed too late								*					1
cause	floor eggs										*			1
cause	pellets											*		1
cure	red light				*	*		*	*	*				5
cure	selection/removal					*	*						*	3
cure	stable climate							*		*		*		3
cure	tar					*	*						*	3
cure	pickout									*			*	2
cure	reduction by oats					*				*				2
cure	salt		*										*	2
cure	music				*									1
cure	remove sick hens							*						1

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Cannibalism in the Netherlands: some new data

Introduction

In 1995, a survey was done in the Netherlands concerning the existing problems of the cannibalism related to the conditions of housing and management in organically farmed poultry. Results are presented in a Dutch report (Van de Wouw and Koene, 1995). However, results of this short survey must be interpreted with care because of the small sample size. Impressions (Koene, 1997a) are that more cannibalism is found on large farms, in large groups, keeping Hisex layers, and keeping hens only recently and with a high percentage of floor eggs. Factors that seem to be of less importance are BD (with a rooster) or EKO (without a rooster) farming, wheat availability, age at arrival on the farm, and fine or pelleted food. The survey showed that mortality due to cannibalism is sometimes very high (the range was 0-30%). On the question of how the pecking started one farmer responded ‘by extreme feather pecking’, one ‘by extreme pecking between cloaca and legs’, and nine ‘by cloaca pecking’.

The problems for the ‘animal friendly’ egg market were thus very serious. In 1996, the problem seemed to be not any smaller. Main results of the survey are presented elsewhere (Koene, 1997a). Furthermore, the problem seemed to be widespread in Denmark, Germany and the Netherlands (Koene, 1997b). The cause of cannibalism in reported cases was not revealed, but genetic factors, experience of the farmer, and the quality of laying nests seemed to be important. The investigation was repeated in 1997, combining several methods of estimating conditions for the chicken on the farms, including behaviour research.

Materials and methods

a) Housing

In 1997, some 50.000 layers were kept under organic conditions in the Netherlands. In the Netherlands, the Skal Foundation controls the quality of organic poultry farming. Hence, the housing of laying hens in the survey is comparable on some controlled and regulated points. However, large differences occurred concerning surface, substrate and laying nest. Part of the organically kept layers consisted of so-called BD (Biological Dynamical) layers and another part consisted of the EKO layers (labelled Ecological). The main difference between the two is that BD layers are kept together with roosters (at least 1 per 40 hens). In both housing conditions the layers' beaks are not trimmed.

b) Subjects

The number of laying hens per farm varied between 100 and 8500. In this survey, three strains were found, i.e. Lohmann Brown (Lohmann), ISA Brown (ISA) and Bovans Nera (Hendrix). In all BD farms, roosters were present in a rooster/hen ratio of generally 1 to 30.

c) Methods

<u>Questionnaire</u>

First, questionnaires were sent to 42 farms with questions and especially a question, whether behavioural observations of the layers indoor and outdoor were allowed. In 15 the answer was positive (response rate is thus very low, 36%) and 13 of these were visited. The items in the questionnaire ranged between question for opinions, yes/no answers, and estimations. The numeric questions involved the quantities of the number of (#) layers, percentage cannibalism in the last complete laying round, percentage of current cannibalism, farmers’ experience in # years, surface inside in m2, surface for scratching in m2, surface outside in m2, # times/day grain was given, # cm feed/layer, # cm water/layer, # nests/layer, and % floor eggs. It is pointed out that these figures were farmer’s estimates, not exact measurements.

<u>AN-index</u>

The German Tiergerechtheits index (Animal Needs Index; Bartussek, 1999; here called AN-index) is an animal welfare index based on a point system for relevant parts of the farming. There are separate indexes for different species; Striezel (1994) describes the AN-index for layers.

Table 2. Example of one of the categories (Locomotion) of the ANI-200. Columns a-g are the sub-categories ranging from space per hen to the structure of the area. Under the table the columns relevant for the system are indicated. Also, a short explanation of each item is given.

column	a	b	c	d	e	f	g
points	aviary # / m2	floor # / m2	perches in diff. heights	green outdoor m2 / hen	green outdoor duration of usage	ratio outdoor layers / m2	structure of the outdoor area
6	< 10						
5	< 11			> 10		< 8	
4	< 12	< 4	present	> 7,5		< 11	shadow givers, feed and water
3	< 13	< 5		> 5	total vegetation period	< 15	feed and water
2	< 14	< 6		> 2,5	> 2 / 3 part veg. period	< 18	feed or water
1	< 15	< 7			> 1 / 3 part veg. period		

Aviary	Column a
Strawyard	Column b
General	Column c
Green outdoor area	Columns d and e
Stone outdoor area	Column f
General	Column g
Column	Points
Column a	Different for each type aviary
Column b	Total available surface, including scratch area and wooden slats, excluding nesting area.
Column c	When the manure area is covered by the wooden slats and perches, then 'perches in different heights' will not be valued. The perches must use the space.
Column d	Green outdoor area is that surface that is covered mainly by grass. The total surface has to be estimated. In case no limits are found the maximum score is given.
Column e	Us E. data from the farmer. Limitations dependent on the kind of weather are possible.
Column f	The surface in the direct neighbourhood of the indoor facility, with substrate that enables ground scratching. This substrate must be sand, stones or other material, and must be available the whole year round. Limitations dependent on the kind of weather are possible. Daily outdoor availability is at least 4 hour.
Column g	Shadow givers are shrubs, trees, and penthouses as protection against bad weather and raptors. Feed and water reservoirs must be judged, when hens are not outdoors due to the weather.

The index is based on 8 categories in which possibilities of behaviour are recorded, i.e. (1) locomotion (max. score of 31 points on variables as outdoor structure), (2) feeding behaviour (max. score of 27 points on variables as trough width, and feeding times), (3) social behaviour (max. score of 31 points on variables as density, feather quality, and number of outdoor pop-holes), (4) resting behaviour (max. score of 25 points on variables as perch length, and light intensity), (5) comfort (max. score of 22 points on dustbath possibilities, and substrate), (6) nesting (max. score of 29 points concerning the laying nest, and floor eggs), (7) hygiene (max. score of 26 points on variables of substrate, water, smell, and outdoor use) and (8) care (max. score of 24 points concerning the facilities, feathers, cleanness, administration) and many more variables within categories. An example of one category is given (Table 2). The total sum of these values gives the index (maximum is 215 points). A relatively high index indicates a relatively good farm. The AN-index is determined for each farm during one morning after observer habituation to the specific farm.

Behaviour

In each farm, behaviour observations were done during 2 days for 5 hours a day. Scan sampling was done with 10-min intervals. The time budget of beak related behaviours is determined by scoring feeding, drinking, preening, object pecking, feather pecking and dustbathing indoor and outdoor (object pecking included ground pecking).

IBPW

The plumage quality of 10 randomly selected individuals indoor was determined according to the system of Herremans and Decuypere (1987) with some minor adaptations (IBPW = Index of body plumage wear). A high index indicates much wear and a bad plumage condition.

Analyses

Correlations between all variables from the questionnaire, the categories of the AN-indexes, the observed pecking behaviours and the IBPW-values are calculated. Factor analyses are done per method and correlations between within-method factors are presented (varimax rotated factor analysis; SAS, 1996). Factors extracted are based on a criterion of an Eigenvalue above 1. Significant factor loadings (>0.57, p<0.05) are printed bold in the tables (3-7). Factor names are given based on best professional judgement. Differences between BD (n=7) and EKO (n=6) farms are calculated using the GLM procedure (SAS, 1996).

Rooster presence

In an indoor experiment the effect of the presence of a rooster on pecking behaviour and cannibalism is investigated. In short, ISA Brown layers arrived at 18 weeks and were at random subdivided in groups of 10 of which 3 groups with a rooster and 3 without one. The cages measured 1.5x1.5m, and had a wooden floor, two laying nests with artificial grass, two perches, three drinking places, and a feeding trough. The temperature varied between 15 and 20 degrees. A 16-hour light period was given from 500h to 2100h through 6x40w TL bulbs. Observations using behaviour sampling were done during 5 weeks, 5 days a week, twice a day and lasted 25 minutes per cage. Behaviour elements were based on the pecking categories of Savory (1995). Furthermore, the pecking goal was recorded; the peck was hard, medium or soft and pecking was intensive or extensive in frequency. Only results of cloaca pecking will be presented here. Analysis was done by GLM (SAS, 1996) based on 2 conditions and three replications.

Results

Questionnaire

According to the farmers' estimate, the percentage cannibalism in the former complete laying round ranged from zero % (8 farms), 2% (BD; Bovans Nera), 4% (EKO; Bovans Nera), 5% (EKO; Lohmann Brown), 8% (EKO; ISA Brown) and 10% (EKO; ISA Brown). This was much less than in 1995 ($F_{1, 20}=11.02$, $p=0.003$; in 1995 cannibalism was in BD farms 11% and in EKO 9.7%; in 1997 it was in BD farms 0.4% and in EKO 4.5%). In 1995 especially the Hisex strain showed high percentages of cannibalism. Factor analysis using the numeric variables of the questionnaire revealed four factors with Eigenvalue larger than one (Table 3), explaining a total of 83% of the variance. Factor 1 explained the majority of variance (43%) and had significant loadings of surface inside, surface to scratch, number of cm feed trough per layer and number of nests per layer. This factor is tentatively named *density*. The second factor shows significant loadings of cannibalism in the last and present laying cycle, surface to scratch, cm water per hen. This factor is named *cannibalism*. The relatively high loadings of surface and water indicate a relationship between cannibalism and those variables. The third factor had significant loadings of surface outside and # grain/day and indicates the *ecological* aspects of the housing. The fourth factor has a significant loading of number of years the farmer is keeping laying hens, and is consequently named *experience*.

Table 3. Factor analysis of questionnaire data.

Q'nnaire Variable	Factor	1	2	3	4
1	# layers	0.53	0.35	-0.33	-0.35
2	last cannibalism	0.31	**0.78**	-0.09	-0.11
3	current cannibalism	0.05	**0.89**	0.17	-0.30
4	experience	-0.10	-0.08	0.00	**0.89**
5	surface indoor	**0.81**	0.28	0.05	0.30
6	surface scratch	**0.70**	**0.65**	0.07	-0.08
7	surface outdoor	0.12	0.04	**0.92**	0.14
8	# grain/day	-0.02	0.19	**0.67**	-0.48
9	# cm feed/layer	**0.74**	0.45	-0.12	0.02
10	# cm water/layer	0.19	**0.92**	0.11	0.18
11	# nests/layer	**0.89**	0.17	0.09	-0.20
12	% floor eggs	**-0.79**	0.24	-0.34	0.39
	Expl. Var. %	43	15	13	11
	Cum. Var. %	43	58	72	83
	Eigen value	5.19	1.82	1.61	1.33
	Label	densit.	cannib.	Ecol.	Exper.

AN-index

Factor analysis revealed three factors with an Eigenvalue larger than 1, explaining 77% of the variation (Table 4). The first factor explains 40% of the variation and has significant loadings of locomotion, feed, social and rest scores. It seems mainly related to the behavioural activities and is named *activity*. The second factor has significant loadings of comfort, hygiene and care scores, and is named *body care*. The last factor has a significant loading of only the nest score and is named *nesting*.

Table 4. Factor analysis of AN-index data.

TG-index	Factor	1	2	3
Variable				
1	locomotion	**0.64**	0.20	-0.18
2	feed	**0.68**	0.26	0.53
3	social	**0.71**	0.31	0.15
4	rest	**0.91**	-0.25	0.00
5	comfort	0.45	**0.85**	0.11
6	nest	-0.05	-0.01	**0.94**
7	hygiene	0.14	**0.70**	0.37
8	care	-0.10	**0.90**	-0.25
	% Expl. Var.	40.00	21.00	16.00
	% Cum. Var.	40.00	61.00	77.00
	Eigenvalue	4.17	1.69	1.28
	Label	activity	body care	nesting

Behaviour

Factor analysis of the 6 pecking behaviours sampled reveals three factors explaining a total of 74% of the variation (Table 5). The first factor explaining 33% of the variation has significant factor loadings of feed pecking and dustbath pecking and negative loading of object pecking (mainly ground pecking), it is named *normal* pecking. The second factor explaining 23% of the variation has a significant positive loading of feather pecking and a significant negative loading of preening, the factor is named *FP*, related to feather pecks. The third factor has a significant positive loading of drink pecking and a negative loading on object pecking (mainly ground pecking), it is named *drinking*.

IBPW

Factor analysis of the body parts with plumage coverage revealed only one factor explaining 90% of the variation (table 6); the factor is named *Fibpw*, i.e. different from the calculated IBPW.

Table 5. Factor analysis of pecking behaviour data.

Pecks	Factor	1	2	3
Variables				
1	feed	**0.79**	-0.02	-0.07
2	drink	-0.32	-0.10	**0.89**
3	preen	-0.18	**-0.78**	-0.11
4	object	**-0.59**	-0.08	**-0.67**
5	feather	-0.06	**0.82**	-0.16
6	dustbath	**0.86**	0.17	-0.08
	% Expl. Var.	33	23	19
	% Cum. Var.	33	56	74
	Eigenvalue	2.27	1.94	1.08
	Label	normal	FP	drinking

Table 6. Factor analysis of plumage data.

IBPW	Factor	1
Variable		
1	head	**0.85**
2	breast	**0.94**
3	vent	**0.94**
4	thigh	**0.99**
5	back	**0.97**
6	wing	**0.98**
7	tailbone	**0.95**
8	tail	**0.97**
	% Expl. Var.	90
	% Cum. Var.	90
	Eigenvalue	8.23
	Label	Fibpw

Correlations between factors

The four methods of observing characteristics of organic poultry farms revealed several significant factors distinguishing those farms. To find relationships between variables correlations are calculated, but often high correlations between measurements obtained through the same method hamper interpretation, for instance #cm feed per hen is highly correlate with #cm water per hen in the questionnaire. Thus, the correlations of factor scores of each farm on factors with Eigen value larger than 1 are calculated (Table 7). Factors from the questionnaire (4), from the AN-index (3), from the pecking behaviour observations (3) and the IBPW (1: Fibpw) are correlated with the factors that best measure the targets issues, i.e. the factor *cannibalism* from the questionnaire, the factor *FP* from the behaviour measurements, and the factor *Fibpw* from the index of body plumage wear (IBPW). Furthermore, factors are correlated with the calculated AN-index and the calculated IBPW scores. Correlations above 0.57 are significant (P<0.05). Concerning *cannibalism* only a highly significant negative loading of *nesting* in the AN-index is found (Table 6), together with a negative relationship, with the overall AN-index. Concerning *FP* pecking only a significant correlation with the *IBPW* and the *Fibpw* is found; indicating that on farms showing more feather pecking birds more body plumage wear is found. Last but not least, the factor *Fibpw* is significantly negative correlated with *body care* and with the overall AN-index.

Table 7. Correlation of extracted factor with three selected factors and the calculated IBPW index and AN-index.

Correlations	Factors	cannibalism	FP	Fibpw
Questionnaire	density	0.00	0.20	0.14
	cannibalism	.	0.09	0.33
	ecological	0.00	-0.09	-0.20
	experience	0.00	-0.03	-0.48
TG-index	activity	-0.40	-0.23	-0.31
	body care	-0.11	-0.51	**-0.82**
	nesting	**-0.78**	0.17	-0.03
Pecks	normal	0.45	0.00	0.16
	FP	0.09	.	0.68
	drinking	0.45	0.00	0.33
Plumage	Fibpw	0.33	**0.68**	.
Calculated	IBPW	0.32	**0.68**	1.00
	TG-index	**-0.62**	-0.40	**-0.71**

Rooster presence

The mean AN-index for BD was 115 points and for EKO 97 points (not significantly different). In the AN-index a rooster in a layer group is valued 4 points; consequently a difference between BD and EKO of 14 points is to be explained. Significant differences between the BD and EKO farms were found for the factor scores on *body care* (0.50 vs. –0.58, $F_{1,11}$=5.06, p=0.045), *FP* (-0.56 vs. 0.66, $F_{1,11}$=7.39, p=0.020) and *IBPW* (-0.53 vs. 0.61, $F_{1,11}$=5.94, p=0.033). On BD farms *body care* was higher, *FP* was less and *IBPW* was lower than on EKO farms. All these differences are in favour of the BD systems.

In the indoor experiment the amount of vent pecking was significant lower in the first week in groups with a rooster (0.05 vs. 0.34 pecks per 15 min., $F_{1, 4}=17.56$, $p=0.014$), associated with the start of egg laying. During the whole 5-week period the difference was only marginal significant (0.09 vs. 0.33 pecks per 15 min., $F_{1, 4}=5.20$, $p=0.085$). In conclusion, the presence of the rooster may be the causal difference between BD and EKO ecological poultry farms.

Discussion

The survey

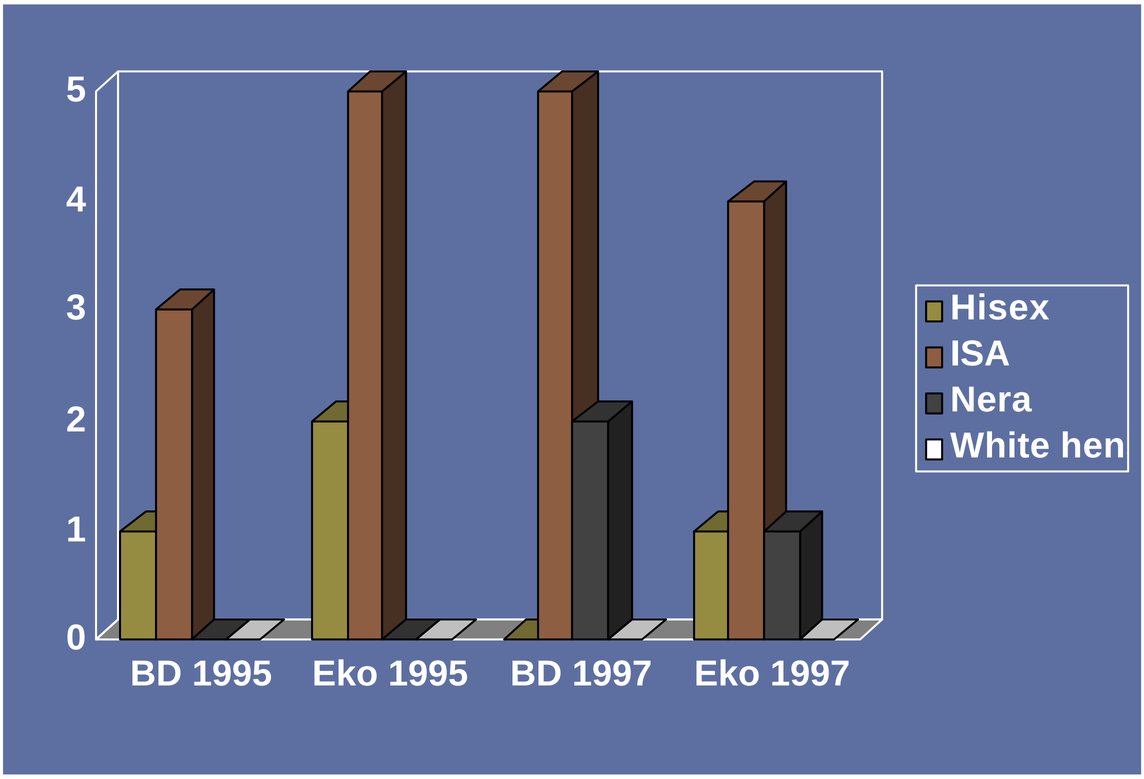
Factor analysis of the questionnaire data revealed four factors. Some interesting relationships are suggested by the rotated factor patterns found. The percentage floor eggs loads negatively on the density factor, suggesting that if the density factor increases, the percentage floor eggs decreases. The *cannibalism* factor suggests a relation between the occurrence of cannibalism and water availability per hen and the surface for scratching, so suggesting more cannibalism with an increase in scratch area, which could not be explained yet. The factor analysis of the AN-index suggests that the categories locomotion, feeding, social and rest measure the same variation, and are different from the other four factors. Care for the hens' body, for hygiene and for the facilities loads on the same factor, while nesting loads on a separate factor. This suggest the importance of behavioural possibilities for comfort behaviour and nesting facilities apart from each other, and apart from other activities; probably the different factors did not receive the same attention of the farmers.

The factor analysis of the pecking behaviour shows the relationships between feed, dustbath and ground pecking, and partly unite the feather pecking theories of Blokhuis and Vestergaard, mentioned in the introduction. A negative relationship between food pecking and ground pecking, but also a negative one between dustbath pecking and ground pecking is suggested. Probably both ground pecking and dust bath pecking are part of the feeding system; in this case both not related to the FP factor. The opposite loadings of preen and feather pecking suggest that less comfort pecking is found when much feather pecking is found. Determination of parasite load will give additional information on the cause of preening. Drinking pecks are negatively related to ground pecking. It suggests that water availability is important as is also suggested by the relationship with the factor *cannibalism*.

The correlation between the factor scores of the farms show that good farms have less cannibalism, and that good farms have probably better nesting facilities for the laying hens. This is in agreement with the suggestion that cannibalism often starts with vent pecking and often in the context of egg laying, when the cloaca is visible and glistening, probably attracting pecking behaviour. *FP*, although not the prime subject of this study is not related to *cannibalism*, which fits with earlier remarks concerning this point. It logically is related with worse body plumage (*Fibpw*) as a result of the pecking. Last correlation is between the *Fibpw* and the factor *body care*, suggesting that bad feather plumage probably has to do with the care of the environment and the care of the layers for their own body.

The above findings are corroborated by the data based on farmer experience of the, 1995 survey; vent pecking is often the start of cannibalism, not feather pecking. Apart from the importance of the resting facilities for the layers, also a change in the strains used in, 1995 and, 1997 is apparent (Figure 1). The farmers seem to have done a good job; i.e. the percentage death due to cannibalism is reduced from 10% to 2.5%. The Hisex breed is found only once in this survey, maybe due to farmers' experience of extreme cannibalism or due to our, 1995 report (Wouw van de and Koene, 1995). The Bovans Nera strain is new in the field and seems to perform reasonably well. A remark can be made concerning the use of white layers in organic poultry farming. Although it is found that white layers may perform better in organic conditions concerning feather pecking (Van Rooijen, 1997) and cannibalism (Koene, 1997b), such strains are not used in the Netherlands. This is due to the marketing facts: the consumer learns that brown eggs are laid in animal-friendly strawyard systems, and that white eggs come from battery cages! So the choice of strain is for marketing/consumers, not for the layers welfare! In conclusion, farmer's initiatives change already the breeds used in organic poultry farming by trial and error. Developing the tools for breeding an even better adapted layer may accelerate this process.

Figure 1. Number of poultry farms with different breeds of layers in the survey of 1995 and in 1997.



<u>Rooster presence</u>

All investigated organic farms were BD or EKO farms. In BD farms roosters are present, which subjectively seems to increase rest in the indoor stable. This is conform the literature, in which a third party, i.e. another hen or rooster in a conflict seems to have a reducing effect on pecking behaviour (Bshary and Lamprecht, 1994; Ylander and

Craig, 1980), in particular the rooster (Bhagwat and Craig, 1978). In contrast, some BD farmers in the past have necessarily changed to EKO farming due to severe cannibalism of roosters (probably too young roosters, which were harassed and eaten by the hens). Part of the difference between BD and EKO farms is due to a somewhat different attitude towards farming of the farmers, i.e. BD farmers seem to have more attention for their hens (see rooster effect). Still, the most probable reason is the presence of roosters. Within a natural way of farming laying hens the presence of roosters fits very well. From the indoor experiment the influence of the rooster on vent pecking is significant although no specific behaviour is found as an explanation of these differences. In contrast, the presence of roosters is not mentioned in the handbooks in Table 1 as a cure for cannibalism.

Welfare

Cannibalism in poultry husbandry indicates a welfare problem; certainly for the cannibalised birds, and maybe also for the cannibals themselves, dependent on what causes their behaviour. Different causes are mentioned earlier, but most probably strains of layers can have a predisposition of intense pecking behaviour that can expresses itself in cannibalism. When cannibalism occurs some actions can be taken, as reducing light intensity, red light, providing more distraction and so on. However, data show that despite such steps the problems still are not solved (Blokhuis and Wiepkema, 1998). As it appears that chicken lines used in organic poultry farming are not the best suited, and may be better adapted to the environment, especially to a social environment with non-beak trimmed conspecifics.

Siegel (1989) already suggested to use genetic selection to change laying hens and broilers. In his Gordon memorial lecture concerning 'The genetic-behaviour interface and well-being of poultry' he stated that 'arousal is needed for meat stocks and calming for egg-stocks'. Whether that is true is still dependent on the way selection programmes are designed in the near future. In extensive organic farming in addition the animal should be a strong animal with a high survival, high fitness and adaptability. Webster (1994) stated that, 'The welfare of an animal must be defined not only by how it feels within a spectrum that ranges from suffering to pleasure but also by its ability to sustain physical and mental fitness and so preserve not only its future quality of life but also the survival of its genes'. In a short definition of welfare 'The welfare of an animal is determined by its capacity to (1) avoid suffering and (2) sustain fitness' (Webster, 1994). But how to measure welfare in organic poultry farming?

Behavioural measurement

Laying hens in organic farming have some explicit advantages compared to hens in intensive husbandry. Positive aspects of their welfare are, however, difficult to quantify. For instance, freedom is probably one of the positive aspects to the welfare of free-living and free-range animals. In quantifying harm to welfare of free-living animals Kirkwood (1994) assessed the scale and severity of harm to welfare by considering (1) the number of animals affected, (2) the cause and nature of the harm, (3) the duration of the harm and (4) the capacity of the animal to suffer. Kirkwoods approach gives some indications for determining and quantifying the positive welfare aspects of freedom or free-living (i.e. the lifespan of an animal without harm to welfare). However, as long as we are dealing with obvious negative welfare aspects, it is needed first to diminish abnormal behaviours, such as cannibalism and feather pecking.

For adaptation to the environment outdoor laying hens need behavioural flexibility to react on internal and external stimuli that threatens homeostasis. Detection of the important defensive mechanisms and associated behaviours are important for creating means for genetic selection. We need to know behavioural parameters associated with the cannibalistic pecking behaviour for starting a selection programme. The feather peck device of Bessei *et al*. (1997) could be of great help as a direct measure of the abnormal pecking behaviour. Animals - when challenged by changes in the environment - show first behavioural reactions or adaptations (McBride, 1980). Such first reactions can be described as acute stress reactions or emotional expressions (Wiepkema *et al.*, 1992). Siegel (1989) stated that 'poultry farmers routinely use sound to judge flock well-being', i.e. vocalisations are practical tools to judge well-being (Huber and Foelsch, 1978; Koene, 1991; Zimmerman and Koene, 1998a, 1998b, 2000a, 2000b).

So, emotional expressions like vocalisations may be clues to estimate welfare in laying hen houses. For instance, birds thwarted in getting food often vocalise (gakel-call). Thus sound could be a behavioural parameter related to the occurrence of a welfare problem (e.g. hunger). Heritabilities of traits and genetic correlations with other traits are estimated rather easily, but they are dependent on the particular environment. One hypothesis is that behavioural or rather emotional expressions of the animal are related to experiences of the animal in its environment (Wiepkema et al., 1993). In this context, it is appropriate to mention that the uttering of positive emotional expressions may be a better indicator of well-being, although difficult to make operational as a tool in selection for optimal welfare of in- or extensively kept animals. For instance, Huber and Foelsch (1978) found more Ku-calls (the ‘friendly contact call’), indicating more positive social contact in strawyard systems compared to battery cages. Behavioural parameters such as vocalisations, which show explicit strain differences (Zimmerman and Koene, 1998b) can provide the target for genetic selection.

Genetics

The relationship between feather pecking and cannibalism remains unclear (see Koene, 1998 and the, 1995 survey, in which farmers mention mostly vent pecking as the cause and start of cannibalism). Line differences in cannibalism are often found (Hughes and Duncan, 1972), but the precise genetics are unclear. The only reported heritability, directly related to cannibalism is obtained by selection on beak inflicted injuries in laying hens, showing a high realised heritability of 0.65 (Craig and Muir, 1993).

It is promising that breeder companies are now becoming aware and active in the field of alternative laying hen farming as is shown in the following citations of Preisinger (1998), ‘Especially in Europe consumers are more and more concerned about animal welfare issues. Well-known management tools like beak trimming or reducing light intensity may not be accepted in the future to manage the birds adequately. Under alternative housing systems birds are challenged with problems unknown in cages. With increasing demand for eggs out of alternative housing systems and increasing welfare regulations more and more egg producers are asking for a different type of hen, specifically adapted to 'animal friendly' production systems. Up to now, the major sources of information related to strain differences is based on cage testing. If there are significant genotype x environment interactions, different strain combinations may be required for alternative housing systems than they are for cage; and based on specific line-crosses, special attention will be required in specific programmes to develop a bird for alternative housing systems. Major breeding targets will include low prevalence of cannibalism and feather pecking without beak trimming. Selection against aberrant behaviour has become more important to meet market requirements and to improve overall productivity.

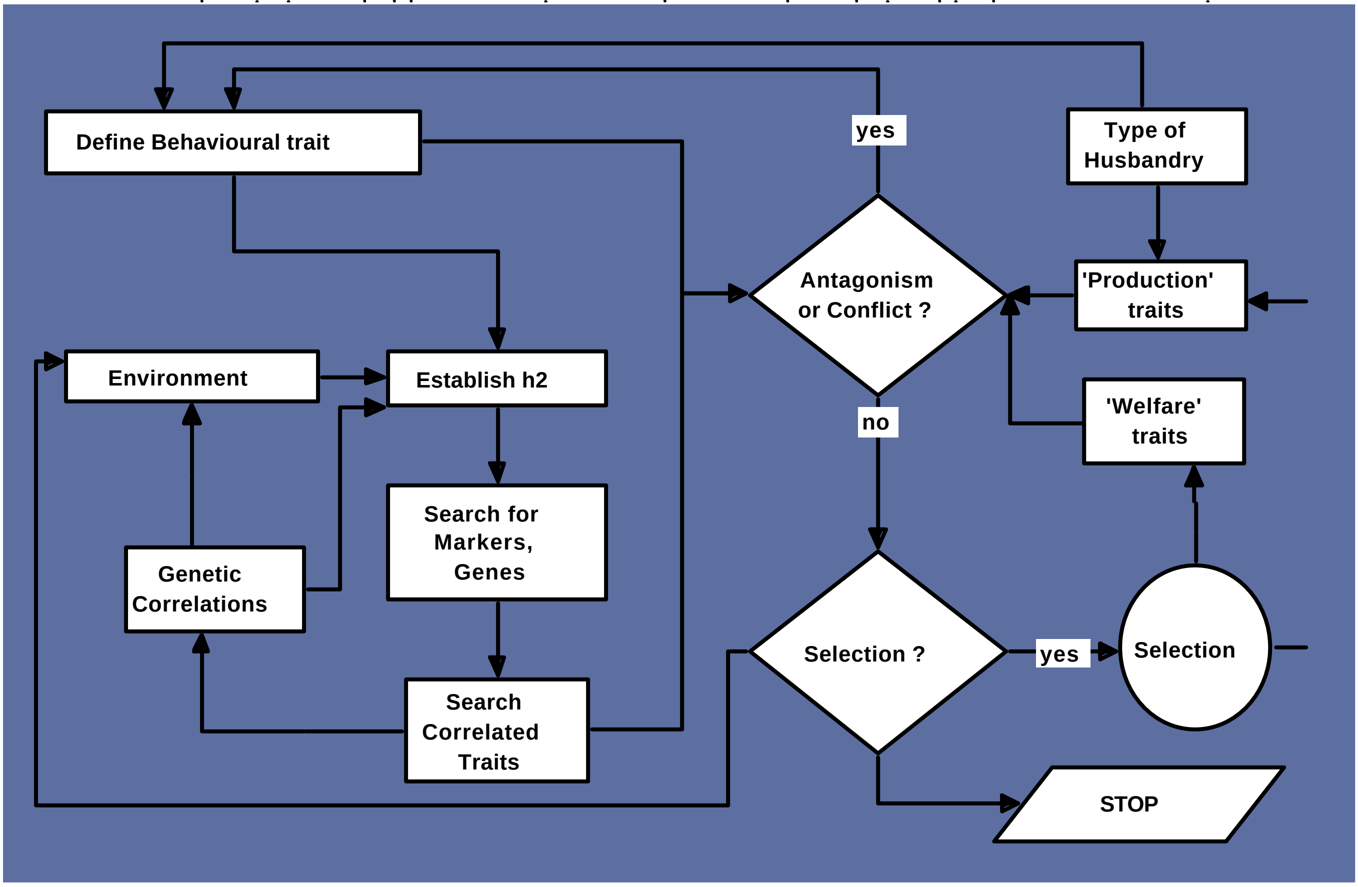
The ontogenetical aspects of the causation of cannibalism are unclear in the case of vent pecking as a precursor to cannibalism. In the case of feather pecking as the precursor to cannibalism, the theories concerning the causation of feather pecking concentrate on the ontogenetical aspects, but also here for practical purposes solutions are also sought for in genetics. The so-called high (HF) and low (LF) feather pecking lines show significant differences in amount of feather pecking, but also significant differences in physiology (Korte *et al.*, 1997) and in behaviour and vocalisations (Jones et al., 1995; Rodenburg and Koene, 2000). Both behavioural parameters have potential as target for genetic selection.

Genetic selection

A flow-chart model or strategy for selection for behavioural traits in animal farming was partly given elsewhere (Koene, 1992; cf. Newman, 1994). The strategy for breeding for welfare traits is dependent on the type of farming which is the starting point of the model that determines the environment in which the selection has to take place. Such a selection strategy can be done in 7 steps (Figure 2).

Quantitative genetics show that selection probably can be done better on group or family level than on individual level (Griffin, 1967). In multi-bird cages it is shown that adaptability and well-being of layers were improved by group selection (Muir, 1996). Improvement of well-being, nesting, viability and egg production can be achieved by selecting families on the parameters of (1) days of survival, (2) willingness to lay eggs in nests and (3) egg production over two laying cycles (Liljedahl, 1999). However, such a selection method seems to be not (yet) feasible in the practice of organic poultry farming.

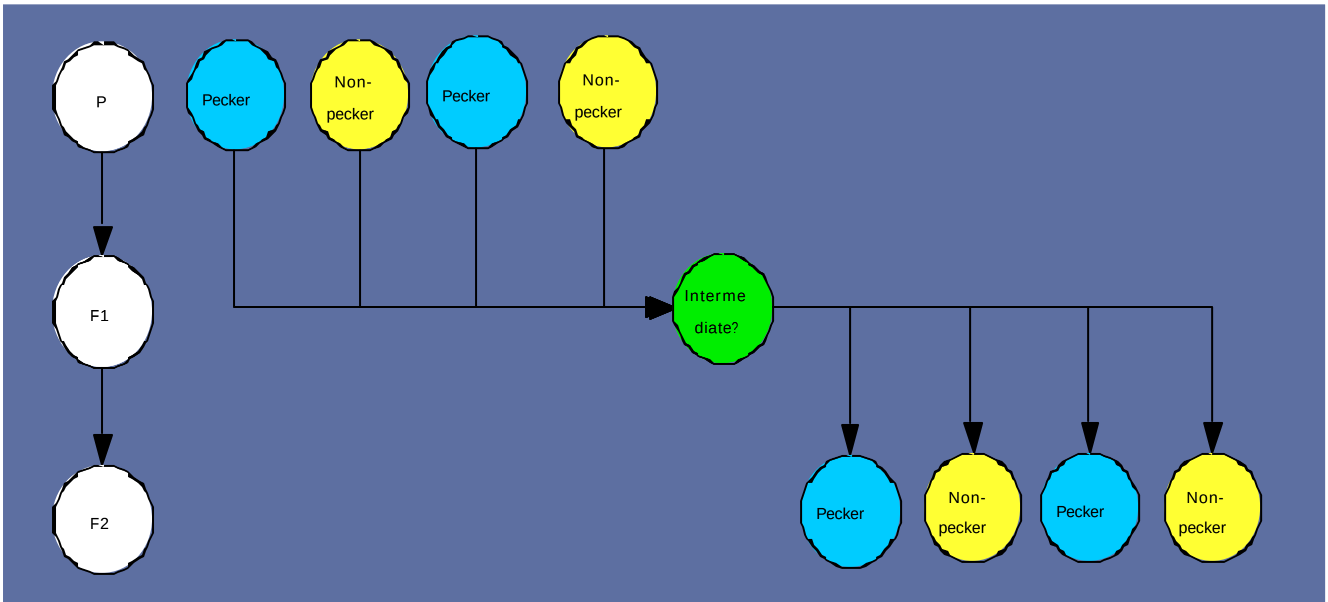
Genotype by environment interactions will be a limitation in all interpretations of heritabilities and genetic correlations. Therefore the environment has a pronounced place in the model. Future behaviour genetic research has to be aimed at (1) emotional expressions as welfare parameters (negative and positive), (2) unravelling the heritability of behavioural (welfare) traits and their phenotypic and genetic correlations with production traits (sustainability), (3) the dichotomy in behavioural traits (types of animals) (Korte *et al*., 1997) (4) the use inbred strains and/or of twins in fundamental research. Selection against cannibalism in laying hens may be successful. Especially genotype-environment interactions (effect of light intensity and group size) are important and must be included in the selection procedure. The best strategy seems to select a specific breed without cannibalism. The genetic correlation of cannibalism with production is not clear. It is thus difficult to estimate the effects on production in this



<u>Molecular genetics and pecking</u>

Molecular genetic techniques and behaviour research (Newman, 1994) allow for genetic identification of cannibals. With a set of high polymorphic microsatellite markers a total genome scan procedure can be done. Segregation for behavioural parameters may reveal chromosomal regions that are basic to cannibalism or related traits by identification through 'linkage analysis'. Such markers are guides for characterising the responsible genes (Crooijmans *et al.*, 1996). From a genetic point of view cannibalism is not very predictable, but seems to be often associated with vent pecking which is more predictable, and associated with nesting quality. Molecular genetic techniques can probably identify gene-complexes responsible for cannibalism, following the global procedure in figure 3 which is now investigated in Wageningen (Buitenhuis and Van der Poel, Animal Breeding and Genetics, Wageningen, and Rodenburg and Koene, Ethology, Wageningen).

Figure 3. In a F1 generation of genetically different lines - the best is divergently selected lines - concerning cannibalism, i.e. cannibals and/or non-cannibals are determined by behavioural research. By pooling samples of many individuals



Time phase	Phase 1	Phase 1	Phase 1	Phase 1	Phase 2	Phase 3	Phase 3	Phase 3	Phase 3
Individual	1	2	3	4		1	2	3	4
Marker 1									
Marker 2									
Marker 3									

In summary, the possible future strategies to solve the cannibalism problem in organically farmed laying hens could be:

- Keep beak-trimming layers. However, this is not allowed in BD and EKO layers in the Netherlands. Only symptoms of the pecking problem are removed, causing pain in the animals (Gentle, 1997).
- Use regular commercial strains and keep trying to adapt the environment to animal. Better management, human-animal relationship, ontogenetic conditions are needed.
- Use regular commercial strains and wait until breeders deliver animals according to welfare standards enforced by legislation.
- Choose a commercial breed composed of non-pecking parent lines and accept the possibly correlated lower egg production. Don't forget breeds used in other countries like for instance the Australorps.
- Breed and select your own animals or family group of animals. Biological dynamic farming pay special attention to welfare and an ecological approach. A Darwinian approach in which the fitness of an individual can be determined by its reproduction and survival is really ecological! Roosters and a brooder (or broody layers) are essential. Such a strategy is possible in BD systems in the Netherlands.

- Select the animals that are the best under practical conditions and determine their genetic make-up by molecular genetic techniques. In this way breeders may compose the hybrid with the best traits for organically farmed farming.
- Select the animals that are the cannibals under practical conditions and determine their genetic make-up by molecular genetic techniques. In this way breeders may select against cannibalism. This technique is currently used concerning feather pecking in laying hens.
- Use the above mentioned selection model and try to balance welfare and production traits in making a new organically farmed hen strain ('Freehen' or 'Biohen').

Although it is commercially probably the most attractive option to sit and wait for the perfect hen, it is better for the welfare of the hen to start asking for a new type of laying hen without the vice of cannibalism. In the Netherlands and Germany there is a market for a ‘biokip’ or ‘Biohuhn’. The best strategy seems to select for a specific cannibalism-free breed. The search for such breeds has started already. In England the Colombian Blacktail is claimed to show no cannibalism. In the Netherlands the brown Hisex layers showed more cannibalism than ISA hybrids (Koene, 1997a). Hisex birds are not found anymore in organic poultry farming after 1997. White (LSL) breeds are preferred in Germany for showing less cannibalism (Koene, 1997b)! However, they produce white eggs, which could not be marketed as welfare-friendly eggs in the Netherlands.

For health and welfare reasons, composition of new races of laying hens with a large adaptation ability for changing environments is preferred above using animals of current battery cage breeds. Information of individual animals about health, welfare and production must define the features and traits for selection in future. Natural selection should determine the genetic basis of the future production animals in organic farming. Animal variation in health, welfare and production must identify the optimal combination of genetic characteristics in relation to environmental characteristics. Thus leading to identification of the necessary characteristics of future animal friendly, natural, ecological, biological housing systems. The limits of selection are still difficult to determine if we adapt the animal to its environment. The example of blind hens (Ali and Cheng, 1985) that produce better than sighted birds, show no damaging pecking and have probably less stress is a challenging subject for an ethical discussion concerning welfare. Although this example is beyond ethical limits, it seems the best way forward to adapt the hen to a new extensive environment within a framework using the natural variation within the species (Simm *et al.*, 1996).

Conclusions

Composition of new races of laying hens with a large adaptation ability for changing environments without too much loss of production has a number of advantages for the producers and for the animals' welfare above just releasing animals of current battery cage breeds, that share a high propensity for cannibalism. As outlined in the introduction, the aim was to find a solution for severe cannibalism with special emphasis on a genetic solution. Surveys in practice provided ways of improving welfare in laying hens, i.e. experience and probably training of the farmer, changing laying nests and most important adapting a non-cannibalistic hen to the organic farming environment.

The eco-ethological approach (natural behaviour in a natural environment) complemented with a molecular genetic approach seems to be the most promising. If successful, and beak trimming is no longer necessary, also billions of intensively kept hen may benefit from such an effort.

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Breeding and feeding pigs for organic production

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Introduction

This paper describes the progress to date in an ongoing three-year research project, Optimising Production Systems for Organic Pig Production (OF0169), funded by the UK Ministry of Agriculture, Fisheries and Food with additional contributions from PIC and Tesco. The research team consists of personnel from ADAS Consulting Ltd, Newcastle University, Eastbrook Farm and Eco-Stopes Consultancy.

The project aims to provide information to organic farmers, and those considering conversion, on several aspects of organic pig production. There is considerable demand for such information with the rapid expansion of this sector, but little is currently available. The project is scheduled to finish in April 2002, and many of the results will not be available until nearer the end, however, details of the work in progress and some preliminary findings are presented here.

The project covers such areas as sow breed type; available feedstuffs; the interaction of breed, feed and housing for growing pigs, and meat quality; pasture rotation systems for pregnant sows; welfare of all ages of pig under organic management; formulation of “best practice” management advice for farmers; and appraisal of economic aspects of organic pig production.

All the research is being carried out on commercial organic pig farms, and the Research Team are grateful to the farmers and staff for their support and commitment. With the exception of specific areas discussed below, the farms are following their own individual management practices, which they or other farmers have found to be effective.

As part of the project, trial herds of gilts have been established on two commercial organic pig farms ("Focus Farms", see "Breeding" Section below for more details). In addition, data such as herd physical and financial performance, management practice and objective measures of welfare, are being collected from a further five commercial organic pig farms ("Link Farms"). These herds range in size from about 75 to 700 sows.

Organic pig production systems in the UK

Organic pigs in the UK are housed outside throughout their lives, however some farmers house the fattening pigs indoors for a short period (typically 1-2 weeks) before slaughter to allow sorting, or feeding of high forage diets to improve carcase grading.

The sows and boars are always housed outdoors, in paddocks with straw-bedded arcs. On many farms, service is unsupervised, sows and boars running together in a paddock, although some farms use supervised service or AI. Sows may be kept in groups with the boars until just before farrowing, or they may be moved into separate "dry sow" paddocks. The sows may be penned individually or in small groups for farrowing. Where they are penned individually, the fences are arranged so that the piglets can mix before weaning.

Individual penning of lactating sows allows for individual feeding, although some farmers who group house their sows use *ad libitum* hoppers for the lactating sows from about 3 weeks *post-partum*. The piglets may feed from these as well, or separate creep feeders may be used. Farmers report that piglets start to eat significant amounts of creep feed from about three weeks of age.

The minimum weaning age is 6 weeks, with 8 weeks being recommended (Soil Association, 2000). Some farms remove the sows and rear the piglets until slaughter in the paddocks in which they were born, others move the piglets to clean ground after weaning, rearing boars and gilts separately.

Some organic sector bodies prohibit nose-ringing of sows to preserve pasture, as this restricts the sows' behaviour (Soil Association, 2000). However, this means that the vegetation cover is rapidly destroyed, with detrimental consequences for nutrient leaching, as well as nutritional and welfare implications for the sows. To overcome this, some farmers use a rotation system where the sows are moved every four months, so that once the vegetation cover has been destroyed, the pigs are moved to a fresh paddock.

As part of this project we are comparing this frequently moved rotational system with one where the pigs remain in the same paddock for the whole year, but at a lower stocking density. Both systems therefore use the same total land area over the year (Kelly *et al*., 2001).

Breeding

Organic production standards (Soil Association, 2000) favour traditional breeds of livestock, which may be more suited to local conditions than some “improved” or synthetic genotypes. A survey of UK organic herds in 1999 as part of this project indicated that nine different traditional breeds were in use, with the most numerous being the British Saddleback. This is noted for its hardiness and mothering ability, however, the levels of fat in the carcase may make the progeny less efficient in feed utilisation and their meat less acceptable to consumers. Informal work by farmers (Browning, pers comm) has suggested that the Saddleback x Duroc sow retains the beneficial characteristics of the Saddleback, produces improved litter sizes and carcase grading, and has a good temperament for free-ranging systems.

The PIC Camborough 12 ((Landrace x Large White) x Duroc) is the most popular breed of sow in UK conventional outdoor production, being reasonably hardy, prolific and producing fast growing, lean progeny. Conventional pig farmers wishing to convert their units are likely to favour the breed of which they have previously had good experience. However, there is some concern about the welfare of these sows under organic conditions, particularly regarding the 6-8 week lactation period, which is double the 3-4 weeks favoured by conventional outdoor producers. Lifetime performance and longevity of the different breeds under organic conditions of nutrition and health management need to be considered when setting up a herd.

The present study is comparing the traditional (Saddleback), with “improved traditional” (Saddleback x Duroc), with “improved modern” (Camborough 12) breed strategies. Twenty sows of each breed were integrated as maiden gilts onto each of two commercial organic pig farms, giving a total of 40 sows of each breed. It was intended to establish a further 20 sows of each breed on a third farm, however this has not been possible with current biosecurity concerns.

The sows have been managed according to the commercial practice of each farm. The sows were all served by Duroc boars, with unsupervised service. The individual boars have served all three breeds of sow to eliminate any confounded effect of boar fertility on sow performance. The sows were introduced in small batches over 4-6 months, to provide an even spread of farrowings over the year. The different breeds were matched by age at entry, and were first served at their third oestrus. On one farm, the sows farrowed in individual paddocks, with the piglets being able to mix before weaning; on the other farm, the sows farrowed in groups of 4-6.

Sow performance is being recorded over four parities. At the present time (March 2001), the second parities are nearly complete on both farms. Results from the first parity are shown in Table 1.

It should be noted that in outdoor systems with unsupervised farrowings, it can be difficult to distinguish piglets born dead from those which die in the hours immediately following birth (Edwards *et al*., 1994). Also, in free ranging systems, piglets may roam large distances from their home paddocks. This increases their vulnerability to fox or other predation, and the bodies may not be found to record pre-weaning deaths. Therefore, the most reliable indicators of performance are "total born", "number weaned", and the difference between these (with allowance for fostering of piglets (data not shown)), "total losses".

Where some sows had very poor litters (four or less piglets born alive), and suitable foster sows were available, their piglets were fostered off soon after birth, and the sows returned to the boar. These have been excluded from the second phase of the analysis as "early weaned with 0" in order to reduce the variability in the data set.

Table 1. First parity performance figures for three breeds of sow at two commercial organic farms.

	Saddleback	**Saddleback x Duroc**	**Camborough 12**	Pooled breed sd	Sig of breed	Sig of farm
All litters						
N	39	40	40			
Total born	9.66	8.85	10.70	2.69	**0.010**	**0.054**
Born alive	9.27	8.40	9.98	2.67	**0.034**	0.13
Born dead	0.41	0.49	0.72	0.95	0.25	0.12
Weaned	8.60	7.26	8.35	2.83	0.11	0.29
Weaning age	63.4	58.2	57.9	18.58	0.37	0.12
"live losses"	0.90	1.06	1.22	1.44	0.68	**0.037**
"total losses"	1.28	1.52	1.93	1.75	0.33	0.33
Excluding sows early weaned with 0						
N	39	34	38			
Total born	9.66	9.85	11.09	2.08	**0.007**	**0.035**
Born alive	9.27	9.44	10.32	2.05	**0.061**	**0.004**
Born dead	0.39	0.41	0.77	0.97	0.16	0.12
Weaned	8.60	8.62	9.08	1.71	0.48	0.74
Weaning age	63.4	68.3	60.8	10.22	**0.011**	0.19
"live losses"	0.91	1.11	1.30	1.43	0.56	0.10
"total losses"	1.28	1.53	2.08	1.76	0.20	0.58

The Camborough 12 gilts produced significantly more piglets in total per litter, and more born alive, however, there were no significant differences between the breeds regarding numbers weaned or losses. Total losses represent 13.3%, 17.2% and 18.0% of total births for Saddleback, Saddleback x Duroc and Camborough 12 respectively, or 13.3%, 15.5% and 18.8% when the early-weaned sows are excluded.

Both farms reported a problem with fox predation at times during the year. One also reported piglet losses due to badgers. On one of the farms, all three breeds of sow were brought in. On the other farm, the Saddleback and Saddleback x Duroc sows were home-bred, with only the Camborough 12s being brought in. Therefore on this farm, the

Camborough 12s would have been exposed to a greater immune challenge than the home-bred gilts, and this may have affected the viability of their piglets. If this was the case, the difference would be expected to disappear over subsequent parities as the sows mature and acclimatise to the microbial environment. As might be expected, the two farms showed different levels of performance. However, the same trends were apparent at each farm (no significant farm x breed interactions), suggesting that factors other than acclimatisation differences were also influencing piglet losses.

Feeding

One of the objectives of the present study was to appraise the range of feedstuffs available to organic pig producers and appropriate utilisation strategies. A handbook has been drafted, and will be updated as results from this and other worldwide studies become available (Edwards, 2001).

Self-sufficiency is an aim of organic farming. The use of high-density cereal based diets, where many of the ingredients have to be imported onto the farm, goes against this principle and may be in competition with human food requirements. Many conventional producers successfully use co-products from food processing (such as brewer's grains or whey) to reduce feeding costs and promote sustainability. As demand for processed organic foods increases, some of these products may become available for organic farmers; however, at least in the short term, a more reliable alternative feed source is likely to be home grown forages.

In outdoor-reared stock, the pasture itself is a source of forage; pigs may be observed to spend long periods grazing, as well as rooting pasture. The palatability and nutrient content of pasture, and the intake of grazing pigs, will vary with time of year, climate and plant content (Rivera Ferre *et al.*, 2000).

During the summer of 2000, a small study was conducted within the main project (Mowat *et al.*, 2001) to assess the nutritional contribution of pasture for growing pigs. This involved two groups of six pigs of 50-60 kg liveweight, on a one-year old grass-clover ley. Each group of pigs was housed in a paddock approx. 10m x 30m (50 m^2 per pig), with one straw- bedded arc, a trough drinker, and *ad libitum* access to the farm's standard 80% organic grower concentrate.

Grass consumption was evaluated using an established technique (Wilson *et al.*, 1999). The pigs were trained to accept hand-feeding of a small cake twice daily. Five of the twelve pigs learned to do this reliably, and thus were selected for further study. For ten days, the cakes were loaded with a natural plant wax marker dose containing 125mg C_{32} alkane. The first five days were used for adaptation; during the second five day period, all faeces voided between 08:00 and 16:30 were collected and frozen. Herbage samples were taken on the first and last days of collection. Grass, clover, concentrate and faeces were analysed for their content of alkanes of different chain length, permitting intakes of individual feed components to be estimated. The contribution of herbage and concentrate to daily organic matter intake are shown in Figure 1. Herbage contributed approximately 4% to daily organic matter consumption. This is comparable with the 3% forage intake reported for commercial organic farms in Denmark by Lauritsen *et al.* (2000).

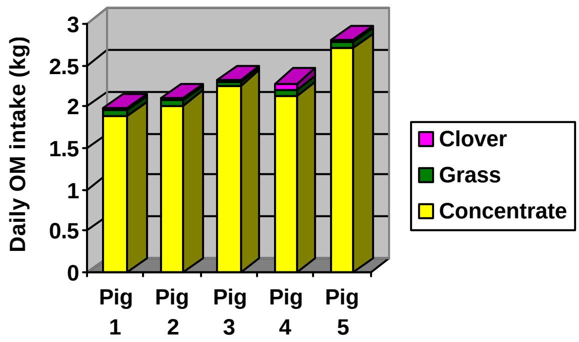

Figure 1. The daily organic matter intakes of individual growing pigs at pasture.

Higher forage intakes can be achieved if concentrate is restricted. Hansen *et al.* (2000) reported that pigs fed concentrate at 70% of their *ad libitum* intake consumed 5-9% of their daily energy intake in the form of grass or barley/ pea silage. This reduced daily liveweight gain by 14-16%, but feed conversion efficiency was not significantly affected.

Lactating sows have a high energy requirement due to the demands of milk production, and may not be able to eat sufficient quantity of bulky feeds to meet this demand if concentrate supply is limited. The extent of this is likely to be partially breed dependent, as breeding for leanness and improved feed efficiency has inadvertently selected for reduced appetite in some modern genotypes (Webb, 1989).

Pregnant sows are restrict fed at levels well below appetite, and forage in the form of grass-clover silage may contribute up to 40% of daily DM intake (Larsen and Kongsted, 2000), or whole crop silage up to 80% (Lauritsen *et al.*, 2000). However, results are very variable and more information in this area is needed.

As well as nutritional advantages from feeding forages, there are welfare benefits due to increased gut fill, and provision of an additional behavioural substrate. Braund *et al.* (1998) reported that pregnant sows, without nose rings, fed a diet containing 60% sugarbeet pulp, performed significantly less rooting behaviour than those fed standard diet, and pasture damage was reduced, although not significantly. There may also be beneficial influences on health, both through promotion of a healthy gut microflora and due to the fact that low fibre or finely ground diets are known to lead to an increased prevalence of gastric ulceration (Lee and Close, 1987).

Breeding and feeding

In the current study, on one of the two farms, we are using the progeny from the three breeds of sow to investigate the separate and interactive effects of breeding, feeding and housing strategies for the growing pigs. The design of this part of the project is shown in Table 2.

Table 2. Design of the breed/ feed/ housing study

3 breeds	-	Saddleback; Saddleback x Duroc; Camborough 12
x		

3 feeds	-	Concentrate only; Concentrate + silage; Concentrate + fodder beet
x		
2 housing	-	Outdoors (paddock + arc); Indoors (deep bedded + outside run)
18 treatments	-	replicated four times each: 2 groups of boars, 2 groups of gilts

The forages used in the trial represent readily available organic forages, which can be grown in most parts of the UK. Other possible crops such as maize silage are limited geographically, and thus were not investigated for the present study. Fodder beet gives one of the highest yields per hectare of the forage crops.

Outdoor housing of pigs provides welfare benefits in terms of greater behavioural freedom, and a varied environment, however, extreme weather conditions, in summer and winter, may not be adequately compensated for by the available shelter. Different breeds of pig are likely to be affected to different degrees by this. In this study we are comparing outdoor housing at pasture with indoor housing combined with an outdoor run, an alternative which is permitted under EU organic standards.

All pigs have access to straw throughout the study; water is available *ad libitum*; concentrate feed, and forage where allocated, is offered *ad libitum* until the last 1-2 weeks before slaughter when concentrate is restricted in line with commerical practice on this farm to produce carcases with acceptable levels of backfat (P_2).

Pigs are weaned at approximately 8-9 weeks of age, and spend 1-2 weeks in weaner chalets (arcs with straw-bedded run) before groups of six allocated to this part of the study. Liveweight at approx. 10 weeks of age is typically 25-30kg. The pigs remain in their allocated housing until slaughter at pork (70-85 kg liveweight) or bacon weight (90-105kg liveweight). Growth and feed use are recorded throughout the study period, together with indicators of welfare such as pig and housing cleanliness, and faecal worm egg count. At slaughter, cold carcass weight, P_2 fat depth (mm) and calculated carcass lean meat % are recorded for each pig. The lungs are examined for signs of pneumonia or pleurisy, the livers for milk spot (*Ascaris suis* infestation), and the stomachs for pathological changes (including ulceration) to the *pars oesophagea*. Meat samples are taken from boars and gilts for future evaluation by a taste panel. Samples of fresh pork, as well as the processed products of sausages, bacon and ham, will be examined.

This work is ongoing, with approximately half of the 72 groups allocated. Results will be made available when analyses of the completed data set have been carried out at the end of this part of the project.

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Breeding goats for organic production in Germany

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Introduction

With only 120,000 females (year 2000), goat keeping is a niche activity in animal husbandry in Germany. Most of the goats (about 90%) are kept on part-time farms. The main reasons they are kept are as a hobby, for milk production and for landscape management; in many cases it is a non-profit oriented activity. There are estimates (no official statistics exist) that 20,000 goats are milked and 10,000 are used in landscape management to avoid shrub succession on protected biotopes. In the year 2000 10% of the goats (12,000) were kept on organic farms but not all for economic reasons.[1]

Because the dairy breeds in Germany (White and Brown German Alpine) are selected under intensive keeping conditions, breeding under the restrictions of organic farming is necessary to get adopted and high yielding flocks. This is even more true in the case of harsh environmental conditions in landscape management. The German breeds are not suitable for the needs while grazing on marginal biotopes. This paper will show some results of:

- a ten-year breeding programme for more milk ingredients, fat and protein, in a flock of 30 mother goats on an organic farm and
- the breeding programme of the “Witzenhäuser Landschaftspflegeziege WLZ” for the new purposes of landscape management.

[1] This is the highest proportion of an animal species on organic farms. In 2000 only 0.5 to 1.5% of the total cattle, pigs and hens were kept on organic farms.

The history of goat breeding in Germany

Goat keeping has a long tradition in Germany. They were kept by poor and landless people, rarely by land owners. Goats were the “poor people's cow”, easy to keep, cheap to purchase, quick to reproduce, and they delivered milk and meat in home consumption quantities (Benecke, 1994). Breeding was based on the knowledge and capabilities of the goat owners, inbreeding the method of reproduction (Abel, 1978). Therefore many different local breeds appeared. The animals were small and low yielding but very tough in harsh environments and keeping conditions. In the 18th century, with the devastation of the woodlands, goat browsing in the forests was prohibited under penalty of severe punishment and a hefty fine. Goats left the forests and pastures and went into the stables. At the end of the 19th century about three million goats were kept in small herds of between one to five animals in small stables in the backyards of people's houses (Gall, 1982). Most of the goats were kept by workers in the villages and cities but also by people living in remote areas. Large numbers of goats could be found in industrial areas ((e.g. the Ruhr), mining areas (e.g. Salzgitter/Peine, Harz) and big cities (e.g. Berlin, Hamburg, Munich) (Comberg, 1984)).

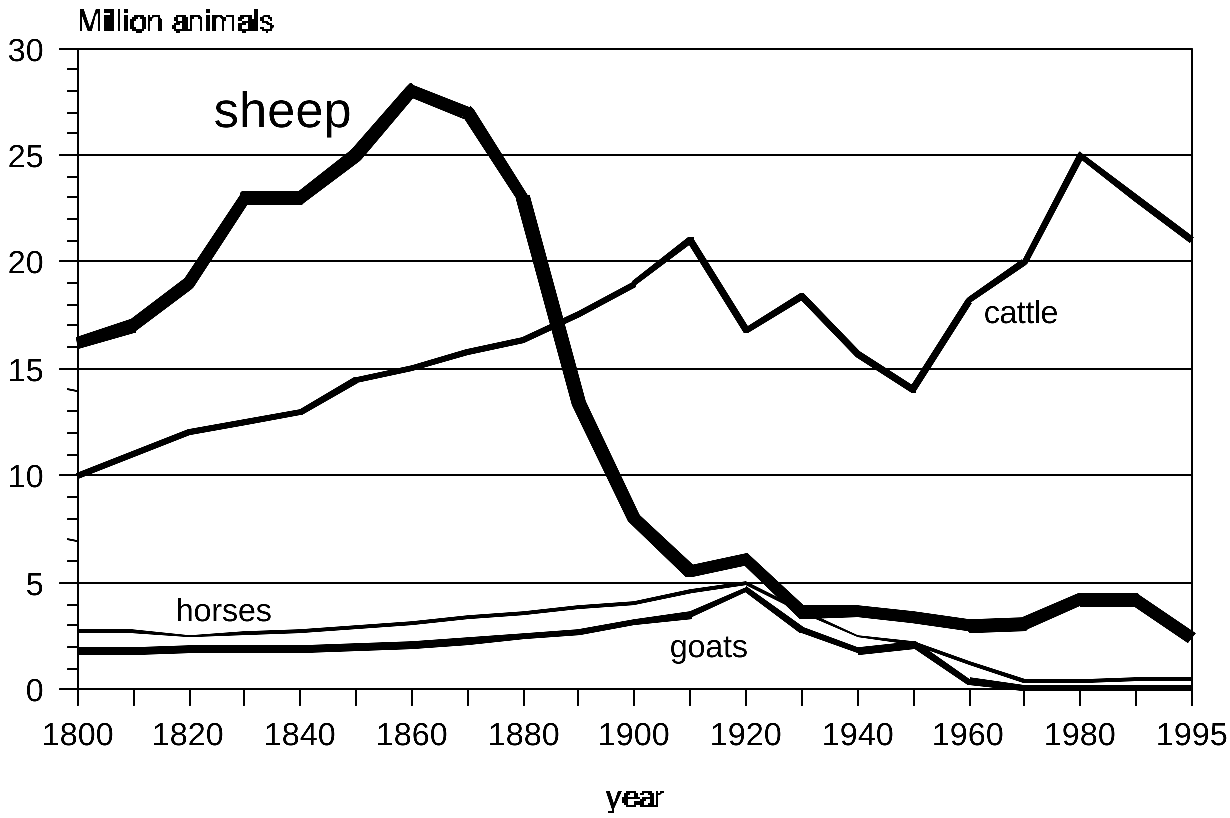


Figure 1: The development of animal keeping in Germany in the last 200 years

Source: Rahmann, 1998

No planned breeding took place until the end of the 19th century. In the year 1884 the first bucks of Saanen and Toggenburger breeds were imported from Switzerland to improve the milk yield of the local breeds (Dettweiler, 1902). Since 1902 breeding bucks have required breeding certification by law. Every village had to keep a buck for mating. The first private breeding associations were established in Hesse and in some cities in the Ruhr. After the First World War five million goats were kept in Germany. After that peak the numbers decreased rapidly and reached their lowest level of only 36,000 animals in 1977 (Figure 1). It was decided that goats would be excluded from the statistical farm livestock census (Gall, 1982). Because there are no official statistics and no goat census has been conducted since 1977, only estimates of goat numbers are available. Nowadays about 120,000 goats are kept in Germany, most of them in Bavaria (27%) and Baden-Wuerttemberg (26%) (Rahmann, 2000).

Two native dairy breeds are of importance: the White German Alpine and the Brown German Alpine (Weiße Deutsche Edelziege and Braune Deutsche Edelziege). The former make up 30% and the latter 65% of the German goat population, while 5% come from 12 other breeds.[2] The reason that only two dairy goat breeds exist today is that in 1928 the "Reichsverband Deutscher Ziegenzuchtvereinigungen"(goat breeding association) decided to combine all white and all coloured breeds into a single breed of each. In Germany the milk yield of well-managed dairy goat herds is about 1,000 kg per year in conventional farming systems (Table 1) and 700 kg per year in organic farming systems. Top yields of individual animals can reach 1,500 kg and more per year. The fat and protein content is an important factor for cheese production. In conventional farming the production of 50 to 60 kg fat + protein per goat per year is common with the high yielding dairy goats (Lange, 1999). (see also Table 2)

Table 1: Comparison of high yielding dairy sheep, dairy goats and dairy cows (figures from conventional farming)

	Dairy sheep (East Frisian Milk Sheep)	Dairy goat (White German Alpine)	Dairy cow (Holstein Frisian)
liveweight in kg	80	60	650
Metabolic liveweight $kg^{0,75}$	27	22	129
Fodder intake in kg dry matter/day	2.7	3.0	18.0
Lactation yield in kg	600	1,000	7,000
Fodder intake in $g/kg^{0,75}$	100	139	140
Lactation yield in $kg/kg^{0,75}$	22	46	54
Fat yield in $kg/kg^{0,75}$	1.3	1.7	2.2
Protein yield in $kg/kg^{0,75}$	1.1	1.3	1.8

Source: Bellof & Weppert (1996); Heindl (1997)

[2] During the last few years the South African Boer Goat has gained some importance in Germany for meat production.

Table 2: Contents of cow, sheep and goat milk (dairy breeds)

	Cow milk	Sheep milk	Goat milk
Water	87.7%	83.2%	88.0%
Fat	4.0%	6.2%	3.5%
Protein	3.4%	5.3%	3.0%
Lactose	4.8%	4.4%	4.7%
Minerals	0.7%	0.9%	0.8%

Source: Lange (1999)

The flock size of a full-time dairy goat farm is not more than about 50 lactating goats plus youngstock.[3] Dairy goat farms are established under conditions of shortage of high productive land and lack of capital. Therefore goats are still the "poor people's cow". Income is generated by high levels of processing and direct marketing of goat cheese. About 80 labour hours per year are needed for one dairy goat: 30 hours for keeping and milking, 30 hours for processing and 20 hours for marketing. In Germany goat cheese is a niche product with a very limited market potential (one goat farmer per 100,000 inhabitants is enough to satisfy market demand). About 20 EURO are paid on the farming markets for one kg soft cheese and 25 for hard cheese. With established dairy goat farming 7 to 8 EURO per labour hour is the usual return.

Breeding in organic dairy goat farming

The high yielding dairy goat breeds in Germany are kept on organic farms as well. The improvement of these breeds is focused on the fat and protein content of the milk. Because of the regulations a specific type of breeding in organic farming is needed. Selected breeding goats from conventional farms are tested under conditions which are not comparable with conditions under organic farming regimes. Therefore productivity and fitness is much lower than expected. The restrictive factors influencing the productivity of the animals are as follows: the purchase of animals from non-organic sources, limited concentrate feeding, roughage qualities that greatly fluctuate seasonally and annually, and the prohibition of preventive and allopathic veterinary intervention, in particular endo-parasite control. The breeding strategy respects the needs and health of the animal and takes the keeping conditions into consideration.

An analysis of the development of milk parameters and breeding strategy success was carried out on a full-time organic dairy goat farm in the middle of Germany from 1992 to 1998.[4] The farm has been managed under organic farming rules since 1982 and keeps

[3] Because many goats are kept on part-time farms and for hobby reasons, only four goats are kept per goat keeper (33,844 goat farms with 120,000 goats). It has been estimated that only 100 farmers in Germany keep goats as the main activity at their full-time farm. There are only a few farms where more than 100 dairy goats are kept. The goat density is very low: 0.591 goats per km^2 farmland and 1.957 goats per km^2 pasture. Figures for dairy cows: 30 per km^2 farmland and 100 per km^2 pasture; beef cattle: 62 and 157; pigs: 91 and 301; sheep: 14 and 45 (RAHMANN, 2000).

[4] Professional, well-run organic dairy goats farms are very rare in Germany. Other farms with the same quality of production, long-term experience in organic farming, a controlled breeding strategy and good data recording were not available. This study was and is still the first scientific analysis of breeding success in organic dairy goat farming in Germany.

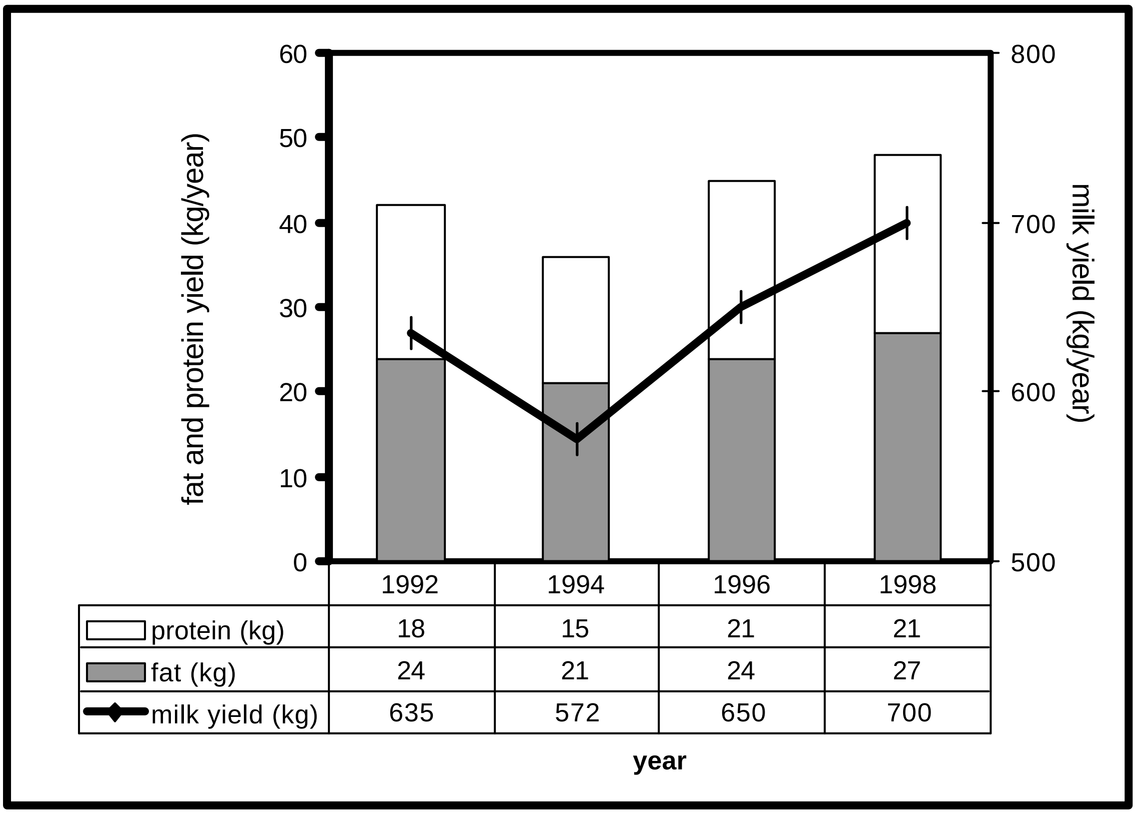
30 to 35 dairy goats (Brown German Alpine). The farmer is well experienced in management and animal production. The feeding is 30% concentrates (on-farm production of barley, wheat, carrots and peas) and 70% roughage (dry matter) during lactation with considerations of the lactation status. The goats graze on pastures from May to October and in a warm stable in the winter season. No female goat has been bought since 1982. Breeding bucks only are bought every second year. The breeding is focused on increasing the total fat and protein yield per lactation and per life of the goat on the basis of independent milk control results. In addition to the milk control results, the number of twins, fertility and udder conformation are parameters for selection.

Results

In the six-year period from 1992 to 1998 the milk yield of the total dairy goat flock increased by 10% (1.67% per year), the fat yield by 12.5% (2.08% per year) and the protein yield by 16.7% (2.76% per year) (Figure).[5] Not every year is quite so successful. In the year 1994 the goats suffered from cold and wet summer weather. The energy requirement for body maintenance, low quality wet fodder and reluctance to graze intensively are the reasons for low milk, fat and protein yields. In organic farming the long term trend is more important than in conventional farming due to environmental impacts. This could lead to the interpretation that a breeding strategy should focus on protein yield. The close relation between fat and protein yield in relation to fodder quality hinders this. The breeding strategy should give attention to the total yield of both fat and protein.[6]

[5] It is surprising that all figures are positive. There is a slightly positive correlation between protein and fat yield but a negative correlation to milk yield.

[6] For goats the heritability of 50% for fat and protein yield is slightly above the figure for cattle (40%). The heritability of milk yield is 20% for cattle, while goats show a slightly higher heritability here, too (LANGE, 1999). From cows we know that the best selection parameter is the fat content.



	1992	1994	1996	1998
protein (kg)	18	15	21	21
fat (kg)	24	21	24	27
milk yield (kg)	635	572	650	700

Figure 2: Development of the milk yield and the fat and protein content of the dairy goat flock from 1992 to 1998 (n = 30 to 35)

In addition to the annual impact (Figure 2), the seasonal impact on fat and protein yield is also obvious in Figure . The year 1998 enjoyed good summer weather. Even without milking in November, this year gave the highest quantities of fat and protein. The weather in 1997 was also very good for goat keeping. This can been seen in the good quality of winter roughage in February 1998. The breeding season in autumn 1997 was also successful and had an impact on the fat and protein yields in 1998. An unusually greater number of twins was born (+20%). With twins there is a higher milk, fat and protein yield than with single kids (roughly 10%; Gall, 1982).

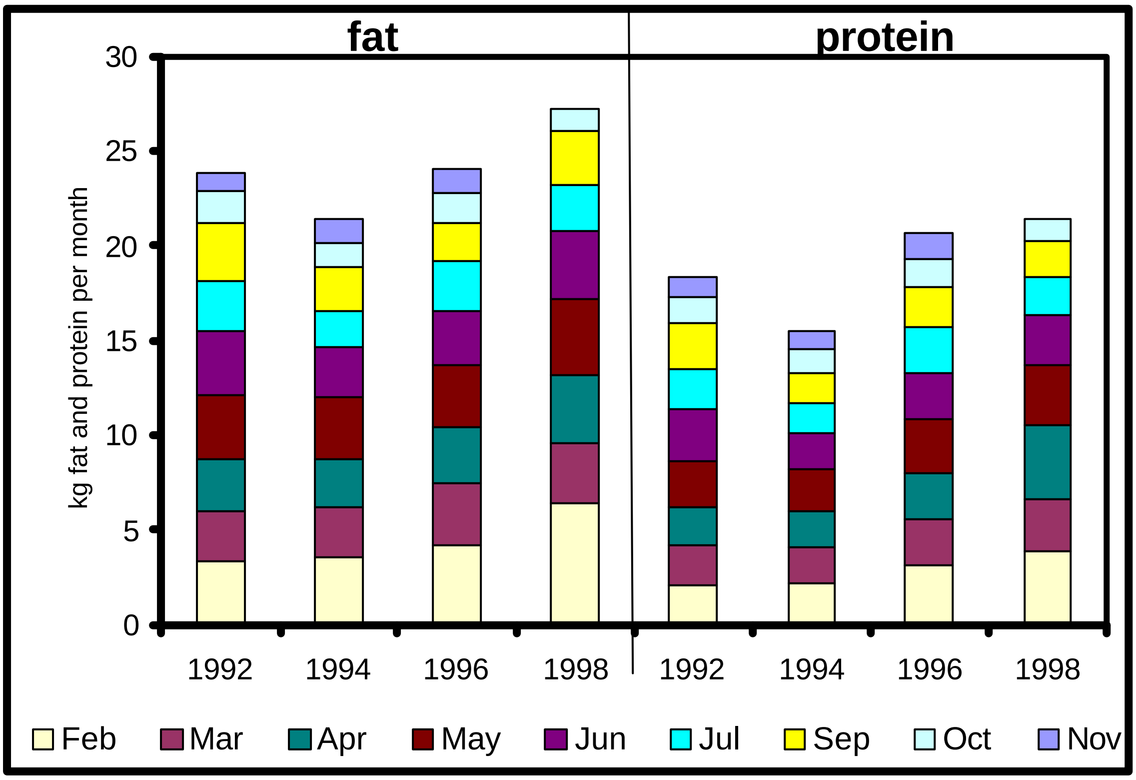
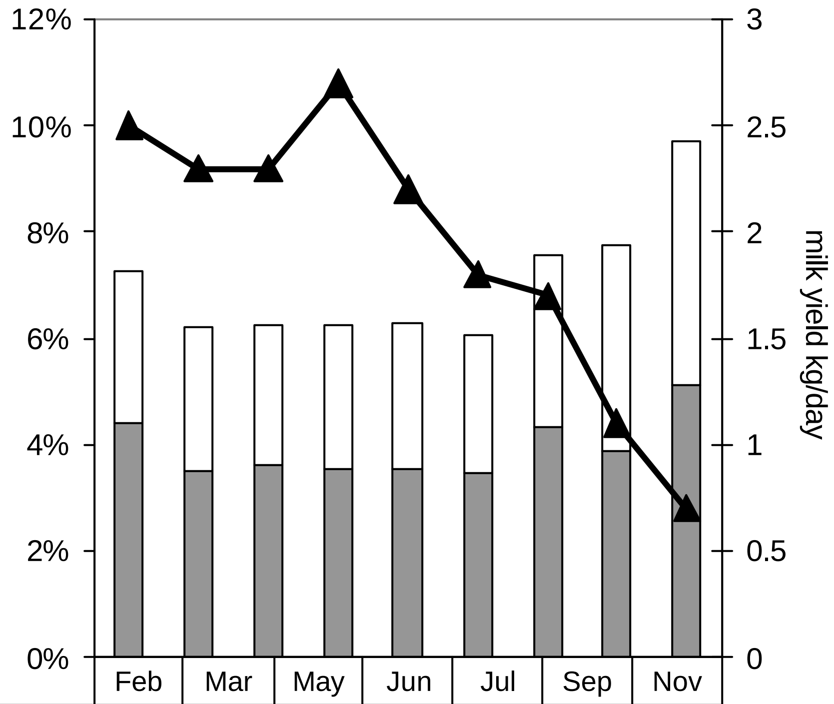


Figure 3: Fat and protein yield by lactation months 1992, 1994, 1996 and 1998 in kg/months (n = 30 to 35)

Breeding should not only look for the annual milk, fat and protein yield but also for even distribution over the lactation period (especially soft cheese production). In Figure 4 it is obvious that the milk content increases with increasing lactation status (thickening effect). Over six months from March to July the fat and protein content in the milk is stable. Breeding should aim for homogeneous distribution over the lactation period. This is also important for the health of the animal.



	Feb	Mar	May	Jun	Jul	Sep	Nov
protein content (%)	2.87%	2.71%	2.70%	2.75%	2.60%	3.23%	4.61%
fat content (%)	4.40%	3.50%	3.54%	3.53%	3.48%	4.34%	5.12%
milk yield in kg/d	2.5	2.3	2.7	2.2	1.8	1.7	0.7

Figure 4: Impact of lactation status on milk yield and fat and protein content (1998; n = 33)

The breeding strategy should take into consideration the fact that the milk, fat and protein yield depends on the lactation number. The second lactation year seems to be the best in organic goat flocks (Figure). But the yield will be lower in the next lactations. The breeding strategy should select young stock from older mothers, which can be compared after several years of lactation. Only these production figures give reliable data about the individual potential of the flock. If data from several years are not available, remontation stock should only be selected from mothers in the fourth or fifth lactation.

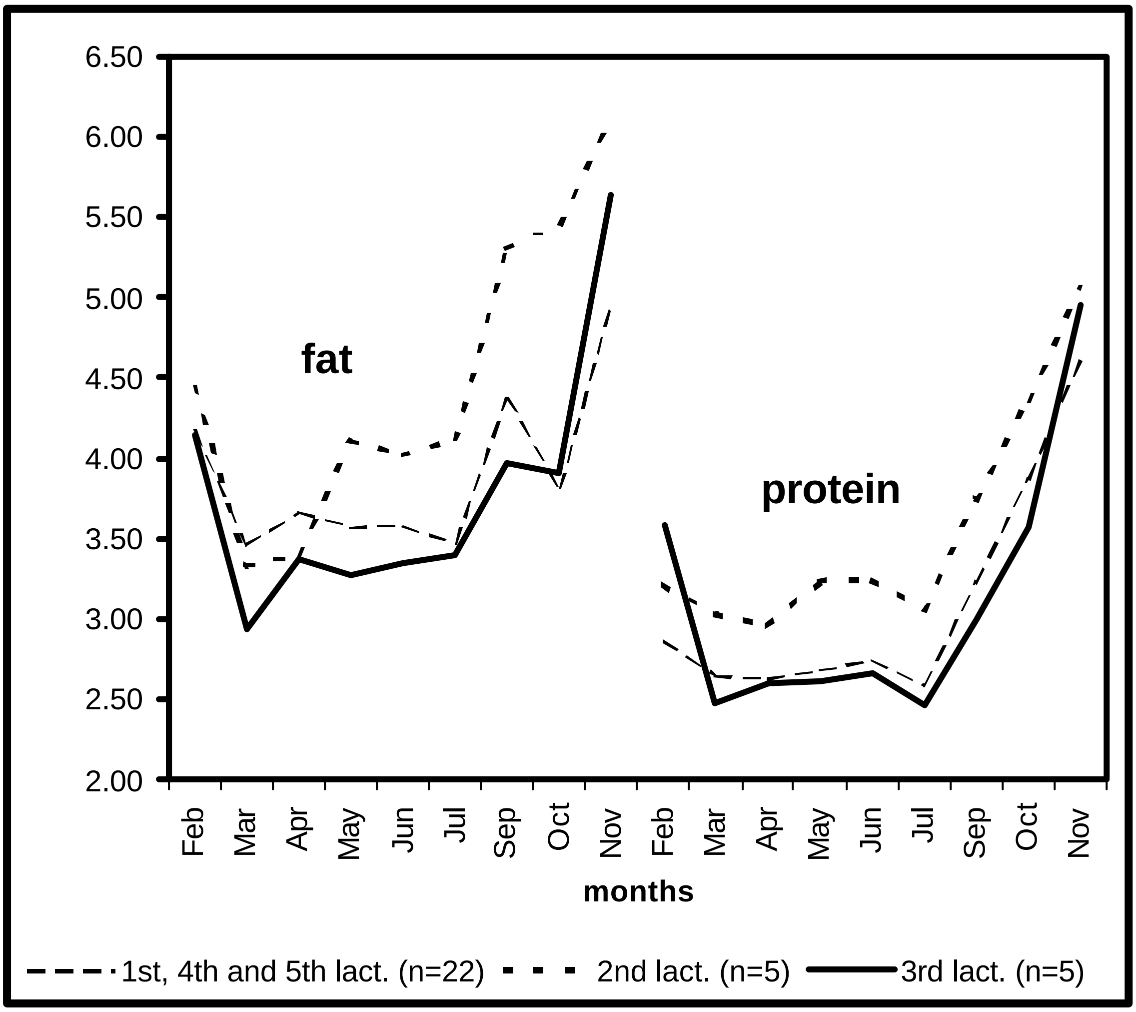


Figure 5: The impact of the lactation number on fat and protein content (1998). (The "Y" axis is fat and protein content (%))

Breeding of robust goats for landscape management

None of the German goat breeds[7] is suitable for extensive grazing on marginal land (no shelter, no supplementary feeds, low roughage quality on the biotope). All German breeds suffer under harsh conditions. In order to develop a robust alternative breed which can cope with extensive conditions, the breeding programme for the "*Witzenhäuser Landschaftspflegeziege*" was set up (Rahmann & Tawfik, 1995)[8].

[7] Goats have an advantage in prevention of shrub invasions on protected biotopes. Up to 50 percent of a goats intake can originate from eating shrubs and bushes. Shrubs and leafs are excellent fodder for goats. This is not considered in the regulations for organic farming in Germany. The pastures in Germany are not acceptable from point of view of animal welfare. Steep, stony and shrub invaded fallow pastures are the best environment for goats.

[8] In Germany, this is the first breeding programme for new functions in animal husbandry since the Second World War. In German agriculture the pure breed strategies are dominant. By selecting from the pure breed populations it is hoped that new functions or keeping conditions might be achieved. From organic farming we know that that is difficult or impossible. The

The aim was to breed a new species of goat which is optimally adapted to the conditions of marginal areas - such as protected calcareous grassland - by crossing the German Alpine goat, the Boer goat and the Cashmere goat (Figure 6).

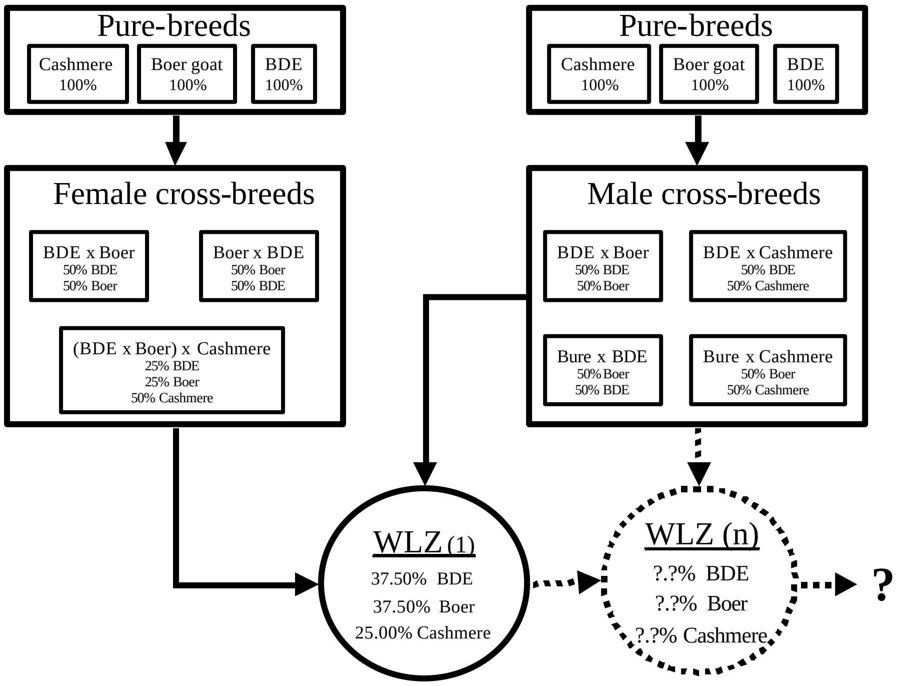


Figure 6: Breeding programme of the "Witzenhäuser Landschaftspflegeziege"

Source: Rahmann & Tawfik (1995)

In general, existing or newly developed husbandry systems have to be adopted to the needs of the conservation site, to the livestock used and to the animals' keeper so that the resulting product satisfies consumer expectations. In Germany goats are mostly known as a dairy animal, and goat meat is often neglected by the consumers. A sizeable amount of kid meat can be sold only at Easter. Thus, there is great need for awareness-raising around the quality and taste of goat meat. This means that constant investigations into carcass and meat quality are necessary. The advantages of good meat quality and quantity cannot compensate the disadvantages of extensive keeping in the climate of LFAs in Germany when the meat cannot be sold for a high price.

The best weight of goat kids for selling is 12 to 25 kg liveweight with a carcass weight of 6 to 14 kg (52-57% of liveweight). The weight of 20 kg was achieved by kids of the high yielding German goat breeds BDE and WDE at an age of 2.5 to 3 months, the meat breed Boer goat at 2 to 2.5 months. The kids are supplement fed and suckled. The best selling time is Easter when there are high prices and relatively high demand. The kids cannot be slaughtered when the mothers of milk breeds are not milked (mastitis problems), so suckling during the summer season is necessary. When the kids are sold

keeping of high yielding animal breeds (e. g. hybrid hens, turkeys, Holstein Frisian, Piétrain pigs) is like "using a Ferrari off-road".

in autumn after biotope grazing they are too big to sell for a high price. Boer goats as a meat breed have been seen as a solution to the constraints of biotope grazing. The kids grow much faster than the milk breeds and have an excellent carcass in quantity and quality. The problem is that this breed is not tolerant to harsh conditions during biotope grazing and winter time. Low yielding breeds (e.g. Cashmere) traditionally do not exist in Germany but are important for biotope grazing because they are climatically more tolerant than all German breeds. The disadvantage is in marketing. They have very low growth rates (below 100 g/day) (see Figure 7) and the kidney fat and subcutaneous fat are immense. They are not preferable as meat (Rahmann, 1998).

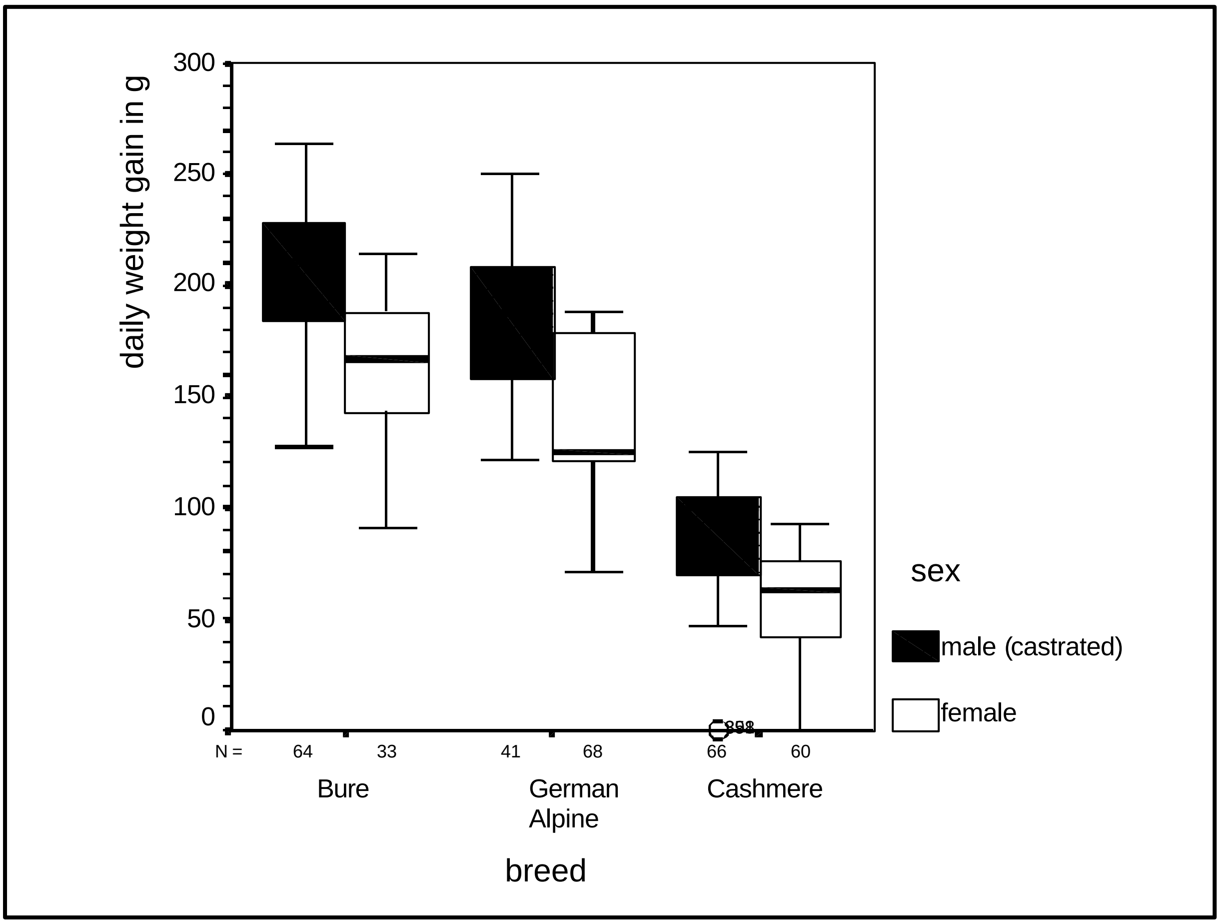


Figure 7: Growth of kids of different breeds under marginal conditions

Source: Rahmann, 1998

Goats generally have a lower weight gain than sheep. Secondly, the quality, distribution and concentration of fat are different to lamb. The intramuscular fat is very low and hardly exists at all during biotope grazing. Kidney fat content is high and smells after a second warming up. Thirdly, the meat is not preferred culturally and many consumers will not eat the meat.

The quantity of meat produced during biotope grazing is less important than for lamb, as direct marketing is the major way of selling. Small carcasses are preferred. When Germans buy goat kid meat they do it for special occasions, like Easter, and they prefer not to store it (freezing). Only some slaughterhouses slaughter goats and they are located in towns with many Muslim or Greek consumers (Berlin, Ruhr, Munich, Hamburg). The transport of goats to these markets is not normally done by goat keepers because it is too expensive; instead the animals come from abroad. The wholesaler price for goats is very low because there is no real competition, and traders and suppliers of meat do not like goats because the market is very small.

Table 3: Carcass quality of kids reared under different environmental conditions

	Intensive, female	Intensive, male	Biotope, female	Biotope, male
Dressing percentage:				
• mean (%)	48.55	48.39	45.53	48.08
• Standard deviation (%)	1.26	1.60	1.73	5.72
High quality parts of carcass:				
• Mean (% of carcass)	42.75	44.69	45.00	44.42
• Standard deviation	1.84	1.17	1.85	1.01

Source: Haumann (2001)

Goats have a higher percentage of muscles than sheep. Unfortunately the meat is not concentrated in special parts of the body - "high quality parts" like hind legs and back - but spread evenly (Haumann, 2001). Looking at the feeding strategy, intensively fed females had a lower amount of "high quality parts" than extensively fed ones (Table 3). For male kids there was no distinct difference in the amount of "high quality parts" for the two feeding strategies.

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Breeding for race diversity, herd adaptation and harmony of animal build: a breeding concept in organic farming

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BOX 8.1: The future of DNA - Presuppositions in science and expectations in society
(Van der Wal and Lammerts van Bueren (eds), 199@)

The rapid progress in biological and biomedical sciences in the last twenty years has brought with it an extensive development of the methods of molecular genetics. This has had impacts on society in many fields. Practical applications in medicine, pharmacology, agriculture, food design and biotechnology are firmly established and will grow enormously in the years to come. The scientific views of DNA and genes which underpin these applications are challenging our fundamental concepts of life, nature, society and humanity. It is beyond doubt that these developments need to be evaluated and reflected upon, both from a scientific and philosophical point of view, as well as from a cultural and social perspective.
This book provides a wide range of discussions about the effects of DNA thinking in science and society, in biology and in relation to what it is to be human. Insights are provided into transdisciplinary approaches and divergent views are compared. The reports on the plenary discussions and the many workshops show progress towards a power-free dialogue, i.e. an exchange of thoughts, free of economical and political pressure.
The viewpoints of a variety of specialists including scientists (microbiologists, molecular geneticists and clinical researchers), clinicians, philosophers and members of NGOs are presented. The contents will be of particular interest to those involved in genetic engineering, from students to policy makers, who face the challenge of the new technology in their work and who are looking for a substantial expansion and complementation of their basis for judgement forming.

Introduction

Within a group of scientists the spiritual side of genetic modification was discussed. However, genetic modifications is not a large issue in farm animals and the group discussed a vision of animal breeding from the point of view of organic farming. The results were published in a discussion report (Van der Wal and Lammerts van Bueren, 1993).

Methodology

Initially, a report was written about the practice of family-breeding (Baars, 1990). Working from the scientific background of an ecologist (Ton Baars), there was immediately a feeling that family-breeding was the key solution for site related adaptation. Secondly, a farmer group was established around the subject of dairy breeding in organic farming. Within this group, contact was made with professor Bakels, emeritus professor at the Munich University and founder of the Program for Lifetime Breeding for the Holstein race (Bakels and Postler, 1986; Postler, 1990 and Haiger *et al.*, 1988). Professor Bakels visited the Netherlands several times (1989–1991). Thirdly, the research group (Louis Bolk Institute) was asked to become a member of the Dutch network on genetic engineering. This network was started by concerned antroposophist dealing with the impact of DNA manipulation life (Van der Wal and Lammerts van Bueren, 1993). Additionally, two new findings were important to finalise the vision. Firstly, there was a meeting with the breeder of Dutch Friesian cows, Cees Dekker, who formulated the sense of beauty as a viewpoint within breeding. This farmer had developed a complete, harmonious animal based on relations which fitted very well with the harmony of the so-called Golden Section. This attention for harmony was for us an answer on the conventional breeding strategy based on animal parts. Secondly, the work of a biologist, Schad (1977), about the wholeness of our mammals and the inner interrelationship based on the antroposofical, holistic principle of threefoldness of the human spirit: thinking, feeling and willing was explored. Schad developed a feeling of the cow's integrity, based on the spiritual interrelationships within the world of mammals.

Results

The answer to the decline in diversity: site adapted landraces

In organic farming, breeding should be used to reinforce the relationship between the bred animal and the environment in which it has to live. Plants and animals are the expression of a certain (semi-) natural environment. Plants show this, in the first instance, in their appearance and their capacity to adapt to a particular environment, animals show it not only in their build but also in their physiology and their behaviour. Differences between farms spring from differences in soil quality, their situation in climatic zones, etc. Breeding and improvement should therefore, from the organic point of view, follow on from the improvement of the original native breeds. That is to say, a small-scale improvement in which one looks consciously to reinforce those qualities which suit a particular environment, not so much adapting as fitting in.

The family breeding method, as currently practised by a handful of individual breeders, ensures that within a current farm environment a farm-specific cow will emerge (Baars, 1990). Among the remaining Dutch-Friesian farmers in the Netherlands, some have started breeding farms based on the family breeding system to provide foundation stock for this ancient breed. They can serve as an example for the aspirations of organic dairy farming. At the same time, organic dairy farmers will have to be realistic and not restrict themselves too quickly to home-bred bulls. This requires the presence of a certain standard in one's own herd. In the first stage, it may be worthwhile to buy in animals from other farms and to use bulls from suitable families. At a later stage, it may be sufficient to introduce new blood by using a single bull or by buying in a female animal.

However, it is important to continue breeding as much as possible within one's own herd. Family breeding offers ideal opportunities for achieving versatility. Regional breeding of this nature makes it possible to reflect the diversity present in the different landscapes in the build, physiology and behaviour of a domestic animal. Animals and surroundings can thus be brought into balance and be further improved together.

A sense of beauty and proportion: harmony in build

In addition to biased production characteristics, some breeders also consciously take account of the 'harmonious proportions' of the animal. An animal's build and bone structure are considered important determinants of whether an animal will be a good milking cow. The American, Bill Weeks, developed the 'aAa' (triple A) system, in which he supplements production-based criteria with the strong and weak points of an animal's build. In pairing a dam and sire, he tries to select animals in such a way that their offspring will be a harmoniously built dairy cow. Weeks concluded that the better farms succeeded in 'harmonious' pairings, the longer the mean life expectancy of the herd, as compared with farms, which did not practice compensation pairing. This can be explained by the fact that good milk production does not depend on a good genetic basis for milk production alone: it is also important that the animal is healthy and remains fertile and problem-free. The result of this approach is a harmoniously built, strong, balanced cow that adapts readily to conditions on a working farm, comparable to the growing conditions of a healthy crop. Weeks originally distinguished two types of animals: a more flat-ribbed type and a more round-ribbed type. Later, he made further distinctions within these types, dividing each of the main types into three subtypes. The ideal cow averages out all the extreme types in its build.

Another view of the harmony concept can be traced back to Dutch Friesian breeder, Dirk Endendijk (Baars, 1990). As a breeder he values a harmoniously built cow. Harmony in build makes a milk cow into a good breeding cow. Endendijk judges this by eye, from his own sense of harmonious proportions. In the Seventies, Dutch Friesian breeder Cees Dekker from Vierpolders defined 'the ideal Dutch Friesian cow' for the Dutch Friesian breed. Dekker goes so far as to indicate the ideal cow in numerous sizes. What is striking about Dekker's definition is that essentially it comes down to the numeric ratios of 1:2 and 1:3. When we asked breeder Endendijk to show us what he considered harmonious animals, his choices reflected the standard measurements of Dekker. It should be noted that Endendijk, Dekker and Weeks are all concerned with the relationships between body measurements, and not with the absolute value of the different variables. Thus, Weeks' system can be applied equally well to Blaarkop cows as to Jerseys and Holsteins. Absolute height, for example, is considered irrelevant; harmony has to do with relationships.

Consciously or unconsciously, all three breeders have an instinctive sense of beauty, which is normally only discussed in art. The ratios used by Dekker show much similarity with the proportions of the Golden Section, which was used in the built up of paintings and led to a harmonious partition of the painting. All three breeders looked at the interrelationships between the different characteristics. In this way, they can prevent breeding too singularly for a specific characteristic such as height or INET. The danger in reducing everything to numbers is that the context in which the data were collected can no longer be assessed. For this reason it is essential to test data continuously in real life, looking at the animal as a whole. This also prevents certain characteristics, such as fertility and life expectancy, being forgotten or overlooked.

This feeling for beauty and paying attention to interrelationships is not only important for breeding and the animals' build. The family breeding system, in which efforts are made to match a cow type (native breed) to a particular landscape and soil type, also appeals to our sense of beauty. It is, after all, a matter of fitting a type of animal into a certain environment. Therefore the method of family breeding is a method that takes into consideration the interaction of genotype and environment.

A third way of incorporating a feeling for interrelationships and proportions is to consciously consider the effect that, say, breeding for milk production may have on the rest of the animal. Nowadays people are often inclined to concentrate on a single characteristic. Genetic progress (in milk) appears to proceed fastest when breeding goals focus on only one or a few characteristics. However, in that case one must also consider the characteristics which are changed unintentionally and simultaneously. So adaptive management has to be developed based on insights of the basic needs of each animal.

Acting based on animal's integrity: species-specific criteria
Another alternative to reducing the cow to its component parts was formulated by Professor F. Bakels (Haiger *et al.*, 1988; Postler, 1990). As a geneticist and vet, Bakels developed a breeding programme which centres around 'lifetime production'. Bakels' basic premise is to carry out selection based on characteristics which encompass all the sub-aspects of the cow (this method can also be applied to pigs and poultry). Here we are concerned with finding criteria which are not inspired by economic considerations (for example protein and fat content and now lactoglobulins) but which are taken from the totality of the cow as a living organism and as a living being. The primary selection characteristic is vitality (or fitness), the capacity of an animal to remain productive throughout its life without any serious problems. This is translated into life expectancy and energy production during a life (in offspring and/or milk and meat).

To make a proper assessment of Bakels' viewpoint it is important to understand that he attaches value to, among other things, the process of domestication of the cow and the regular behaviour patterns which the animal itself displays in this process. In this sense, Bakels, unlike Weeks, Endendijk and Dekker, has more consideration for the intrinsic characteristics of the cow. He allows the animal itself, as it were, to indicate the limits which should be observed in breeding in order to evaluate the cow as a cow. Bakels shows in his 'nature-like Breeding' how the domestication process has proceeded from prehistoric cattle to our domesticated cow. From this domestication process he traces all kinds of functional characteristics which are now a proper part of the cow. The following characteristics should be considered in the breeding process of dairy cows:
sexual dimorphism male/female
cows are walking animals
cows are ruminants
cows have a functional build (pelvic shape, flexible back)
physiological traits which are sex-linked.

With this system Bakels developed practical and practicable breeding and selection characteristics which leave the domesticated animal as 'whole' as possible, and which are in keeping with the 'nature' and behavioural preferences of the animal (Haiger *et al.*, 1988).

Schad (1977) chooses yet another approach to identify the typical characteristics of the 'cow being'. Based on the build of the animal species, their behavioural traits, and their vital functions Schad classifies our mammals into three main groups: rodents, predators and ungulates. Schad states that this trinity is a reflection of the threefold structure of man's spirit: thinking, feeling and willing (Steiner, 1904). This way of grouping can be called holistic. In humans these three sole domains are physically transformed into:
- sense and nervous system (upper body part and head),
- respiratory system / circulation system (breast), and
- metabolism / locomotion system (stomach and extremities).

Of the three main groups in mammals the principles and laws of the central nervous system are physically most pronounced in the rodents. These tend to be smaller animals with an outspoken alertness to their surroundings. In their bite the incisors are important. In contrast with the rodents, the animals with pronounced metabolism belong to the group of ungulates. The presence of hooves and in most cases protrusions on the head (antlers, horns) are characteristic of this group. In their bite the molars are the most important. The predators are more of a middle group, characterised by strong differences in appearance and size between male and female, the presence of a dappled skin, while the canine teeth are the most obvious feature of the bite.

The exciting thing about Schad's elaboration is that he continually finds a tripartite distinction at every further sub-division. Within the group of ungulates he makes a further classification into odd-toed ungulates, porcine and ruminant. The odd-toed ungulates (horses, tapirs, and rhinos) have the most clearly developed complex nervous systems, the porcine animals form a middle group and the group of ruminants (camels, deer, and bovine animals) are the most clearly metabolic polygastric animals.

All the different types of animals show a certain bias. By becoming aware of these biases, we can ask ourselves what function the animal (in this case the cow) will serve for nature, agriculture and man. Schad's work clearly illustrates that a cow is in the first instance the perfect example of a roughage converter. The animal exists to metabolise and transform plant substances into milk, meat and manure.

Such an elaboration makes one aware of the typical characteristics of, say, cows. Just as Bakels' approach, it can clarify what kind of being we are dealing with. Human action could now be aimed at housing and feeding all domesticated animals in accordance with their nature. Breeding and selection must let the essential characteristics of each domestic domesticated come into its own.

Bartussek (1991) indicated gradations of 'naturalness' in the agricultural production system. For this purpose he designed an 'animal need index' for feeding, welfare and breeding. Criteria for the index are drawn from animal-specific needs. Rist (1987) also start from the level of animal-specific needs with regard to animal welfare and housing.

Rist points out that the psyche and its expressions, both well-being and suffering, are immaterial. Herein lies the problem with the materialist scientist, whose numerically-based approach overlooks this immaterial level.

Three-part system as a breeding system?

It is striking how often breeding systems are based on 3 lines or families. In pig breeding, for example, often a three-way cross is used of three inbred non-related lines with complementary practical characteristics. The offspring of this cross are the most highly productive animals in practice. Bakels too opted for three lines when choosing his parent material. Further study of these lines (Haiger *et al*., 1988) makes it clear that they complement each other on many points (early maturing, late maturing, conformation, long-leggedness, milk production, fat and protein contents). Dirk Endendijk also uses three main lines on his farm, (Kate, Sjoukje and Jantje) plus a few other complementary families. In Weeks' aAa system we also see a division of the two main types into three subtypes. Qualities can be found in these subtypes which can in part be traced back to the three-part system developed by Schad (1977).

It may be that this three-part system is not coincidence but the elaboration of a natural law, connected to the three qualities of man, as elaborated previously by Schad. It is clear from the above examples that a more balanced, more harmonious entity is created by bringing together and harmonising three different qualities. By consciously striving to harmonise these different qualities for every animal species or breed, a more balanced animal will result. Breeders could become more aware of the different qualities and biases in individual animals. Good, balanced, practical animals occur when the types are brought together by pairing. Bakels, for example, advises farmers to apply rotational crossbreeding in which lines A, B and C continually succeed each other. Further research and further elaboration of this idea with a group of cattle experts would be worthwhile. In so doing it will be important to properly explore the three qualities and assess them on their own merits.

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Discussion report

Breeding for health and welfare

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The presentations on breeding for health and welfare gave a wide overview on the existing breeding strategies and methods of weighting traits for selection in cattle, poultry and pigs. It turned out that the problems in housing and health varied a lot in the different species. Therefore four species specific groups were formed for discussions. The groups were asked to formulate the most important questions, define the problems and search for appropriate solutions. The aim was to identify independently concrete, practical implementations.

1) Dairy cattle

System:

As the variety in dairy farming systems is very wide within the European countries, the animal types that are needed will differ widely. The group specially talked about dairy farms in Holland with very high yielding cows of up to 10,000 kg per lactation. For these farms, the high yielding Holstein Friesians are very suitable. It was, however, argued that a production system with high amounts of imported concentrates might not correspond to organic objectives.

Breeding goals:

Breeding strategies in organic farming are also very different. The two extremes are breeding based on breeding values based on phenotypic expression and on-farm breeding. For the estimation of breeding values, the information is mainly based on data from conventionally kept animals as organic farms are too few to provide independent data. The merit index is thus an average value of the information of daughters on a minimal number of mainly conventional farms and therefore may not be suitable for a specific organic farm.

On-farm breeding is based on the breeding goal and selection of the farmer and the farm system. Therefore, it seems to be the most suitable way to breed animals that can adapt to the local farming system.

The middleground between these two extremes has been demonstrated by the papers presented to the Workshop. Even though the heritability of "health and welfare" is low, it can be selected for by good estimation of breeding values and progeny test respectively (see presentation from Roswitha Baumung, Austria). Other initiatives are the "Ecological total breeding value" (presentation by Beat Babst) developed in South Germany or line breeding developed by Frederik Bakels. It was considered important to consider carefully the desires and opinions of organic farmers/breeders in choosing which way the development should take.

There is also a "Scandinavian breeding programme" that puts strong emphasis on health and fertility in dairy cows. These traits stand for approximately 15% of the available breeding capacity and 85% of available capacity is used for production traits (milk yield, fat and protein). The average production achieved by these breeds is about 8,500-kg milk/cow/year, whilst the genetic potential is much higher. The poor efficiency in utilising this genetic potential is due to failure to adapt to the prevalent production environment. On the basis of this example, it was concluded that there is no need of increasing the genetic potential for milk yield of these breeds unless this potential can be realised in a given system. It would be much more meaningful to utilise the available genetic capacity in improving traits dealing with longevity, health, fertility, roughage intake, temper and other traits that are useful for the farmer and enable him to optimise his management system to achieve high welfare standards.

A further point was made on the need to estimate future cost of fossil energy in planning breeding goals. As energy prices are likely to be much higher in future, farmers will look for healthy and fertile cows rather than for high yielding once. Before a breeding program in organic dairy production is started, a realistic price of energy for the year 2011 should be estimated.

Breeding techniques:
Conventional cattle breeding is today based on such reproductive techniques as artificial insemination, multiple ovulation, embryo transfer and embryo culture techniques. All these techniques, apart from artificial insemination, are not acceptable under organic standards. The workshop considered these restrictions appropriate, but there was a disagreement concerning the sexing of semen. It was suggested that killing of surplus male dairy claves at birth was a greater moral issue than the use of sexed semen, whilst other opinions supported the banning of the use of sexed semen. There was, however, a strong argument that the only way to sustain the restrictions on breeding techniques in organic standards was to develop organic breeding systems. Otherwise, the only alternative would be to use minor breeds where these techniques are not as prevalent as in the major breeds like Holsteins.

2) Beef cattle and sheep

The discussion group on beef cattle and sheep breeding had 14 participants, mainly from UK and the Netherlands but with representatives from Switzerland, Ireland, Spain, Italy and Finland. The group had a diverse range of experience in research, advisory work and certification, contributing to an interesting discussion.

Seven key points were identified:

1. It is important to identify what 'organic breeding goals/objectives' are.
2. It is important to quantify what the potential of animals is within organic systems and to identify what the constrains are preventing the animal performing at its optimum, in terms of encouraging positive health as well as performance.
3. It is important to understand what organic farmers want from their livestock, and why do they do what they do at present. Livestock systems vary enormously, each with their own characteristics and objectives (e.g. replacement policy in stratified crossbreed systems like UK sheep system): Finishing times and target daily live weight gains, the over-riding need to finish within 30 months of age (BSE direction in the UK), carcass quality/grade, supplementary feeding are all decisive factors and may have more weight that "organic" goals.
4. There is a need to have a better understanding of genetic-environment interactions in order to interpret better the "organic" requirement for local or locally adapted breeds.
5. It is obviously important to develop breeding systems that put greater emphasis on health and welfare but these indices need to be able to show economic advantage to be adopted by farmers.
6. It is important to consider what the consumers want and to put an economic value on this.
7. It is important to establish a dialogue with the breed societies and breeding companies in spite of their reluctance to recognise organic farming as a significant player in the field.

The following strategies and practical measures were suggested:

1. Education and empowerment of farmers and consumers. The discussion group believed that this was particularly important for establishing breeding goals that made more of female selection criteria and to avoid falling into the trap of a 'total index system'.
2. There was a strong feeling that the animal and system potential needed to be better matched. Do not keep changing the system to get more out of the animal - match the animal to the farm system! This is a central feature of EU Regulation 1804/1999 (selection of appropriate breeds and strains).
3. Breeding for clear and concise animal health targets should be practiced where possible and where management has already been optimised. E.g. if breeding for worm resistance, select on a whole herd/flock basis rather than on an individual basis.
4. Need to focus on 'harmony' or 'balance' within the animal. More research to define what is 'harmony' within the animal – how do you determine when the animal is 'in balance'?

5. Avoid selection for traits that are linked with a known problem. However, more research is needed to understand linked traits and the environment/genetic interactions.

3) Poultry

Seven scientists and one person from the poultry breeding industry were discussing the situation in poultry breeding. The main problems areas in poultry husbandry were identified as:

- Feather-pecking/cannibalism in laying hens;
- Health problems in fast growing fattening birds; and
- Endoparasites in free-range systems.

It was felt that breeding should address these problems directly and indirectly.

The need to produce special poultry breeds for organic farming was discussed, and optimisation and standardisation of management was suggested as an alternative to breeding. There was no real consensus between the discussion participants on this issue. In general, it was accepted that housing and management has to meet the animal needs, rather than attempting to fit an animal to a fixed system. It was, however, recognised that some of the problems identified, were likely to be related to the high production levels the birds were bred to achieve. The poultry industry representative felt that high genetic merit animals were capable of performing at lower levels and that it would be interesting to see if the problems would disappear if the production pressure was removed. The majority of discussion group felt, however, that this was not something that organic producers should aim for. As organic poultry production is not a fixed system but differs greatly from enterprise to enterprise, there is a need for breeds that are flexible and can adapt to variability of surroundings.

It was agreed that poultry for organic farming should have the following characteristics:

- The animals should show normal behaviour in large groups.
- Fattening poultry should grow slowly (81 day).
- Facilities common in organic farming, like free range and perches, should be used in breeding facilities.
- Birds should be able to adapt to regional characteristics, like local climate.
- Birds should be able to cope with changing food composition.
- Birds should show resistance against diseases and parasites, even if selecting for a certain trait means poorer performance in another area.

It was concluded that, whilst it may not be an easy task to find suitable lines, pure lines and local breeds should be tested on organic farms. For selection, the breeding flocks, and not only the parent stocks, should be kept in floor or even free range systems.

4) Pigs

The experience of the working group was that there is no consensus on what the ideal breed for organic pig production is. In field conditions, any 20 organic pig farms will probably have 20 different breeds, with equally many experiences (positive and negative). New breeding and selection techniques, which may be common in dairy farming, do not appear to be a contrainging factor in pig breeding. Embryo transfer is hardly practical without surgery, and the industry is too small for techniques such as Gene Marking.

There are, however, problem areas in organic pig keeping, which could be addressed through selection or other genetic techniques. Further development of these aspects into new breeds or strains will help to develop the right organic pig. The following issues were identified:

1. It is important that organic pigs have good, mothering abilities, as their behaviour is less controlled (restricted) in an organic environment. Mothering abilities are highly dependent on the individual, and to some extent hereditary. It would be interesting to see whether they could be bred (back) into the organic herds.
2. Leg problems are common in pigs kept outdoors, particularly on hard or stony ground. Strong legs can be selected for, but unfortunately are seldom criteria when finishers are either selected for replacements. It was recognised that this problem was partly due to the fact that these animals are often not exposed to the outdoor environment that they will be exposed to as sows.
3. Meat quality is important, both from the health and taste point of view. Fat has been bred out of modern pigs, but is an important component of flavour in pig meat. Unfortunately, the undesirable subcutaneous fat is very closely associated to the intramuscular fat, so that selection against one will influence the other. Should subcutaneous fat be bred out of organic pigs, or would we be better off trimming some of the subcutaneous fat, leaving the intramuscular fat to add flavour?
4. Sows are replaced in many herds at a rate of 40% per year. The main reasons for culling are leg problems and breeding problems. We need to breed pigs that last longer.
5. Pigs get sunburned. Coloured pigs suffer less, but the consumer dislikes finding dark hairs on their bacon rind. Can we breed “white Durocs” (Dark skinned, white haired animals)?
6. Boar taint is a significant problem, even though it is only found in the cooked meat of 2-3% of male pigs. The taint may put people off eating (organic) pork. At present, castration for pigs that are slaughtered at over 85kg live weight is the only option, and it could be argued that because organic pigs grow slower and boar taint is associated with age rather than weight, even pigs slaughtered at 85kg could develop boar taint. Breeding out boar taint may be an option as long as fertility is preserved.
7. Organic pigs are required to eat large amounts of roughage. The conversion of this roughage into useful nutrients may be dependent on individual physiological characteristics. If this is the case, breeding may help to select for the right pig.

For all of the above points it must be borne in mind that selection can only take place if the trait is heritable. This has not been confirmed yet in most cases. Furthermore, a number of the above issues can more easily be resolved through management or good housing conditions. Finally, the size of the industry will mean that it is very unlikely that a lot of money will be invested into developing particular breeds or strains of pigs for the organic production chain.

General conclusions
The discussion participants were mainly scientists from the wealthier EU-countries. Therefore, the problems probably were considered from the same perspective by most participants.

In general, the education on all levels and the dialogue with the breeding companies was considered to be very important. It was, however, recognised that there were problems in initiating and enforcing dialogue with the breeding companies and associations. It was pointed out that the organic sector needed to felt in the discussion in good faith, and that some degree of courage and personal engagement on the part of the breeding companies was needed for them to embrace “organic” thinking in terms of optimisation rather than maximisation of production. It was also suggested that embracing organic breeding needs might direct the breeding companies to a market leader position of new product with public interest.

A holistic approach to breeding can be found in definitions for health (WHO: World Health Organisation) and welfare (FAWC: Farm Animal Welfare Council). Health is defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Welfare is defined in terms of five basic freedoms: freedom from fear and distress; from pain, injury and disease; from hunger and thirst; from discomfort and freedom to express normal behaviour. It was concluded that organic production systems need to guarantee these minimum requirements for health and welfare in order to maintain credibility and consumer interest.

Some practical proposals for further research and action arouse from the general discussion:

1. There is a need to correlate existing data, in the first instance from the dairy sector, to see how well organic cows “do” in comparison to their genetic potential.
2. There is a need to document what breeding strategies are used and adopted by organic breeders in different European countries (this work has been undertaken by Wytze Nauta at LBI in June 2001).
3. There is a need to establish a relationship/dialogue with breeding companies and societies across Europe. (In a similar fashion with what has been happening on organic plant/seed production).
4. It may be advantageous to draw upon the breeding experience/expertise within Eastern Europe, as many breeding programmes in that region have maintained local breeds and in so doing maintained a wider genetic pool.

Part B:

Feeding for animal health and welfare in organic livestock systems

Results from the Öjebyn-project. Eleven years of organic production

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The research station

The research station at Öjebyn belongs to the Swedish University of Agricultural Sciences and remains so since 1944. Öjebyn is located at longitude 21 ° 24´ east and latitude 65 ° 21´ north, five meters above sea level. The soils are fine sand and silt and give good yields of leys, barley and potatoes. Due to the high light-intensity during the summer months, vegetables of the highest quality are grown here. The research station has 170 hectares of arable land, two separate cowsheds that are similarly equipped for 50 cows each, two silo (400 m^3) and six separate hay-dryers. The herd consists of 100 dairy cows (Holstein-Friesian and Swedish Mountain Cattle).

The project of öjebyn - organic production of food

The aim of the project is to develop organic food production in northern Scandinavia. A full-scale study comparing organic farming with conventional farming on 100 hectares of farmland is being performed at the same time. The project started in 1988 with the first conversion and the first recording of crops was done in 1990. The milk recording started in the autumn of the same year. One of the aims of the project is to achieve a sustainable agriculture that is as considerate as possible towards the environment. We try to recirculate the nutrients within the farm and obtain the nitrogen required from the ability of the leguminous plants to fix nitrogen. The most important plants for this purpose are clovers and peas.

The herd is divided into two separate herds that get their food from specific fields. Manure and urine are kept separately and returned to the respective fields. The project is planned to run for twelve years, i.e. two complete crop rotations (see below). The project will end after the harvest of year 2001.

Crop-rotation

Year	Crop
1	Reseed (Ley sown under green-crop as nurse crop)
2	Ley I
3	Ley II
4	Ley III/ vegetables
5	Barley

Green-crop/Seed-potatoes/vegetables

Seed-mixture (ley)

Organic farming

Kg/ha	Species
1	White clover (Trifolium repens)
8	Red clover (Trifolium pratensis)
10	Timothy (Phleum pratensis)
5	Meadow-fescue (Festuca pratensis)

Conventional farming

Kg/ha	Species
5	Red clover (Trifolium pratensis)
12	Timothy (Phleum pratensis)
8	Meadow-fescue (Festuca pratensis)

Results

Cultivation

The results so far reflect the yields obtained during ten years after conversion into organic farming (Jonsson, 1994; Jonsson, 1996; Fagerberg *et al.*, 1992; Fagerberg, 1994; Fagerberg, 1995; Fagerberg *et al.*, 1996). The average figures for the total production from all crops during these ten years reveal that the organic production is 3% lower on a dry matter basis. The organic production is 5% lower if you consider it on metabolic energy basis. This means that the organic crops have a somewhat lower energy content.

There is a trend of increasing yields in the organic system while there is no such trend in the conventional system. The yields from the reseed and the leys together show for the first ten years 1990-1999 that the organic farming gets 6,140 kg of dry matter/ha. That is 8% lower yield than from the conventional system (Figure 2). The organic barley has for the same period given 5% higher yields than the conventional barley. We have got 3,850 kg/ha of organic barley as an average (Figure 3). The organic seed-potatoes have yielded 3% more kg/ha than the conventional potatoes (Figure 4).

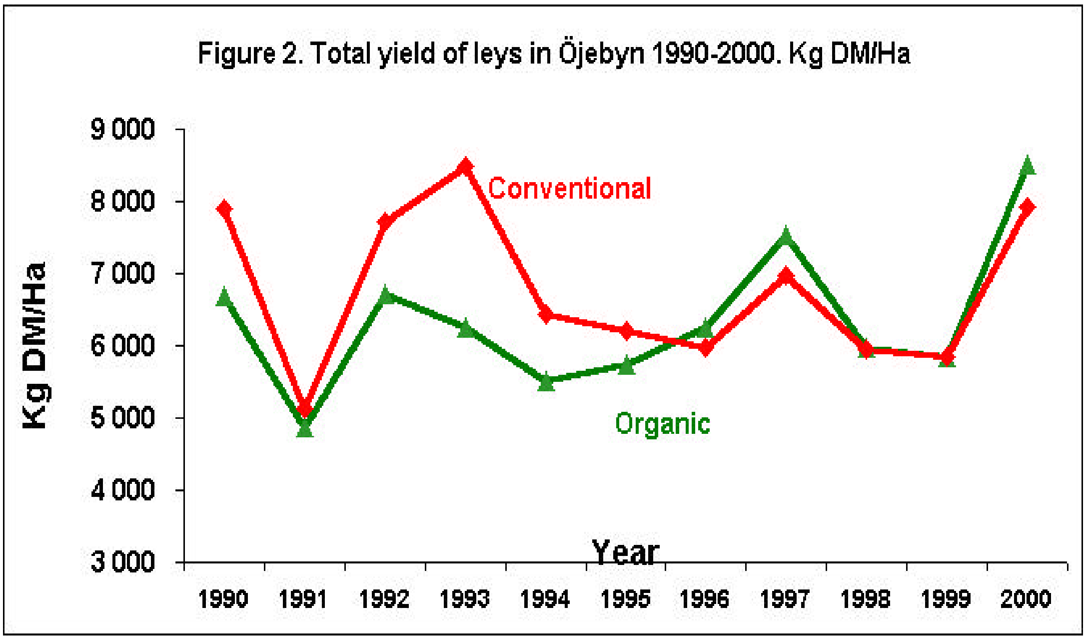


Figure 2. Total yield of leys in Öjebyn 1990-2000. Kg DM/Ha
Kg DM/Ha
9 000
8 000
7 000
6 000
5 000
4 000
3 000
Conventional
Organic
Year
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000

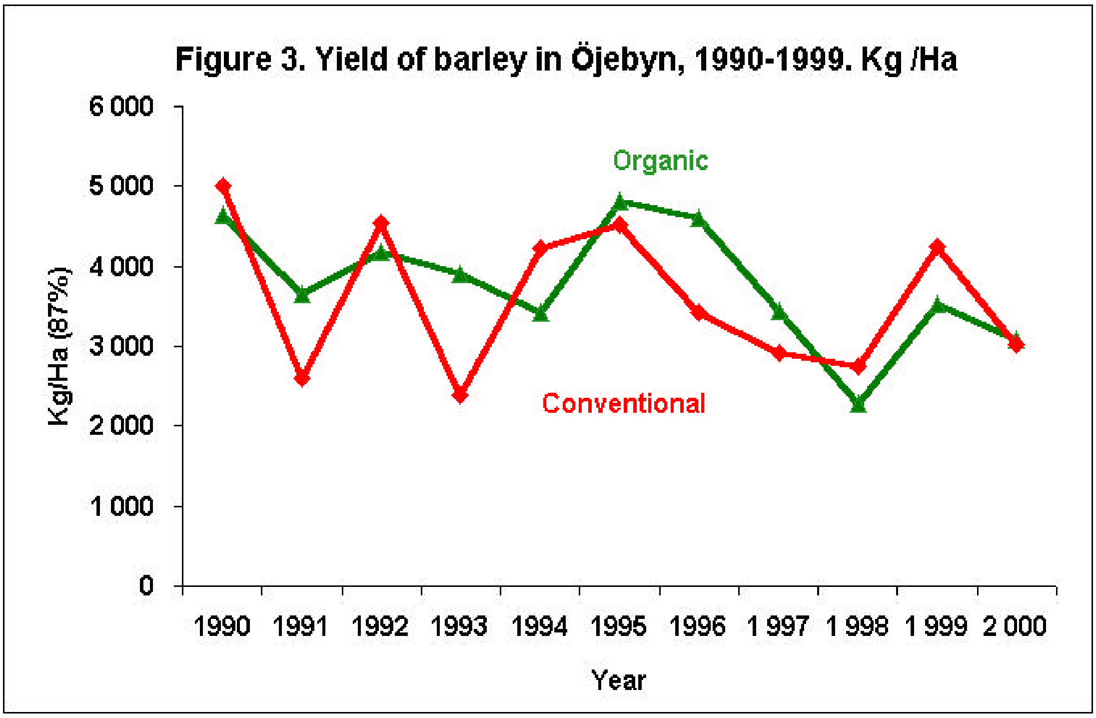
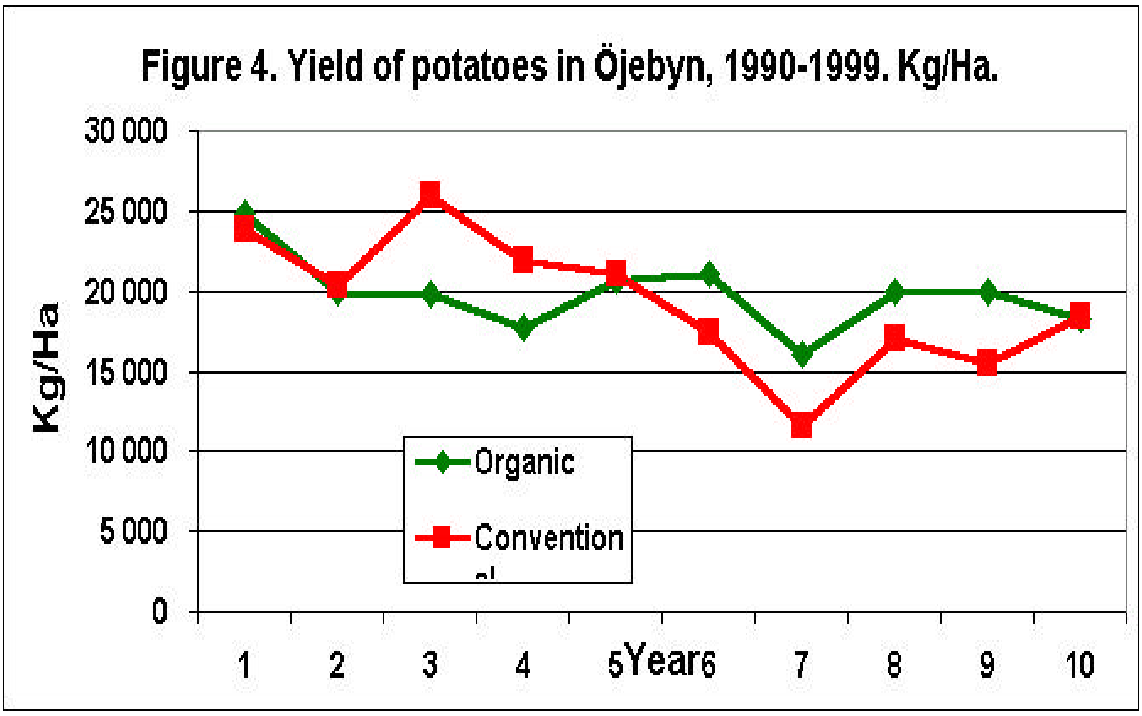


Figure 3. Yield of barley in Öjebyn, 1990-1999. Kg /Ha
Kg/Ha (87%)
6 000
5 000
4 000
3 000
2 000
1 000
0
Organic
Conventional
1990
1991
1992
1993
1994
1995
1996
1 997
1 998
1 999
2 000
Year



Soil-balances

Soil-balances have been calculated for the first six years (Figure 5) and for the following four years, 1996-1999 (Figure 6). The inputs consist of nutrients from manure, urine and lime. In the conventional system, there is also the input from chemical fertilisers. The outputs are entirely what has been harvested and brought from the fields. For nitrogen (N), phosphorus (P) and potassium (K) there has been a continuous surplus of nutrients in the conventional system. This surplus has been lowered due to the fact that lower amounts of chemical fertilisers have been added during the last years. In the organic system, there has been a small surplus of phosphorus (P), which mainly originates from the input of mineral fodder to the dairy cows. For N there is a shortage of 11 kg and that shortage is constant. Even the K shortage is constant at 13 kg/ha. The shortage of N is expected to be met by the fixing of N in clover. The clover-content was 26% as an average in all leys during the first six years. Calculations show that there is a need of a clover content of 30-35% in the leys in order to balance N in the organic system in Öjebyn. During the last four years there has been a clover-content of 32% as an average for all organic leys.

Besides these macro-elements even micro-elements like cadmium and zinc have been studied (Bengtsson *et al.*, 1999), (Bengtsson *et al.*, 2001), (Bengtsson *et al.*, 2001), (Bengtsson *et al.* (manuscript). The fluxes and balances of these elements in the two systems indicate that there is higher accumulation of these elements in the conventional soils.

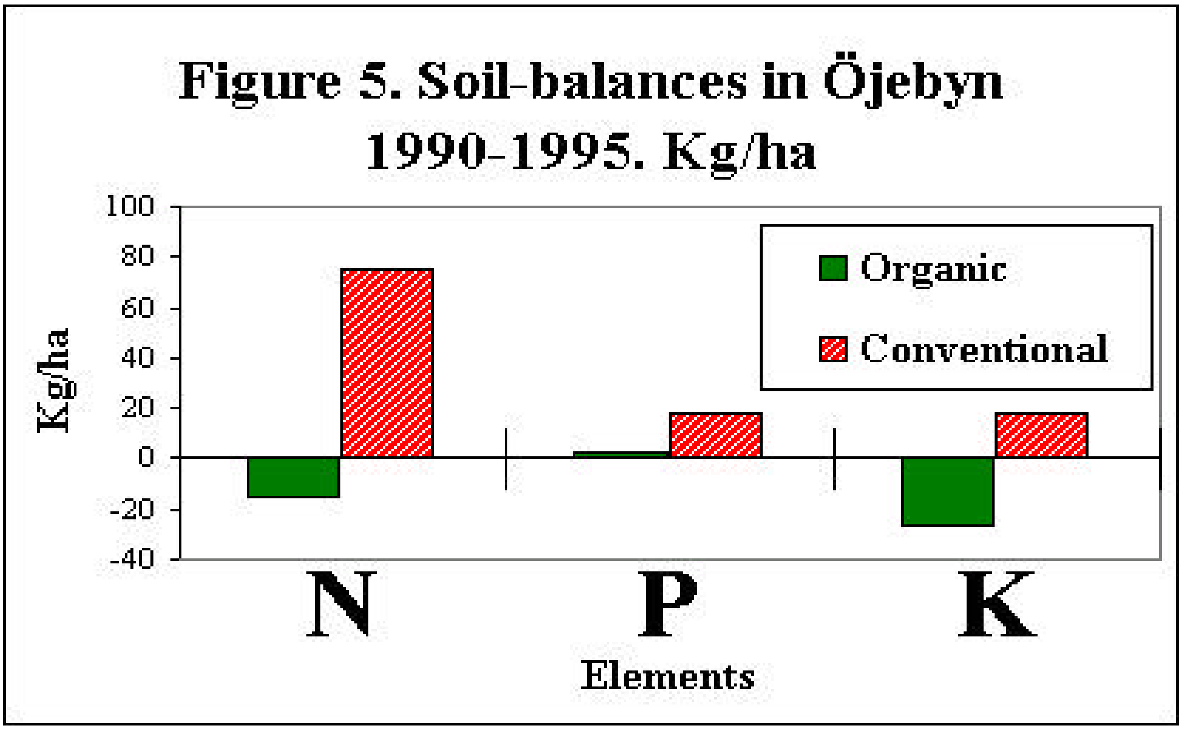


Figure 5. Soil-balances in Öjebyn 1990-1995. Kg/ha
100
80
60
40
20
0
-20
-40
Kg/ha
Organic
Conventional
N
P
K
Elements

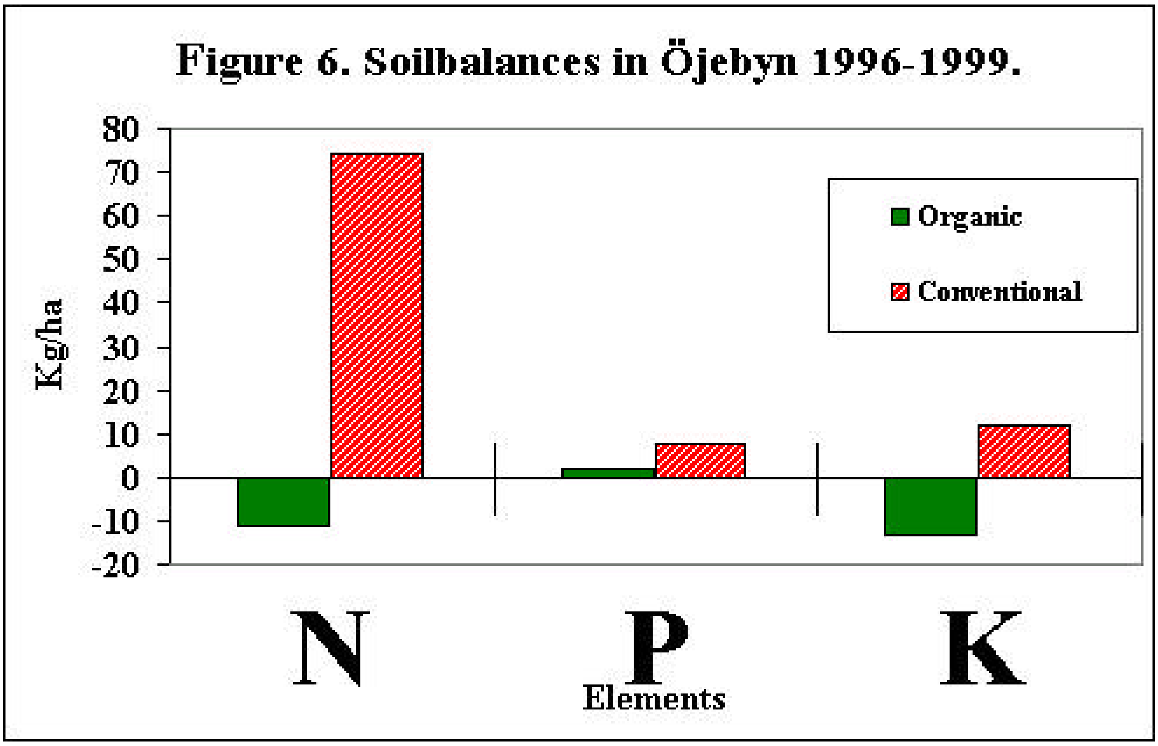
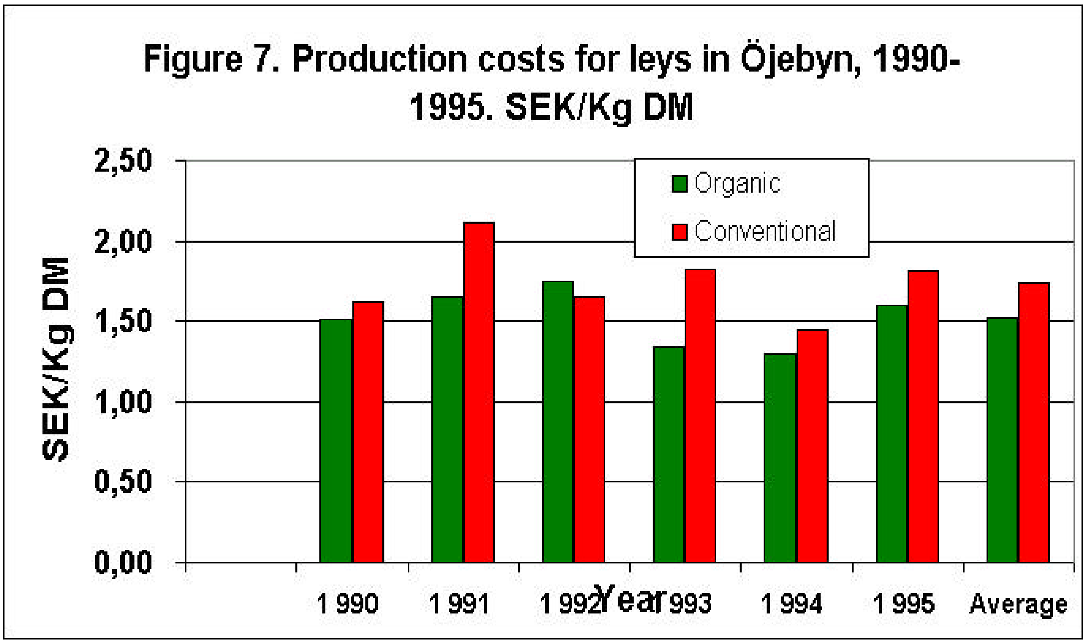


Figure 6. Soilbalances in Öjebyn 1996-1999.
80
70
60
50
40
30
20
10
0
-10
-20
Kg/ha
Organic
Conventional
N
P
K
Elements

Cultivation costs

The organic cultivation gave during the first six years a somewhat lower production but still not much less in comparison with the conventional one. When there is no use of chemical fertilisers and pesticides, there is no labour and no need of farming equipment for these things, it means that the cultivation costs are lower than in the conventional system. For the first six years, 1990-1995 we recorded 12% cheaper cultivation costs for the organic roughage production (reseed and leys). (Figure 7). The cultivation costs for organic barley were 3% cheaper, mainly due to a higher yield than from the conventional barley, (Figure 8). The production costs for seed-potatoes were 7% higher mainly due to higher costs för de-blasting, (Figure 9).



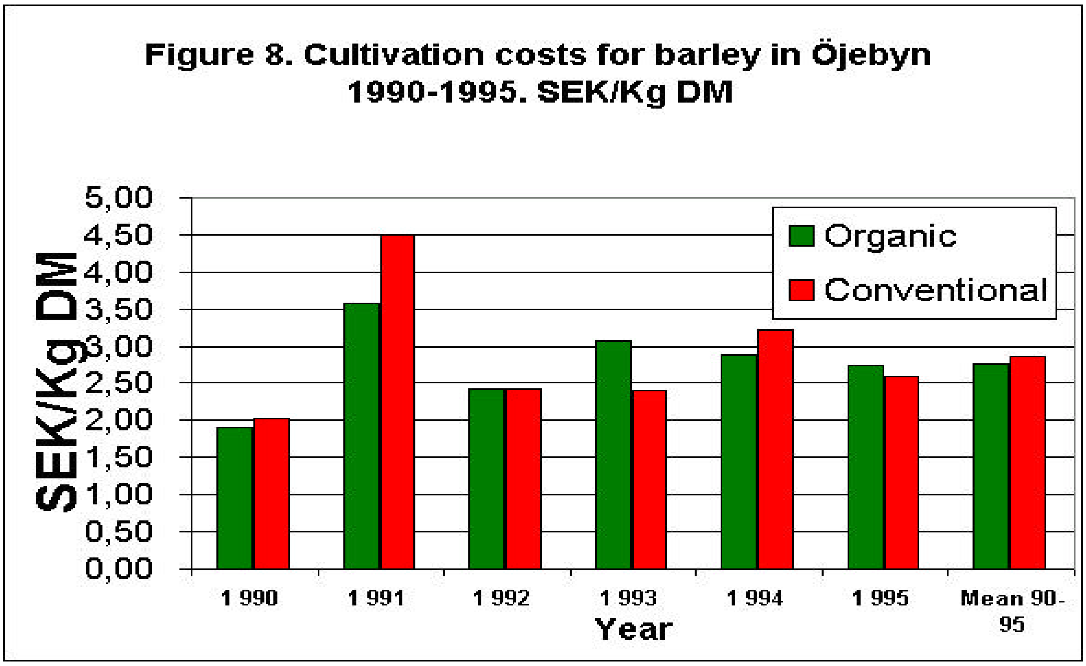
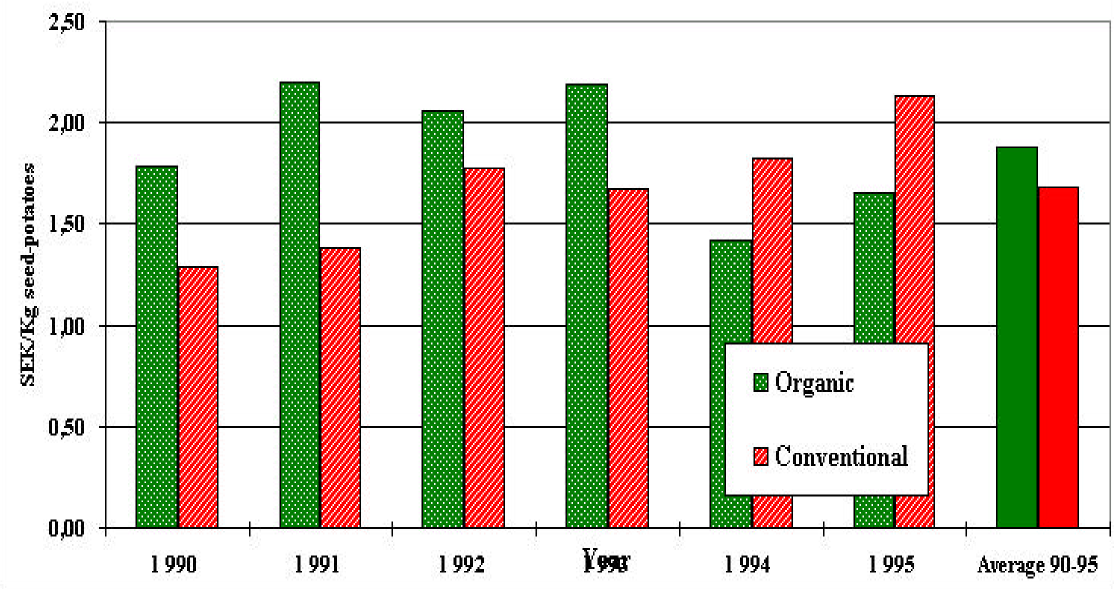
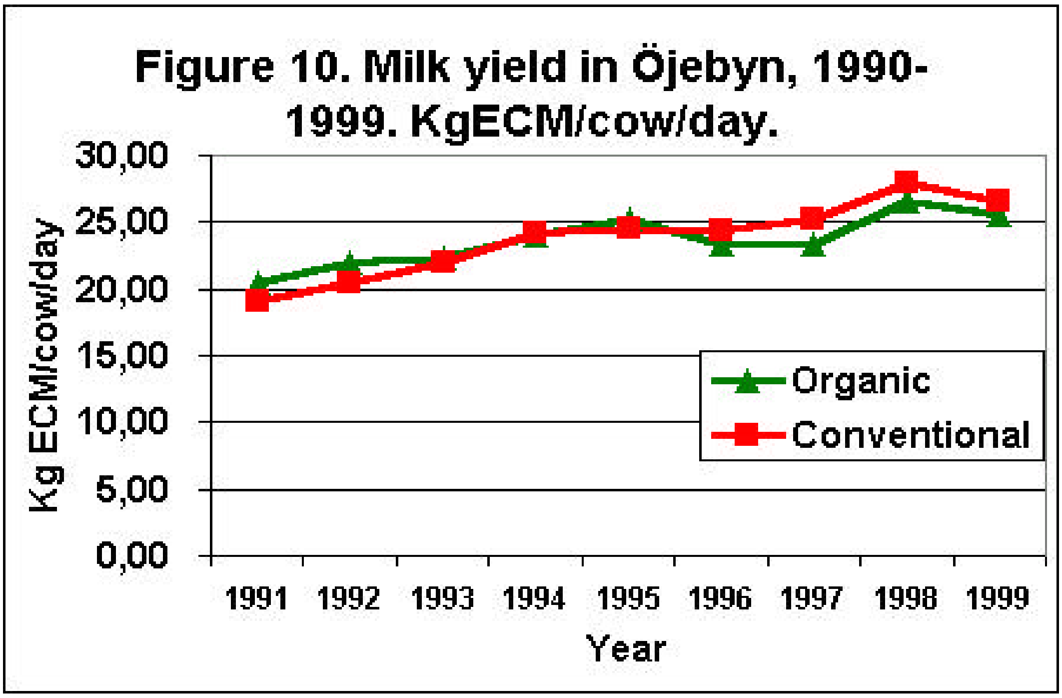


Figure 9. Production-costs for seed-potatoes. Ojebyn 1990-1995. SEK/Kg.



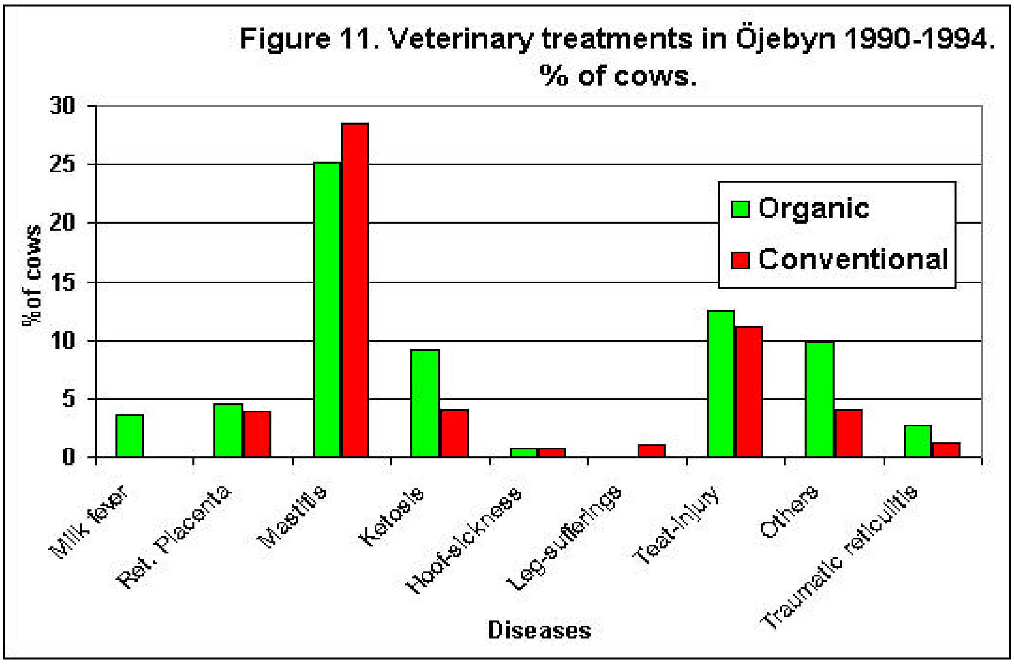
Dairy production
The organic and the conventional cows are fed with the fodder harvested from respective systems (Jonsson, 1996 & 1997). The organic cows are fed with organic roughage and barley from the farm and the roughage is given *ad libitum* at 12.5 kg DM of roughage/day. In addition, they get grains from the farm and concentrates imported to the farm. The conventional cows are fed 8.5 kg DM of roughage/day i.e. 1.5 kg DM/ 100 kg liveweight. They get a higher amount of imported fodder. The milk yield is recorded weekly.

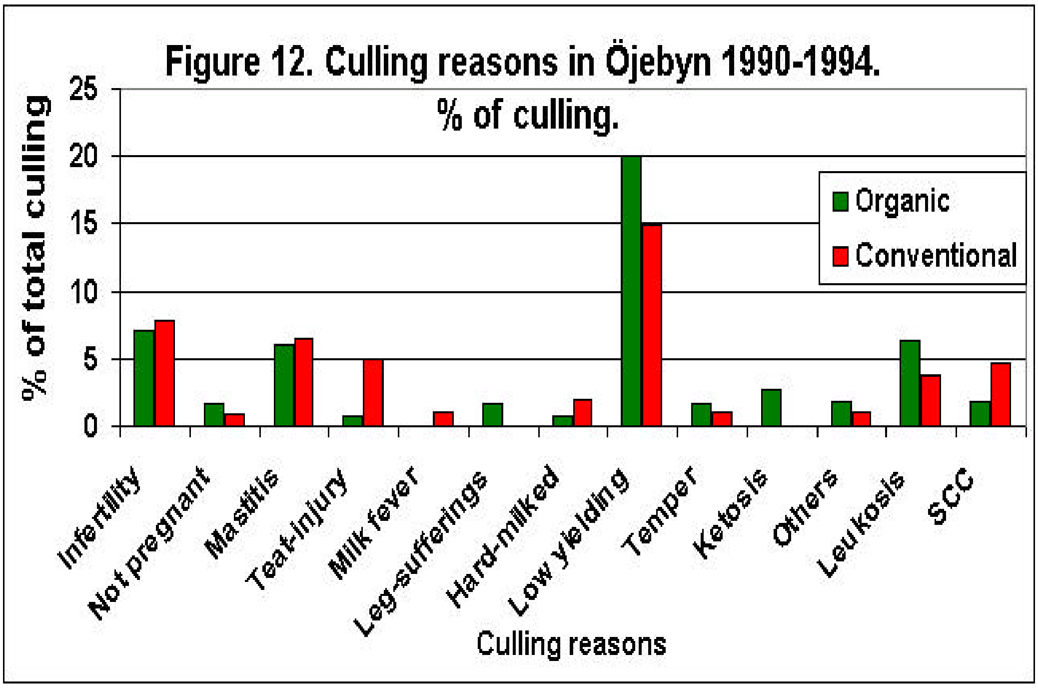
The organic milk production has been 3% higher than the conventional milk production during the first five years, 1991-1995. During the following four years the conventional milk production has been 5% higher, (Figure 10). The herd has an average yield of 8,500-kg ECM/year. The conventional cows have an increasing trend year by year while the organic cows have been increasing their yield up to more than 8,000 kg ECM but then stagnated and even decreased their yield. The composition of the milk is different in that way that the concentration of fat is 0.01% higher in the organic milk while the concentration of protein and lactose is 0.12% and 0.01% lower in comparison with the conventional milk, respectively.



Animal health

The purpose of the project is also to study the effects of fodder from the two different farming systems on health and fertility of the dairy cows. In the herds, records of disease treatments and other treatments of fertility (Figure 11) as well as reasons for culling (Figure 12) have been collected in both systems during 1990-1995, (Jonsson 1997). The results vary from year to year but the average figures for all five years reveal certain trends.





Frequency of mastitis is somewhat lower in organic dairy production, and treatments for fertility disturbances are somewhat less than in conventional dairy production. A notable thing is the number of veterinary treatments for teat injuries and the results of these treatments in the two systems. The culling reasons for teat injuries are four times higher among the conventional. The frequency of total diseases is higher in organic dairy production, which is mainly due to an increased frequency of puerperal pareses and ketosis. Considering matters of fertility in the organic system, there was less need for treatment of anoestrus and suboestrus as well as treatments for cystic ovaries.

A similar statement has been done for the period 1996-2000 (Byström, 2001). During this period some results look like those of the previous period, but there are also differences (Figure 13). The frequency of mastitis was still lower among the organic cows, but the frequency of pareses as well as the total veterinarian treatments was also lower among the organic cows, indicating a better animal health. It is impossible to draw definite conclusions due to the limited number of animals studied. The main reasons for culling in both systems were ‘low yield’ and ‘poor fertility’ (Figure 14). There was a higher percentage for these reasons among the organic cows while the conventional cows had a more even distribution of reasons for culling among several other reasons. The higher percentage of the reason ‘low yield’ among the organic cows might indicate a better health.

Figure 13. Veterinary treatments in % of total number of cows in Öjebyn 1995-2000

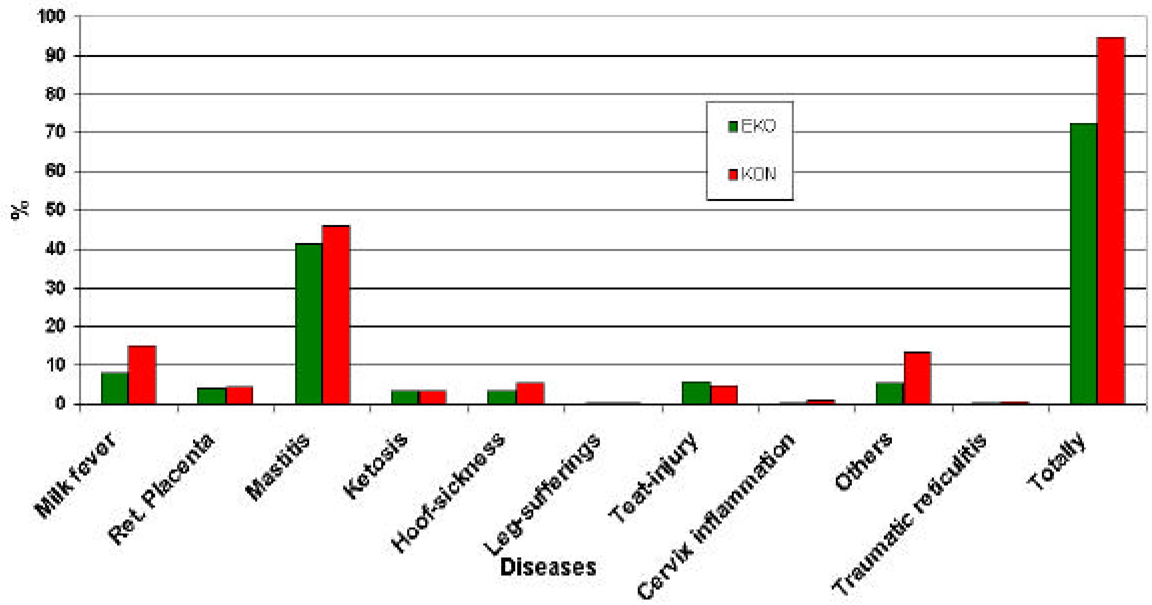
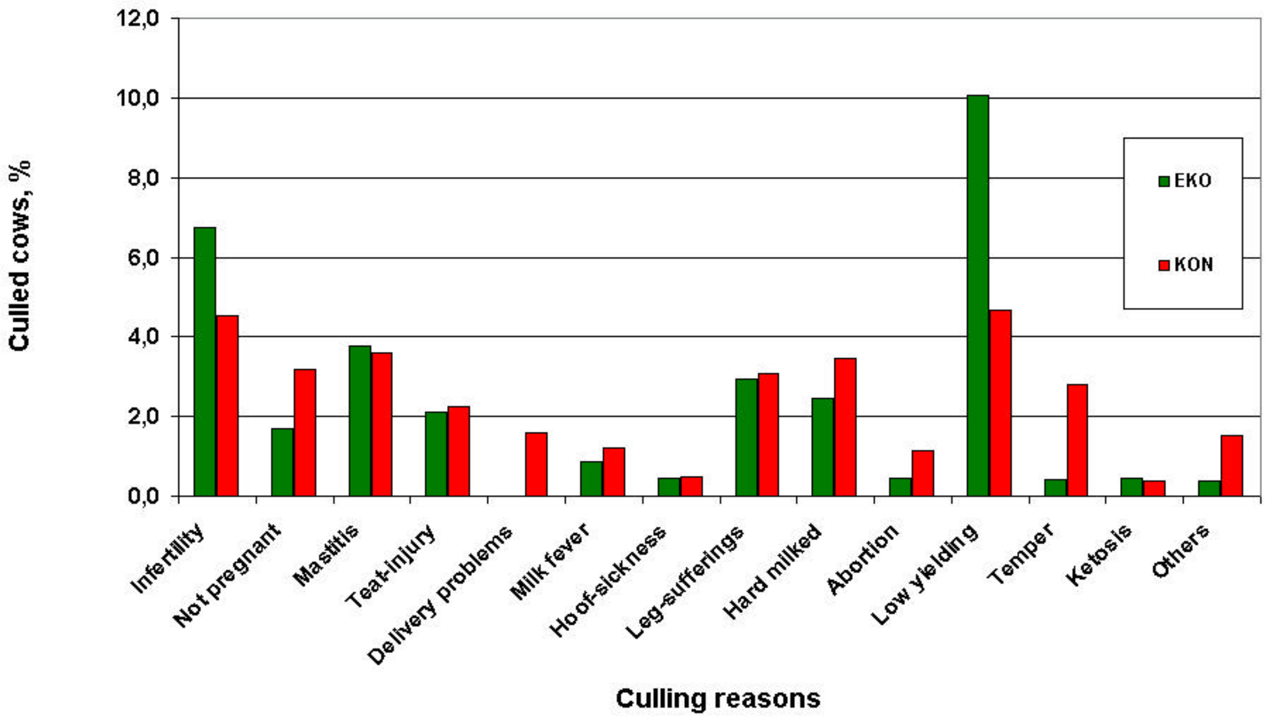


Figure 14. Culling reasons in Öjebyn 1995-2000. Percentage of culled cows.



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Organic dairy cow feeding with emphasis on Danish conditions

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Introduction

Organic milk in Denmark is produced in large dairy units with specialised milk production and high milk yields. Feeding of the cow is based on grazing of clover-grass for 5 to 6 months of the year and feeding indoors during the winter period with silage *ad libitum*. Amount and type of supplement is given according to farm specific conditions, such as milk quota, genetic potential in the herd, amount and type of home-grown concentrates and market condition for foodstuffs and milk. Balancing the energy and nutrient in the ration with the requirements is done under these limitations, therefore feeding strategy and the feed ration often is a compromise between practical and well known biological, physiological factors.

This paper presents given data on feeding, production and health based on information from the central database from milk recording, more intensive case studies and experiments with feeding.

Organic milk production in Denmark

In 2000, 8% of the total milk production in Denmark came from organic herds while about 30% of the milk for sale is of organic origin. Average data from the organic farms as recorded in the national milk recording system are presented in Table 1. The production level is high compared to results from organic herds in other European countries, but around 500 kg milk lower than that of conventional herds in Denmark. The difference to conventional herds was highest for Jersey herds.

6% of the herds had more than 9,000 kg milk per cow and 13% less than 6,000. Somatic cell counts (SCC) are higher than 400,000 in 40% of the herds, and 25% of the herds have SCCs less than 250,000. Replacement rate and time of culling is comparable with conventional farms in Denmark.

Table 1. Average production in organic herds, year 2000 (Nielsen, 2001)

Breed	Dual purpose breed	**Jersey**
Number of herds	504	77
Annual number of cows	87.3	74.9
Milk production		
- kg ECM	7459	6509
- fat and protein, % in milk	4.10 / 3.45	5.73 / 4.12
- peak yield (yield 0-12 weeks post partum) 1^{st} lact / older	22.9 / 30.0	19.9 / 25.2
Somatic cell count (avg. milk recording)	322,000	303,000
Reproduction, number of calving per year	1.07	1.07
Average age, lactation number	2.37	2.67
Culling, days post partum	278	265
Age at first calving, month	28.9	27.1

Case studies

Detailed information about organic feeding and production is given in annual reports from The Danish Institute of Agricultural Science. Mogensen *et al.* (1999) give a complete list to these reports and present results of an analysis of 20 farms during the period 1989 to 1998 with from 2 to 9 years of observation per farm. In Tables 2 and 3 some of the results with relation to feeding are given.

Table 2. Farm results from 1989-98, based on 20 farms with 2 to 9 years per farm

		Average	Variation between farms 1)		Variation within farms 2)	
	Unit		Low	High	SD	% of avg.
Farm land	Ha	82.5	57.5	103.3	8.4	10
Yield	SFU per ha	5,044	4,494	5,450	608	12
Grassland	Percentage of ha	52	44	60	8	15
Clover	Percentage in pasture	44	36	50	12	28
Stocking rate	LSU pr ha	1.10	0.80	1.26	0.09	8
Milk	Kg per ha	5,939	4,950	6,867	507	8
Home-grown feed	Percentage of intake, SFU	83	73	90	9	11

1) Low is 25 per cent fractile, high 75 per cent fractile
2) Average of the standard variation of annual results within each farm

Table 3. Feeding and production of organic dairy cows, dual purpose breeds - average results from 1989-98, based on 20 farms with 2 to 9 years per farm

Feeding	SFU	DM
Total	5,511	6,073
- pasture [1)]	1,448	1,665
- silage [1)]	1,947	2,531
- straw	29	101
- beets etc	235	235
- cereals	1,231	1,046
- concentrate	622	495

1) Ad lib feed

Production	Unit	
Milk	Kg per cow	7,158
- fat	%	4.17
- protein	%	3.43
Live weight	Kg	573
Gain - cows	Kg per year	37
Replacement rate	%	40
Age first calving	Month	27.3

The average organic farm has 82.5 ha, 14,3 ha of which is permanent pasture. The remaining area is arable land with grass/clover and cereals in rotation. The average net crop production in SFU was 5,044, calculated as amount of feed to the herd or sold. Between farms, there is a large variation in crop production and even within farm the variation is 12% of the average yield. Pasture is the most dominant crop in the rotation with more than half the area in leys. Ryegrass and white clover dominate the sward. The typical rotation is one year with barley undersown with a grass/clover mix harvested as whole crop silage, followed by 2 to 3 years with pasture and 1 year with grain harvested as cereals.

The herd, based on Danish Holstein on 18 farms and Red Danish on 2 farms, is run with full young stock of heifers (1.04 per cow), while bull calves are sold as new-born. With a stocking rate of 1.1 LSU (cow incl. heifers) nearly 6,000 kg milk has been produced per ha, with and import of 17% of the energy demand. The feed import is Danish produced concentrates, such as rapeseed cakes, grass pellets and beet pulp.

In Table 3, is shown the average feed intake of the cows and production per year. 70% of the dry matter intake is roughage coming from pasture in the summer period, and silage, such as grass/clover or whole crop grain, in the winter period. Grain, mainly barley, is the most dominant concentrate with more than 1,000 kg DM per cow yearly.

The milk production averaged 7,158 kg milk. Fat content in the milk was 0.4 unit lower in the summer period than during winter, while the protein content was independent of season. An average of 40% of the cows where replaced by heifers each year, as almost all the heifers were taken into the cow's herd. The average lactation number in the herds was only 2.47. The herd structure was very similar to conventional Danish dairy herds (Kristensen & Kristensen, 1998).

Feeding strategy

The flat rate feeding principle, as illustrated in Figure 1, was used on all farms. Within herd all cows are given a fixed amount of concentrates irrespectively of daily milk yield, and roughage is fed *ad libitum*. The length of the period with fixed amount of concentrates is typically from calving to 24 weeks post partum, but on some farms the entire lactation is fed at flat rate. Kristensen & Kristensen (1998) have shown that the slope of the lactation curve is lower in organic farming than in conventional farming, and argue that one of the reasons is a long period with fixed amount of concentrates and high intake of energy from roughage. The high persistency was especially seen for cows in first lactation, where the milk yield only dropped 0.33 kg per month from 6 to 36 weeks post partum in the organic herds.

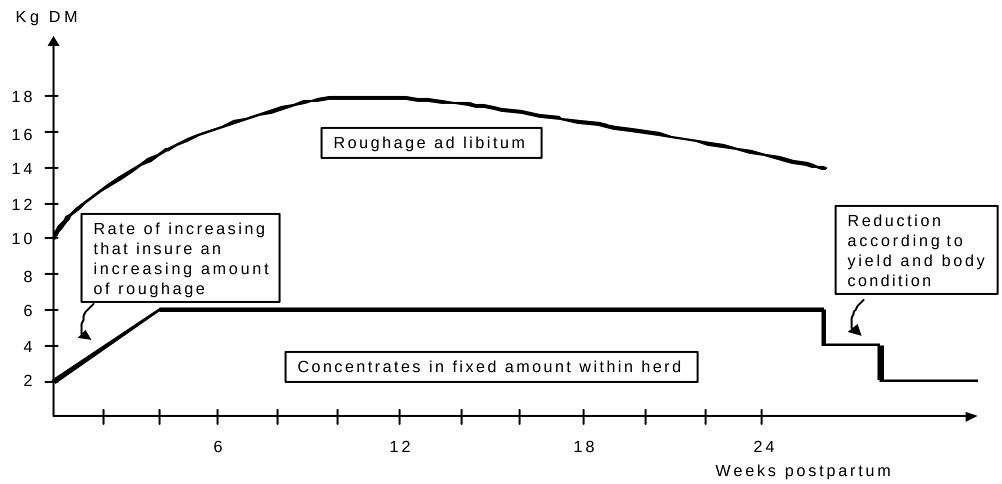

Figure 1 Illustration of the flat rate feeding strategy.

Roughage quality is a very important factor when using the flat rate feeding strategy. The variation between cows in energy demand has to be covered to a high degree by variation in roughage intake. Nielsen (2001) classified 291 herds according to milk production level and found that the digestibility of grass/clover silage increased with milk production level.

Figure 2 clearly illustrates that a high milk production and more than 60% of dry matter from roughage in the feed only can be achieved if the energy content is high in the silage. Silage with high-energy concentration can be made from grass/clover, while it is more difficult from lucerne or grain.

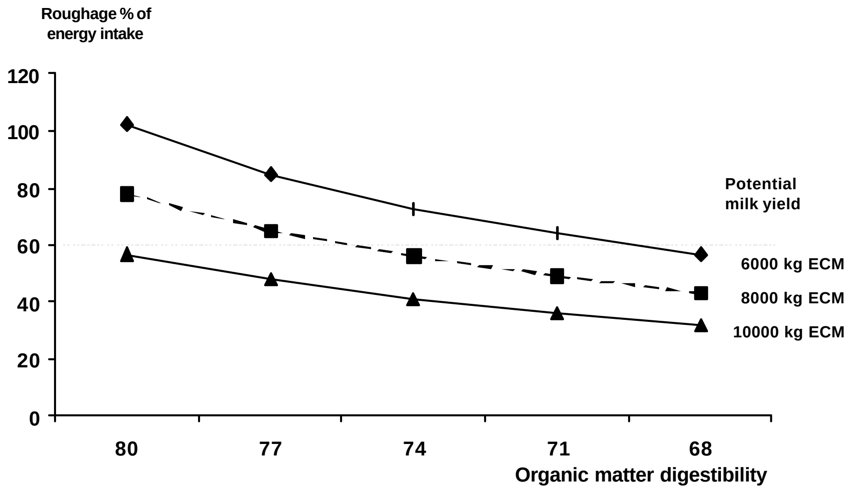

Figure 2 Amount of roughage in the ration to dairy cows, influenced by milk yield and digestibility of organic matter

Vitamin and mineral intake

All herds were supplemented with a mineral mix to a level that meets the traditional recommendations for the major minerals. Only some of the herds use additional supplement with vitamins. Knudsen, *et al.* (2001) investigated vitamin-E status in 12 organic herds. Based on estimated level of content in each feedstuff the intake was calculated (Figure 3). During the winter period the level was significantly lower in the unsupplemented group. Knudsen, *et al.* (2001) also found that 30% of the herds had less than 20 mol vitamin-E per ml milk, which is considered too low. The frequency of mastitis increased significantly with a lower calculated intake of vitamin-E.

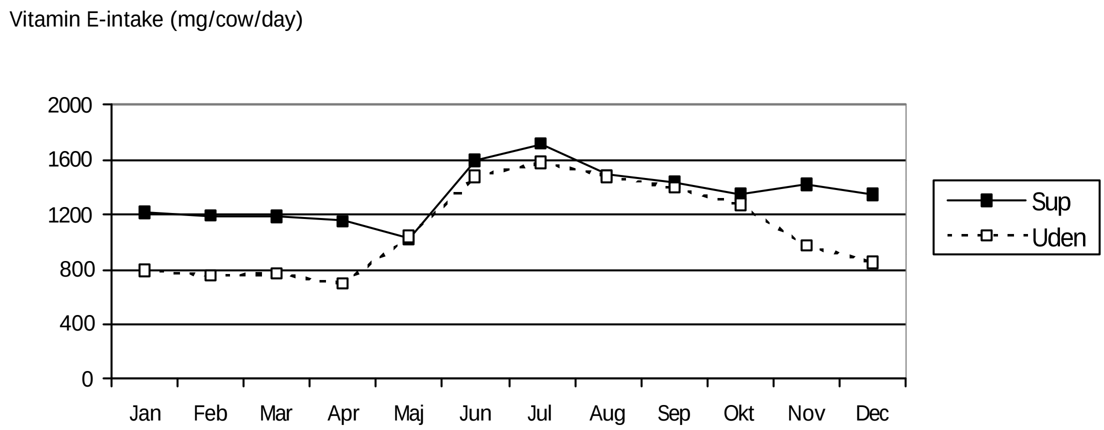

Figure 3 Vitamin E intake, during the year in organic herds with or without supplement with vitamin, *(Knudsen, et al., 2001).*

Supplements with concentrates

Organic dairy cows have to be given some concentrates in order to fulfil the genetic potential for milk production, even if they are fed high quality silage. Traditional feeding trial has been set up in order to find the supplement that maximises production per cow with given roughage. In organic dairy production, there is a need to seek concentrates, which can maximise production per ha land needed for production of roughage and concentrates. In Table 4, some preliminary results are given from the first of a number of experiments on organic farms with the objective to find a combination of roughage and supplement that maximises the production per ha without compromising the health and welfare of the cow.

Table 4. Preliminary results from experiments on five organic farms with different supplement to ad lib feeding of silage (Mogensen, 2001)

	Barley	Rapeseed cake + barley	Grass pellets	Fodder beets	Concentrate mix
Milk yield, kg	23.5	24.4	24.4	22.0	26.1
Fat, %	4.35	4.24	4.01	4.32	4.18
Protein, %	3.39	3.36	3.30	3.31	3.32
ECM, kg	24.1	24.5	23.8	22.4	26.1

On each farm, barley was compared with one of the four organic concentrated supplements on dry matter basis. Supplement was given in amounts of from 3.6 to 6.0 kg dependent on the farm specific conditions. Silage based on grass/clover and barley fed ad libitum on all farms.

Although feeding of fodder beets reduced the milk yield per cow compared to barley, this supplement will maximise the production per ha, as crop yield per ha is more than double of barley.

Conclusions

According to the basic principles of organic agriculture, livestock are kept as a part of the farming system and their nutrition should therefore be based on home-grown feeds. Therefore, both the sustainability and the productivity of the farming system depend on the internal flow of nutrients as represented by feed and manure, which implicates that health and welfare of organic livestock cannot be seen isolated from the whole system. A systemic approach is essential if animal health and welfare should be understood and maintained in organic farming.

During the last decades, economic pressure and consumer demands have made it necessary even for organic farms to select livestock with very high genetic potential for specific performance traits. For dairy cows, the genetic progress achieved in potential milk yield has not been accompanied by a similar increase in feed intake. The requirements for energy and essential nutrients therefore often cannot be fulfilled with the use of home-grown feedstuffs. More work has to be done to find the compromise between optimising the feeding and maximising the production per hectare.

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Energy and protein balance in organic dairy cow nutrition – model calculations based on EU regulations

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Introduction

In Austria, there are almost 20,000 organic farms, which account for a total of about 300,000 ha of land. About 8% of all farms, and about 9% of the agriculturally used land in Austria are organic, making Austria a leader in organic farming in Europe. Most of the organic farms are located in regions where there is permanent grassland. Approximately 60% of all organic farms keep dairy cows (Grüner Bericht, 1997).

In August 2000, the new EU Council Regulation Amendment (EC) 1804/1999 came into effect, incorporating animal production into the scope of Council Regulation (EEC) 2092/1991 regarding organic farming, as well as the regulation regarding the proper labelling of agricultural products and human food (EU Council Regulation Amendment (EC) 1804/1999). Standardised European regulations were created for animal production on organic farms. From a nutrition physiology point of view, the following requirements are relevant regarding ration formulation for dairy cows:

- 60% of the daily ration must come from forages (green forage, silage, hay). Exceptions can be made by the authorities that allow up to 50% of concentrate in the ration within the first 3 months of lactation.
- After 2005, all feedstuffs used will have to be grown organically. Until 2005, authorities can make exceptions and allow 10% of the annual ration and up to 25% of the daily ration to come from conventional production, as long as the components are listed in Appendix 2 of. EU Council Regulation (EC) 1804/1999. (Additional exceptions can be made in the case of catastrophes).

- It is forbidden to use by-products from oil seeds from which the oil was chemically extracted.
- Under organic farming conditions, it is also required that the dietary nutrient supply meets the requirements of the animals in their respective stages of production (EU Council Regulation (EC) 1804/1999).

Gruber *et al.* (2000) did not observe any significant differences in health parameters between cows producing equal amounts of milk either on organic (5,868 kg of milk per lactation) or conventional farms (5,877 kg of milk per lactation). Cows on organic farms had lower fertility rate. One reason for that observation might have been the lower level of energy provided in organic husbandry in early lactation.

In this paper, the level of energy and protein supply of dairy cows is estimated based on model calculations and depending on milk performance, forage quality and composition and within the legal framework (EU Council Regulation (EC) 1804/1999).

Materials and Methods

Feed intake, feed quality and animal parameters

Feed intake was estimated using the equation developed by Gruber (1999) for the whole lactation period. Milk yield as well as milk fat and milk protein yield were calculated using the exponential function ($\gamma_t = at^b e^{ct}$) developed by Wood (1967). The coefficients necessary for the "Wood-exponential function" were taken from Miesenberger (1997), who derived them from calculations based on mean values from all Austrian dairy cows under performance recording.

The coefficients of Brown Swiss (Braunvieh) in the third lactation were taken for the model calculations in the current study. The nutrient supply was calculated for 5 levels of performance (4,000, 5,000, 6,000, 7,000, and 8,000 kg milk within a 305-day-lactation period) and 3 types of forages (high quality grass; low quality grass; high quality grass plus 20% corn silage) (Tables 1 and 2).

Table 1 Composition of forage ration and chemical composition (DM basis)

Trait	Ration types		
	High quality grass	Low quality grass	High quality grass + corn silage
Composition of forage ration	70 % high quality grass silage 30 % high quality grass hay	70 % low quality grass silage 30 % low quality grass hay	60 % high quality grass silage 20 % high quality grass hay 20 % corn silage
Nutrient content per kg DM			
Energy, MJ NEL	5.75	5.26	5.89
CP, g	145	116	132
nXP[1)], g	129	117	129
RNB[2)], g	3	0	1

[1)] nXP = available crude protein in the duodenum; [2)] RNB = ruminal nitrogen balance

Table 2 Nutrient content of feedstuffs (per kg DM)

Nutrient	High quality grass silage	Low quality grass silage	High quality grass hay	Low quality grass hay	Corn silage	HES[1)]	HPS[2)]
DM (g)	350	356	890	863	275	890	890
Energy (MLnEL)	5.78	5.46	5.67	4.79	6.19	8.22	7.99
CP (g)	149	126	134	94	81	124	370
nXP[3)] (g)	130	122	125	106	130	164	228
RNB[4)] (g)	3	1	1	-2	-8	-6	23
Crude fibre (g)	231	312	259	344	216	48	128
Ash (g)	117	102	103	77	45	22	77

[1)] HES = low-protein high-energy mixture of grain
[2)] HPS = high-protein supplement
[3)] nXP = available crude protein in the duodenum
[4)] RNB = ruminal nitrogen balance

Concentrates were added in the form of a low-protein high-energy mixture of grain (HES), and a high-protein supplement (HPS). The HES contained 40% barley, 30% wheat, 20% corn grain and 10% oats. The HPS consisted of rape cake only. The level of concentrates was kept as low as possible, but at the same time, the tolerated deficiency (as defined below) in energy and protein supply at the beginning of the lactation should not be exceeded. The maximum daily proportion of concentrate in the rations was limited to 40% according to the EU Council Regulation (EC) 1804/1999. During the first week of lactation the maximum possible daily amount of concentrate was 5 kg. In order to demonstrate the situation when no HPS was used, one model calculation was conducted in which the concentrate supplementation consisted only of HES.

Tolerated sub-optimal nutrient supply

Energy supply

There is practically no stage of lactation in which the nutrient intake is exactly congruent with the nutrient requirements. At the beginning of the lactation period, energy requirements increase faster than the capacity of feed intake, and fat and protein reserves are mobilised to meet the requirements. Cows that have more than 140 kg body fat reserves at calving can mobilise up to 100 kg of body fat within the first two months of lactation (INRA, 1989). The mobilisation of large amounts of body energy reserves is a burden for the metabolism, and elevates the risk of metabolic disorders (ketosis etc.).

According to Swiss recommendations, the risk for metabolic disorders is not elevated as long as the daily energy deficiency is not greater than 20 MJ NEL within the first and 15 MJ NEL within the second month of lactation (RAP, 1994). This represents a tolerable daily energy deficiency of about 10% to 15% within the first two months of lactation, which corresponds with the energy needed to synthesise 200-400 kg of milk from body reserves, depending on the milk yield and the maintenance requirements. It is estimated that up to 600 kg of milk can be synthesised from body reserves.

French specifications regarding the tolerable energy deficiency level that does not lead to a reduction in milk performance are mentioned in Table 3 (INRA, 1989). Even in high producing cows, the tolerable energy deficiency should not exceed 30 MJ NEL per day, or 20% of the daily energy requirements. A low fertility and a reduced persistence of milk yield are the consequences if a marked energy deficiency is present, and if that deficiency is also maintained beyond the third month of lactation (INRA, 1989).

Based on recommendations in the literature (INRA, 1989), a maximum total energy deficiency of 1,300 MJ NEL at the beginning of the lactation period was assumed in the present calculations, which accounts for about 400 kg of milk to be synthesised by the mobilisation of body reserves. As soon as the energy balance reached zero, concentrate was only added in sufficient quantities to ensure that the cows would reach the goal body weight of 650 kg at drying off.

Table 3 Tolerable level of energy deficiency in early lactation for cows in good body condition at calving (INRA, 1989)

Maximum daily milk yield		Energy deficiency				Body weight
primiparous kg	multiparous kg	duration, weeks	MJ NEL, total	MJ NEL, per day	% of requirement	Loss/kg
10 – 15	15 – 20	4 – 5	170	5	5 – 6	10
17 – 22	20 – 25	5 – 6	340	9	8 – 9	20
	25 – 30	6 – 7	600	13	10 – 11	30
23 – 27	30 – 35	7 – 8	1,100	21	14 – 16	40
	35 – 40	8 – 9	1,700	29	17 – 19	50
over 28	40 – 45	9 – 10	2,120	32	18 – 20	60

Protein supply

Protein mobilisation capacity can reach about 15 kg, and is therefore much smaller than for body fat. Half of the mobilisable protein reserves are in the muscles, the rest comes from internal organs and the degeneration of the uterus. The mobilisation of protein lasts only up to the fifth week of lactation and occurs mainly when there is a large energy deficiency (greater than 20 MJ NEL/day). Even in high producing cows in good bodily condition, protein mobilisation cannot exceed 5 to 10 kg without causing a reduction in milk yield. This equals a synthesis of 100 to 200 kg of milk from body protein reserves (INRA, 1989).

When formulating diets, it is important to take the ruminal nitrogen balance (RNB) into account, as well as the supply of available crude protein in the duodenum (nXP) of the animal (GfE, 1997). Ferguson *et al.* (1986) reported that the amount of rumen degradable protein affects the fertility in cows. Investigations by Bruckental *et al.* (1989) and field studies by Sonderegger and Schürch (1976) also led to these results. Surpluses of ammonia in the rumen led to liver problems and a reduced glucose production in experiments conducted by Weekes *et al.* (1979). A decline in plasma glucose concentration was also observed by Leonard *et al.* (1977) when a surplus of dietary N was present. Excessive N content in the ration, in combination with a lack of provided energy, causes increased incidences of sub-clinical ketosis as a consequence of a reduced feed intake as well as an elevated gluconeogenesis from amino acids (Rossow, 1980). In addition, a surplus of N in the rumen leads to an elevated formation of urea in the liver, a biochemical process, which requires energy. According to Blaxter (1962), about 4 MJ of energy are necessary to excrete 80 g of excess ruminal N. Therefore, when formulating diets, it is important to balance the rumen for N (GfE, 1997).

In the present model calculations, it was assumed that the maximum nXP-deficiency at the beginning of lactation is not greater than 14.6 kg, which corresponds to the body protein mobilisation needed for the synthesis of 200 kg milk (INRA, 1989). The tolerated daily rumen N deficiency was calculated depending on the daily milk yield (RNB_{min} = daily milk yield in kg minus 50). The maximum ruminal N surplus was assumed to be 80 g per day (RNB_{max} = +80 g N).

Results

Ration formulation and average supply of energy and protein during lactation

The results of the calculations, averaged over the entire lactation period, are presented in Table 4. In all types of rations, the amount of forage consumed decreases as the performance level increases, whereas concentrate requirements and total feed intake increase.

Low forage quality causes the concentrate requirements to increase significantly. For example, a low forage quality (low quality grass) at a performance level of 6,000 kg milk, led to an average concentrate requirement of 32%, 10% higher than that of the ration with high forage quality (high quality grass). If the performance potential of the cows is low, then a high forage quality can cause the animal to put on too much body fat at drying off. For this reason, the ration type high quality grass plus corn silage at a performance level of 4,000 kg was calculated with a lower concentrate usage, in order to obtain a somewhat greater weight loss at the beginning of the lactation period.

In accordance with the EU Council Regulation (EC) 1804/1999, concentrate use was limited to 40% at the beginning of lactation. The calculations demonstrate that at a high level of forage quality (ration types high quality grass or high quality grass plus corn silage), a performance of 7,000 kg is possible without exceeding the tolerable restrictions for sub-optimal energy supply. At a performance level of 8,000 kg, 500 (high quality grass plus corn silage) or 600 kg (high quality grass) milk already have to come from mobilisation of body reserves. This results in a loss of body mass of 77 kg over a period of 92 days (high quality grass plus corn silage), and of 92 kg over a period of 108 days (high quality grass) from the beginning of lactation. This represents a significant strain on the metabolism, and lower fertility must be expected (INRA, 1989; RAP, 1994). In comparison, if the forage quality is low (ration type low quality grass), then not even a performance level of 7,000 kg can be maintained without falling below the assumed physiological limits. It could be shown that under organic production conditions, achievable milk production decreased by app. 1,000 kg for every 0.5 MJ NEL/kg DM that forage quality was reduced. Therefore, a high quality forage is necessary in order to achieve high performance levels in organic production.

Protein supply calculations must take not only the cow's requirements (nXP) into account, but also those of the rumen microbes (RNB). Supplementary HPS requirements are influenced mainly by the crude protein (CP) content of the forage, the degradability of CP in the rumen, the energy content of the forage and by energy supply. The close physiological relationship between energy supply and nXP are shown clearly by the results in Table 4.

Table 4. Composition of ration and parameters of nutrient supply according to type of ration and milk yield

Ration types / Parameters	Annual milk yield, kg				
	4,000	5,000	6,000	7,000	8,000
High quality grass					
Forage (kg DM)	13.05	12.91	12.58	12.05	11.18
Concentrates (kg DM)	0.50	1.90	3.39	5.01	6.82
HES[1)](kgDM)	0.50	1.90	3.39	4.74	5.76
HPS[2)] (kgDM)	0	0	0	0.27	1.06
Percent of forage	96.3	87.2	78.8	70.7	62.1
Energy deficiency (days)	82	60	54	68	108
Milk from mobilised body energy (kg)	260	200	214	318	**594**
Body weight loss (kg)	40	31	33	49	**92**
nXP[3)] – deficiency (days)	26	30	40	48	86
Milk form mobilised body protein (kg)	68	90	142	199	**289**
Low quality grass					
Forage (kg DM)	11.56	11.30	10.87	10.12	
Concentrates (kg DM)	2.25	3.70	5.22	6.82	
HES[1)] (kg DM)	2.25	3.60	4.89	5.28	
HPS[2)] (kg DM)	0	0.10	0.33	1.54	
Percent of forage	83.7	75.3	67.6	59.7	
Energy deficiency (days)	62	62	76	118	
Milk from mobilised body energy (kg)	202	211	317	**603**	
Body weight loss (kg)	31	33	49	**93**	
nXP[3)] – deficiency (days)	26	32	52	74	
Milk form mobilised body protein (kg)	67	105	195	199	
High quality grass + corn silage					
Forage (kgDM)	13.42	13.35	13.03	12.60	11.79
Concentrates (kg DM)	0	1.35	2.85	4.43	6.24
HES[1)] (kg DM)	0	1.35	2.81	4.11	4.92
HPS[2)] (kg DM)	0	0	0.04	0.31	1.32
Percent of forage	100.0	90.8	82.1	74.0	65.4
Energy deficiency (days)	114	66	62	58	92
Milk from mobilised body energy (kg)	378	223	242	262	**501**
Body weight loss (kg)	59	35	37	41	**77**
nXP[3)] – deficiency (days)	40	34	44	46	62
Milk form mobilised body protein (kg)	100	105	159	196	**217**

1) HES = low-protein high-energy mixture of grain
2) HPS = high-protein supplement
3) nXP = available crude protein in the duodenum

This explains why, in the case of high quality forage at a performance level of 8,000 kg, or low quality forage at a performance level of 7,000 kg, the nXP supply, like energy supply, falls below the tolerable limits.

HPS requirements are generally increased in corn silage rations as opposed to rations consisting of only grass forages, because of the additional N supplementary requirements needed to supply the rumen microbes. At a low forage quality, more high-energy concentrates (HES) are required even at low performance levels. Since the HES has a negative RNB (-6 g), then there is an increased need for additional HPS even at lower performance levels.

Ration composition, energy and protein supply in various stages of lactation
The results of the model calculations regarding the requirements for forage rations and concentrates as well as energy supply for each ration type in the course of lactation are represented graphically in Figure 1.

As performance levels rise and forage quality decreases, the concentrate requirements increase significantly. At a performance level of 4,000 kg, no concentrate is required for the ration type high-quality grass and corn silage, and for high quality grass the requirement is under 2 kg per day (DM basis). In contrast, up to 4 kg of concentrates per day (DM basis) are necessary in the case of low-quality grass forage. At a performance potential of 6,000 kg, 40% concentrates are needed at the beginning of lactation if the forage quality is low.

Given a milk performance potential of 8,000 kg, then the organic farmer has to feed the maximum allowable amount of concentrates (40%) up to the 7th month of lactation, even when forage quality is high. Even then, energy requirements are not fulfilled until after 4 months of lactation. This is no longer within the tolerable energy deficiency range for dairy cows in early lactation (INRA, 1989; RAP, 1994). In the case of low quality forage and an assumed performance of 8,000 kg, the energy deficiency was so pronounced that the body weight of the cow on the last day of lactation had fallen to 539 kg, a weight loss of 111 kg from early lactation, in spite of the use of 40% concentrates during the entire lactation period. This result was therefore not included in any of the tables.

Protein concentrates are among the most expensive feed components, especially in organic agriculture. The supply situation that results from the exclusion of protein concentrates is represented in Figure 2. Neither an increase in nXP supply, nor the use of protein concentrates to balance for RNB is necessary at low milk performance levels. Even at a performance of 6,000 kg, no protein concentrate supplementation is necessary for a strictly forage ration if forage quality is high. A small amount of HPS in the first 3 months of lactation is necessary in order to compensate for the negative RNB in the high-quality grass and corn silage ration. The ration with poor forage quality (low-quality grass) falls well below the tolerable negative RNB limits in the first 6 months of lactation, making the use of HPS with a positive RNB essential. This also helps to achieve the necessary improvement in nXP supply in the first 2 months of lactation.

As in the case of energy deficiency, the exclusion of HPS at high performance levels also causes a significant lack of nXP.

Requirements of available crude protein in the duodenum are not fulfilled until after 4 months of lactation for both the ration type high-quality grass and the high-quality grass and corn silage ration. The situation is even worse for the ration low-quality grass, where a balanced nXP supply is not achieved until after the 7th month of lactation. The use of HPS at high performance levels to compensate for the markedly negative RNB is necessary in every ration type.

The protein supply situation with the use of HPS is shown in Figure 3. At a performance of 6,000 kg, up to 0.8 kg HPS must be given to compensate for the negative RNB in the first 6 months of lactation in the ration low-quality grass. This also ensures a sufficient supply of nXP. No HPS supplementation is necessary for the ration high-quality grass, whereas small daily amounts of HPS in early lactation are necessary to compensate for the negative RNB in the ration type high-quality grass and corn silage. The nXP supply of the animal at very high performance levels can not be guaranteed, even when large amounts of HPS up to the highest tolerable RNB limit of +80 g N are given. Therefore, an improvement of nXP supply in this case can only be achieved through an improvement in energy supply, the use of protein concentrate components with a low CP degradability in the rumen, or a combination of both of these factors.

Because the energy supply in organic agriculture may not be improved through the use of higher amounts of concentrates (max. 40% in the daily ration), the quality of the forage in the ration is of particular importance. This factor is, however, limited by cultivating conditions, as well as climatic and economic considerations, making protein concentrate components with low CP degradability in the rumen even more important at high performance levels. Extraction meals are not permissible, according to EU Council Regulation (EC) 1804/1999. Of the components available, corn gluten and brewer’s grains, followed by rape seed cake, sunflower seed cake and pumpkinseed cake are those with a relatively low protein degradability. Of these, only corn gluten, rape seed cake and pumpkinseed cake have a sufficiently high energy content.

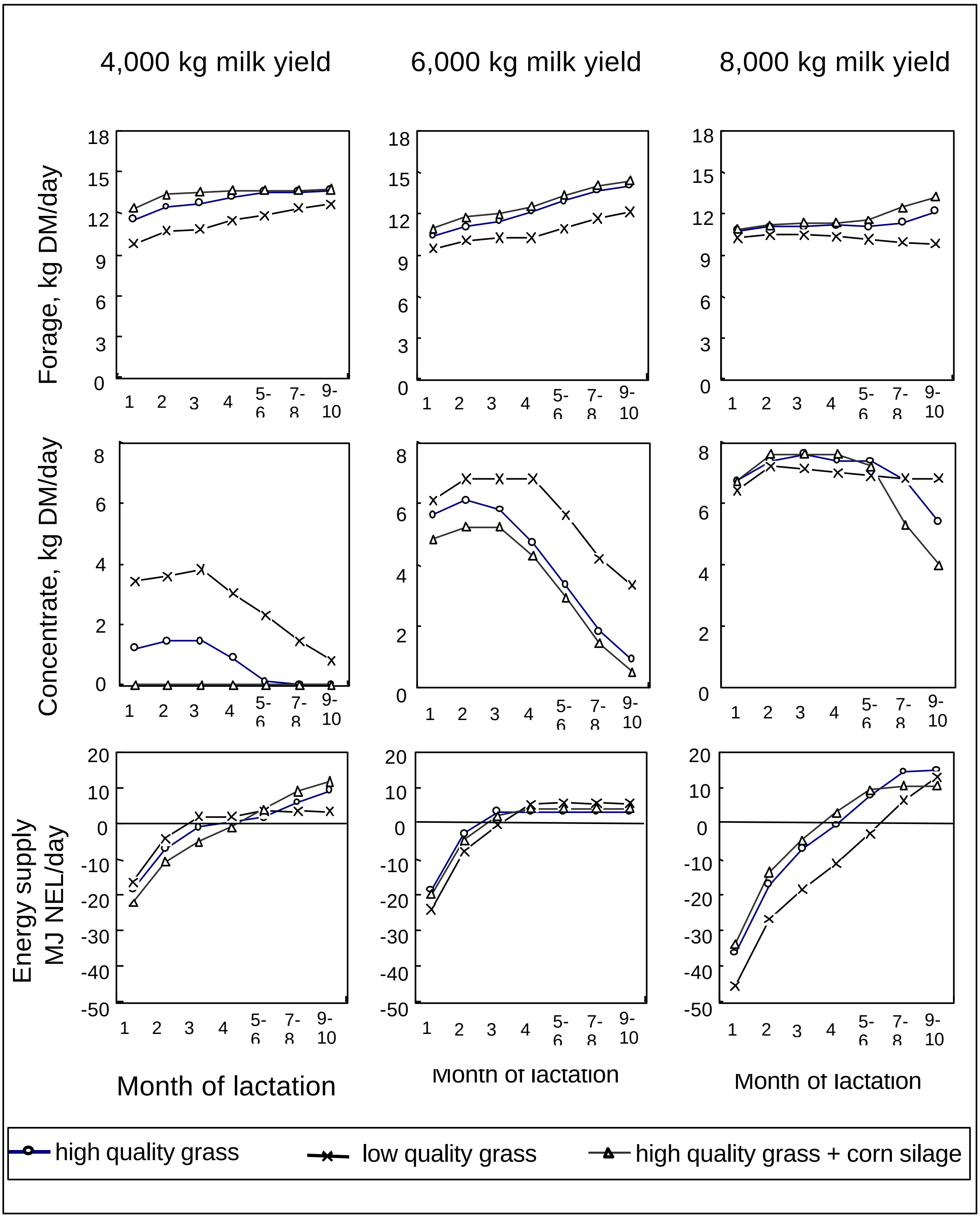

Figure 1 Energy supply and requirements of forage and concentrates during lactation

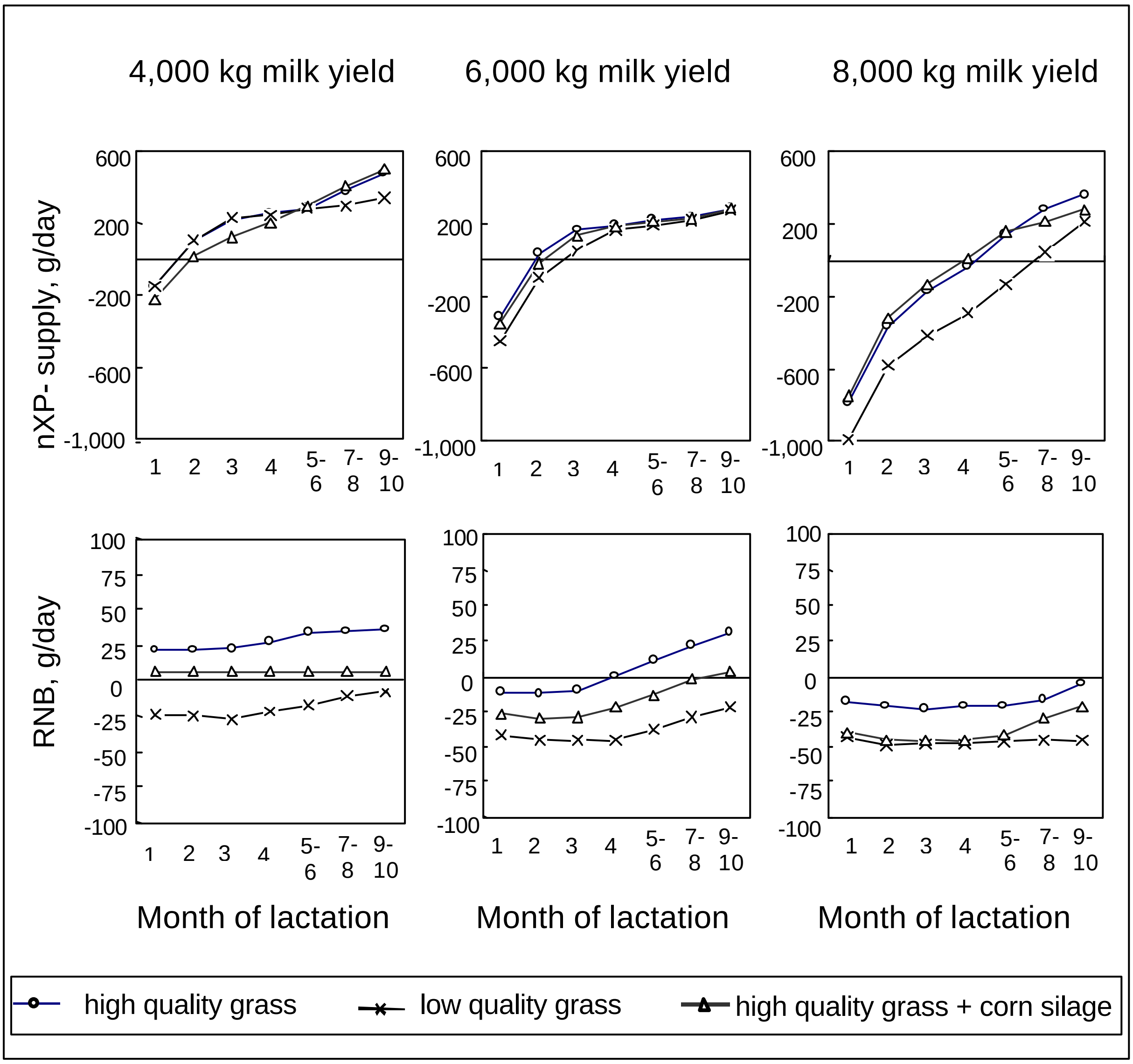

Figure 2 Supply of available crude protein in the duodenum (nXP) and ruminal nitrogen balance (RNB), without protein concentrate

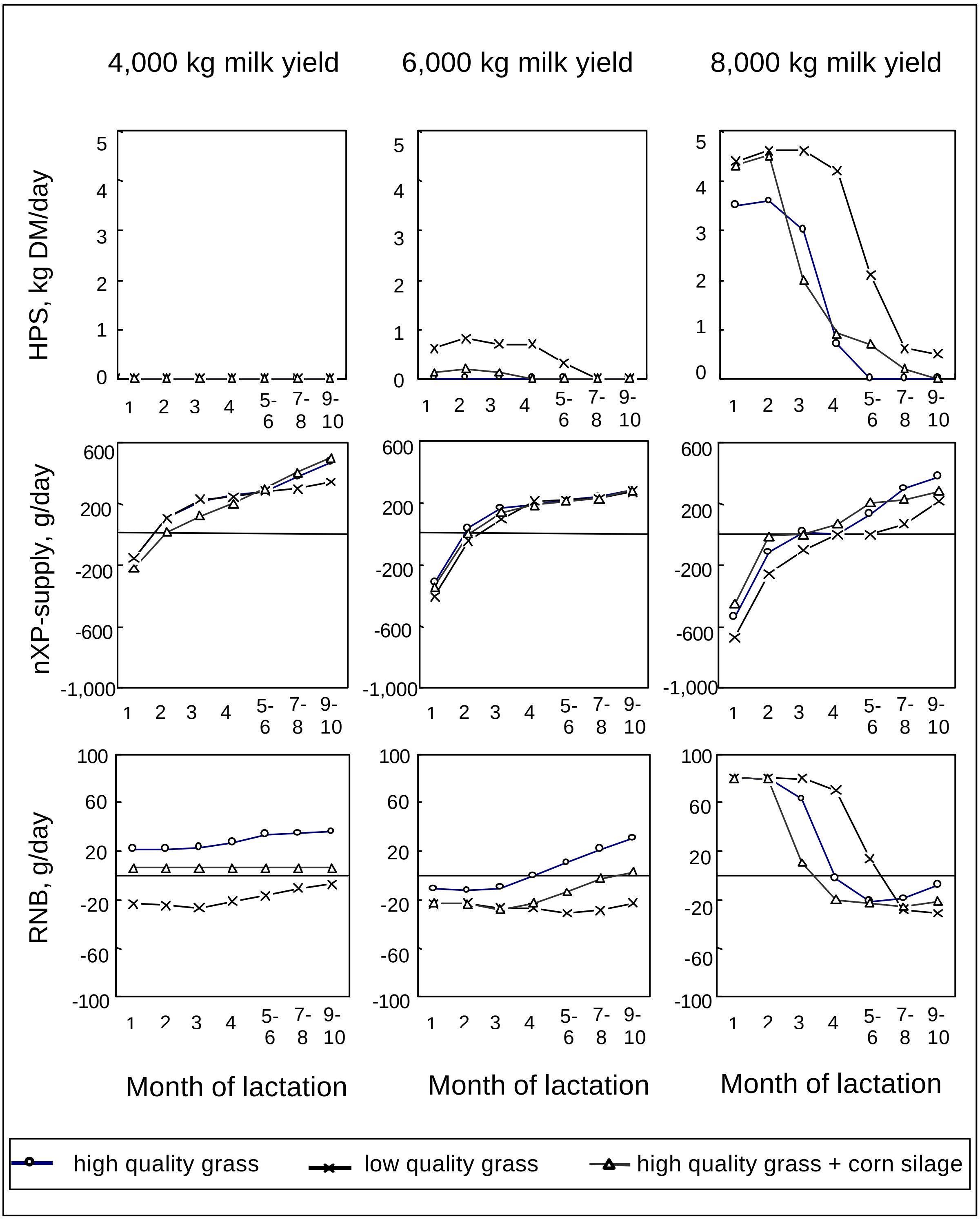

Figure 3 Protein concentrate (HPS) requirements, supply of available crude protein in the duodenum (nXP) and ruminal nitrogen balance (RNB)

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Conclusions

Nutrient supply must be based on the animal's requirements in order to avoid metabolic disturbances, and to maintain fertility and overall health. The limited possibilities for ration composition in organic agriculture (EU Council Regulation (EC) 1804/1999) must lead to consequences in feeding, management and breeding. In organic agriculture, forage quality plays a major role when milk performance potentials are high, as could be shown in the model calculations. Because of the limitations in concentrate usage, only through the feeding of high-quality forage is it possible to obtain lactation performances of over 7,000 kg without extensive nutrient deficits. This is also assuming that husbandry and management are optional, so that the animals achieve a high feed intake as quickly as possible, especially in early lactation.

Since only forage-based rations are common in organic agriculture, there is less risk of ruminal acidosis because of a lack of structured carbohydrates. At the same time, energy and nXP supplementation through concentrates becomes particularly important. For this reason, such concentrate components must be given that have a high energy content or else a high content of fermentable organic mass (grain, etc.). Concentrate components with a high NDF content (low-energy) and those with high crude fat contents should be kept to a minimum (<20%). Greatest attention must be paid to the quality of the components (no weed content, optimal drying, no mould or mildew).

As the results show, supplementation with protein-rich concentrates is necessary in the moderate performance range mainly to fulfil the N requirements of the rumen microbes. The use of components with low protein degradability in the rumen is not essential in this case. However, as milk yield increases, lack of nXP plus excess N in the rumen become more and more limiting to performance. Protein concentrate components with low protein degradability in the rumen and high energy content would be necessary in early lactation and for high performance. These demands can only be partially fulfilled by the feeds available, making protein supply a significant limiting factor.

Furthermore, organic farmers should pay attention to fitness characteristics, persistence and (forage) feed intake potential when breeding or making genetic choices. In addition, measures that encourage high feed intake should be implemented as soon as possible when raising heifers (ration composition, intensity, and age at first calving). Since profitability increases with higher lifetime performance, longevity is an important characteristic, and should have first priority when making genetic choices. In this manner, it is possible to attain a sufficient farm income even at relatively low performance levels (compare Steinwidder and Greimel, 1999). In general, economic and policy conditions should be structured so that restrictions and limitations in performance do not result in economic disadvantages for organic dairy farms (compare Greimel, 2000).

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Organic beef production with emphasis on feeding and health of dairy bred bull calves

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Introduction

Cattle husbandry is an important enterprise on many organic farms. In Spain, 50% of the organic livestock production is beef cattle and only 1% dairy cattle (Trujillo, 2000). In Austria, 97% of the organic farms have cattle, consisting of 65% dairy cattle and 35% beef cattle (Graf and Willer, 2000). In Denmark, 33% of the organic farms have cattle, of this 57% are farms with dairy cattle, forming the majority of organic cattle (Anon., 1999a). There is, however, an important link between these two enterprises.

In Denmark, cast cows from dairy production constitute the largest part of organic beef production, and only 26% of the bull calves born on the organic farms in Denmark are slaughtered as organic (Nielsen, 2000). Many organic dairy farmers sell bull calves for fattening on conventional farms, because organic fattening of bull calves is not as profitable as organic milk production. Lack of resources, such as foodstuff and stall capacity, are other reasons for not fattening bull calves. Selling bull calves may be considered an ethical problem for organic farming, which is supposed to represent a holistic approach to production. Most of the organic dairy farmers that participated in a questionnaire survey agreed with this statement. It was repeatedly stated that: "It is a problem for organic farming, when bull calves from organic dairy farms are sold to conventional farms". However, very few farmers did anything to address this problem.

A survey in Denmark showed that the number of households buying organic meat has doubled from 1996 to 1998 (Borgen, 1999). However, the market share of organic beef in most countries is very low - only 2% in Denmark, whereas other organic products, such as milk, has a market share of more than 20% (Anon, 1999b). Consumer prices for organic beef possibly exceed consumers' willingness to pay, as premiums for organic meat in several countries in the EU result in a price of 52% above the conventional products (Schmid and Richter, 2000).

This paper gives an overview of organic beef production in Denmark with emphasis on feeding and health of organic dairy bred steers. In this context, results from a questionnaire survey from Denmark (1999) are presented. The survey included all organic dairy farmers and some organic plant breeders and resulted in a response rate of 48% (Nielsen, 2000).

Overview of production types

Suckler cows

Beef cattle are typically produced as part of the suckled calf system. This production is based on cow and calf grazing together during summer months. The calves finished and often slaughtered as bulls, or sometimes as steers. Finishing can be based on roughage, but often large amounts of cereals are included to achieve high daily gain in this period.

Depending on breed, the production can be based on the use of marginal areas and low input of concentrates (Hereford, Angus) or on an intensive production with breeds of Limousine or Charolais, having a high daily gain and good carcass quality but also demanding good stall facilities and feed supply.

Cast cows from dairy production

In countries with large production of organic milk, cast cows contribute to a large extent to organic beef production. In Denmark, the replacement rate on organic and conventional dairy farms is about 40%, resulting in beef from cast cows, constituting 43% of total beef production (Anon, 1999c) and approximately 55-60% of the organic beef production. Cast cows are often slaughtered without finishing, resulting in poor meat quality. Finishing of cast cows can be done by feeding cereals before or after drying off. Finishing dry cows results in poor feed utilization per kg gained meat, because maintenance requirements are high. Additionally, finishing of cast cows requires good management concerning drying off, particularly hen finishing is started to avoid mastitis or cull a cow with mastitis, as feeding high amounts of cereals can result in reintroduction of lactation and mastitis (Mogens Vestergaard, pers. communication, 2001). On the other hand, finishing of lactating cows of Holstein Friesians often results in increasing milk yield but not in increasing daily gain.

Bulls and calves

Dairy bred bull calves in Denmark are traditionally reared as bulls and slaughtered at the age of about 11-13 months (400-450 kg liveweight at slaughter), following in-door fattening with high amounts of concentrates. On organic farms, this production is not feasible due to the daily requirement of 60% of roughage in the rations, and grazing in 150 days in the year (Anon, 2000a). Bulls older than one year of age can be housed in stables with access to an outdoor run the whole year. Keeping bulls on pasture is possible, and studies have shown a satisfactory carcass quality after five months of summer-grazing and a finishing period of 10 weeks with concentrates *ad libitum* (Therkildsen *et al.*, 1995).

Finishing organic bulls have to be based on a feed ration based on roughage and only 40% concentrates. However, many Danish dairy farmers find it difficult to rear bulls due to the problems associated with heifers, often reared in the same part of the farm. Public safety and health and safety regulations on farm are also limiting factors in opting for bull rearing.

Calves are slaughtered at an age of 8 to 10 months and a liveweight at slaughter of 300-350 kg. This production also requires great amounts of concentrates to achieve good daily gain. The Danish organization selling the majority of organic beef (Friland Food A/S) has recently paid an additional price to the organic farmer for organic calves. However, with the new EU-rules and the recommendations of 60% roughage, the sale of organic calves has ceased as the eating quality of beef produced under restricted feeding is considered questionable.

The intensive feeding of bulls and calves increases the risk of metabolic or feed-related disorders. Feeding with large amounts of easily digestible carbohydrates, especially cereals, results in high concentrations of volatile fatty acids and lactic acid in the rumen. When salivary production at the same time is low due to a low intake of roughage, pH in the rumen will fall with risk for systemic acidosis. Low pH may result in damage to the ruminal wall and papillae, reduced absorption of volatile fatty acids and low rumen motility. The damaged rumen wall may cause bacteria to enter the circulation and the development of liver abscesses. Both ruminal wall damage and liver abscesses are common findings in intensively fed calves, bulls and steers, as about 30% of animals are found to be affected at slaughter (Andersen, 2000). Most cases do not show any clinical symptoms, unless accompanied by severe acidosis and laminitis. Bloat is another problem related to feeding with high amounts of concentrates due to formation of persistent foam by ingested polysaccharides. If rumen motility is low at this time, eructation of gases is reduced.

Steers

In both Denmark and Sweden, the production of steers has increased in recent years (Nielsen, 2000; Törnquist *et al*., 2000). Results from the Danish questionnaire showed, that out of the organic dairy farmers rearing bull calves, 61% had a steer production enterprise. Steers were preferred to bulls and calves, due to their perceived ability to utilize roughage and marginal areas and their calm temperament. The calm temperament of steers makes grazing - also together with heifers - possible. Steers in Denmark are traditionally slaughtered at the age of 24-27 months (liveweight 550-600 kg), about a year older than bulls. Compared to bulls, steers do not have to have a similar high daily gain than bulls, and therefore feeding with high amounts of roughage is possible. Steers are often finished in 3-4 months to improve meat quality.

Management of organic dairy bull calves with emphasis on production of dairy bred steers

Housing and feeding in the winter

The questionnaire showed, that 94% of the farmers used deep bedding for rearing calves, bulls and steers, 11% used a shelter on pasture and 7% used free stalls with individual bedding. The average area used for the animals in the stable, calculated as a mean for all weight intervals, was in accordance with the new EU-rules. However, great variations can possibly be found among different farms.

As long as nutrient requirements are met, steers can be fed low energy rations in the winter period, and use of resources not otherwise needed is common (remainders from feeding dairy cows, silage with low digestibility, waste products). However daily gain minimum of 500 g should be assured. Notably, when feeding cattle at low energy level in the winter period, the daily gain on pasture will be greater compared to cattle fed at high energy levels in the winter period, as they "compensate" for the low energy intake in the foregoing period.

On Danish farms with organic steer production, clover grass silage is used on 82% of the farms, whole crop silage on79% and cereals on 64% of the farms. Feeding of calves and bulls were based on cereals on 68% and 80% of the farms respectively, clover grass silage and whole crop silage was used on 36% and 80% of the farms. *Ad libitum* feeding of cereals was used to calves and bulls on 60% of the farms and to steers on only 9% of the farms. These results confirm, that steer production is based on high amounts of roughage, and only small amounts of cereals are used.

Grazing

<u>Turn-out on pasture with emphasis on young calves</u>

After turn-out on pasture, weight losses are often observed. Steers and heifers can loose from 4-14% of body weight when grazing on *Lolium perenne* or on extensive pastures 10-15 days after turn-out (Wright *et al.*, 1986). On clover grass pastures, weight losses of 6% were observed 8 days after turn-out (Yarrow *et al.*, 1996). The preceding feeding level in winter had effect on weight loss after turn-out, as high energy levels result in a higher weight loss (Wright *et al.*, 1986; Yarrow *et al.*, 1996). Additionally, a sward height above 7 cm on pastures in crop rotation and above 10 cm on extensive pastures resulted in the lowest weight loss (Wright *et al.*, 1986; Yarrow *et al.*, 1996).

Weight losses may be partly explained by changes in rumen fill, and a trial with dairy cows found that 84% of weight losses after turn out could be explained by changes in rumen fill (Balch and Line, 1957). Low rumen pH when grazing on pasture and a low content of structure in the feed ration, result in increased passage rate in the rumen, meaning a lower rumen fill (Murphy, 1999). However, sudden feed change from winter feeding with cereals and silage to exclusively grazing requires a changed composition of rumen microorganisms, taking time to establish. This management may reduce weight loss following turn out.

The standards for organic farming require that calves at an age of three months have to graze on pastures in the summer. Turn-out of calves at that age often means low daily gain and diarrhoea. Often calves are held on pastures close to the farm building, giving risk for parasite infections. In Sweden, *Eimeria alabamensis* was found to be the cause of diarrhoea in young calves grazing on permanent pastures in the time following turn-out (Svensson *et al*., 1993). It is important, that calves are grazing in closed groups and no new calves should be introduced in a group to minimize the risk of imbalances in the level of immunity to parasite infections.

Low daily gain of young calves could also be caused by low intake of grass, resulting in insufficient supply of energy and protein. The present Danish standards show that dairy calves weighing 100 kg at the age of three months can have an intake of 2.5 Scand. Feed Units (SFU) (24.1 MJ ME) grass with an energy content of 1.4 kg DM / SFU. This feed intake meets the requirements of the calves. Typical clover grass pastures in summer have a quality that meets this minimum. In the autumn, however, the grass quality is reduced, and energy requirements of the calves may not be met. In Denmark, calves younger than six months do not need to be on the pasture from first of September and the rest of the grazing season. However, there is reason as calves have to get used to grazing.

Preliminary results from on-farm trials in Denmark indicated that supplementation of a protein-rich concentrate (crude protein: >15.5%) to young dairy breed calves on pasture resulted in better weight gains compared to supplementation with barley alone (crude protein: <10.0%) (Table 1 and Table 2) (own data, not published). However, at the end of the grazing season no difference was found between the three treatments on Farm 1 (Table 1), but higher liveweight and live weight gain of calves fed with protein-rich concentrate was found on Farm 2 (Table 2). There was a significant effect of liveweight at turn-out on daily gain as animals with low liveweight had lower daily gain during the entire grazing season.

Table 1 Supplementary feeding of Holstein Friesian calves (3-5 months) in 2 months after turn-out on pasture (clovergrass) on Farm 1

Farm 1	**Protein rich supplement, ad lib**	**Barley, ad lib**	**Barley, restricted [1]**
Number of calves	12	12	12
Amounts, kg/day/animal	3	2	½
Dry matter, %	86.4 ± 0.07	85.4 ± 1.27	85.4 ± 1.27
Crude protein, %	15.7 ± 0.28	8.8 ± 0.49	8.8 ± 0.49
Liveweight, start, kg	131 ± 29	132 ± 26	136 ± 18
Liveweight, end of trial, kg	191 ± 39	165 ± 32	179 ± 24
Liveweight, turn-in, kg	271 ± 48	253 ± 56	262 ± 52
Daily gain on pasture:			
turn-out to end of trial (d 0-56), g	1070^{a} ± 240	590^{b}± 270	770^{c} ±143
end of trial to housing (d 56-189), g	599 ± 212	663 ± 242	622 ± 284
whole period on pasture (d 0-189), g	739 ± 158	640 ± 244	666 ± 221

Values in the same row with different superscripts are different (a and b: P<0.01; a and c P< 0.05)
[1]Daily gain for calves fed barley restricted was higher compared to calves fed barley ad libitum. Problems with pneumonia in some of the groups may be an explanation of this result.

Table 2 Supplementary feeding of Holstein Friesian calves (3-5 months) in 2 months after turn-out on pasture (clovergrass) on Farm 2

Farm 2	**Protein rich supplement, ad lib**	**Barley, ad lib**	**Significance**
Number of calves	20	20	
Amounts, kg/day/animal	3	3	
Dry matter, %	86.2 ± 0.21	86.6 ± 0.07	
Crude protein, %	16.1 ± 0.42	9.9 ± 0.0	
Liveweight, start, kg	124 ± 27	125 ± 26	NS
Liveweight, end of trial, kg	191 ± 36	182 ± 36	P<0.001
Liveweight, turn-in, kg	304 ± 26	297 ± 39	P<0.01
Daily gain on pasture:			
turn-out to end of trial (d 0-56), g	1216 ± 200	1042 ± 252	P<0.01
end of trial to housing (d 56-189), g	734 ± 110	749 ± 103	P<0.05
whole period on pasture (d 0-189), g	870 ± 78	831 ± 91	P<0.01

Feed intake on grass

To understand the problems with weight losses of young calves and older steers and heifers when turning-out on pasture, it is important to know the feed intake on grass. Methods based on constant dosing with chromoxide and alkanes can be used to estimate feed intake on pasture, but a sudden change in foodstuff, as it is the case at turn-out, makes these methods unreliable until about 3-4 weeks after turn-out. Estimation of feed intake on clover grass pastures was done for Holstein-Friesian steers 3-4 weeks after turn-out at a mean weight of 203 kg. Preliminary results show, that the intake was 5.5 ± 1.2 kg DM /day, which is 11% lower than the Danish standards predicted with a daily gain of 1055 g (own data, not published). This suggests that the feed utilization of steers may be better than expected.

Grazing on marginal areas versus crop rotation areas

Production systems for steers can be based on high daily gain in summer with grazing on crop rotation areas or on pasture of poorer quality like permanent pastures in marginal areas (Figure 1). When steers graze marginal areas a daily gain of 500-700 g/day can be expected. The grazing season on marginal areas is often short, due to delayed grass growth and wet soil, resulting in a late turn-out (beginning of June) and an early housing (October). This results in a low total weight gain on grass compared to grazing on crop rotation areas, with an expected weight gain of 900 g/day. When grazing marginal areas, the total weight gain on pasture after 2 grazing seasons is lower compared to grazing on crop rotation areas. Therefore weight gain in the stable or in the finishing period has to be higher, when steers grazing marginal areas. Alternatively, a third grazing season is necessary. Grazing on marginal areas can combine nature preservation and livestock production. In general, diversity of most fauna and flora is likely to be greater at low intensity grazing compared to no grazing or high intensity grazing (Milne and Sheldrick, 1997).

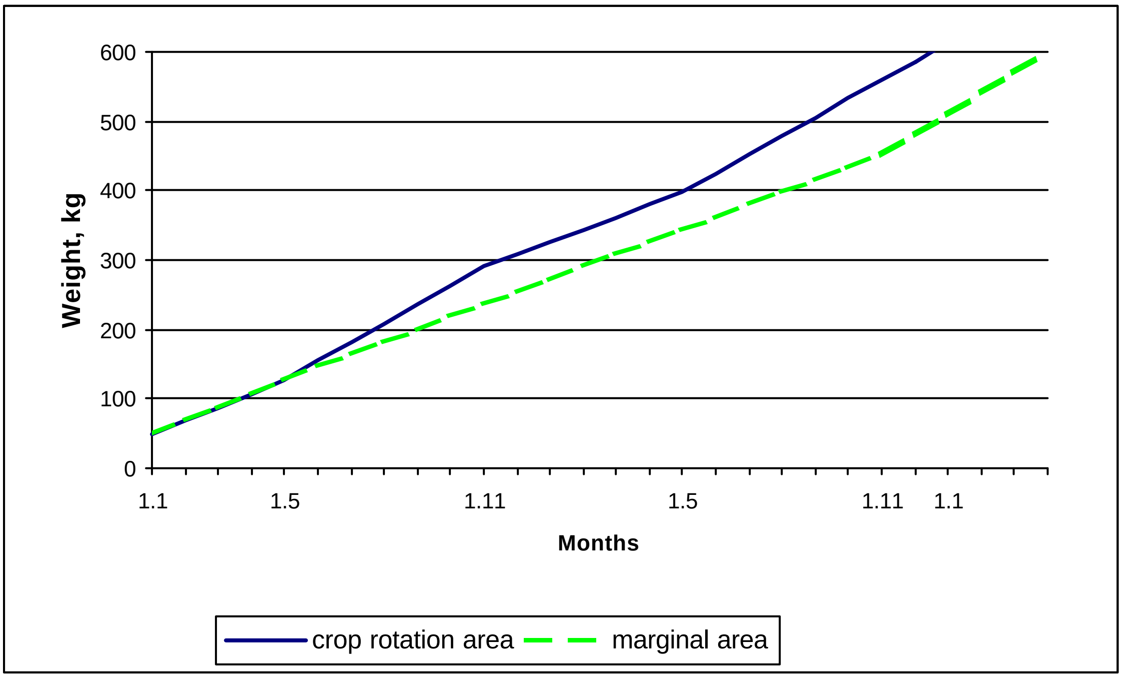

Figure 1 Daily weight gain of steers on crop rotation areas and on marginal land.

Parasites

Grazing permanent pastures leads to an increased risk of parasite infections. Cattle grazing for the first season do not have any immunity against parasites. Stocking rate influences the internal parasitism under extensive grazing conditions, as it was found, that a lower stocking rate with 0.5 first-year grazing steers/ha, resulted in a lower eggs per gram (epg) of *Ostertagia* spp. than at high stocking rate (1.55 steers/ha) (Thamsborg *et al*., 1998). It was concluded, that feed on offer was a limiting factor, especially in late season. Similar results were found with gastrointestinal nematodes in another trial, where steers were grazing on wet meadows, whereas lungworm disease was a problem irrespective of stocking rate (Thamsborg *et al*., 2000).

On organic farms with steer production, the problems mainly mentioned in the questionnaire were coccidiosis, intestinal worms and lungworm. A questionnaire among organic dairy farmers in Sweden showed several management factors to prevent parasite infections (Svensson *et al*., 2000). Calves turned-out on pastures not grazed by cattle in the previous season, changing of pasture within the grazing season and nutritional supplementation in the autumn and in the spring were used by 50-60% of the farmers. Others management strategies used were delayed turn-out, use of aftermath and mixed or alternate grazing with older cattle or other species. Older, more resistant cattle have a low egg excretion, resulting in a "diluting" effect. First-season cattle benefited from mixed grazing with second-season cattle by having a higher weight gain during the entire grazing season (Nansen *et al*., 1990). Epg in feces was higher and serum pepsinogen lower for the mixed-grazing cattle (first season) compared to first-season cattle grazing alone. Additionally, pasture infectivity at the end of the grazing season was much lower on the pasture with mixed-grazing.

Castration and animal welfare

Castration is an intervention in an animal's life. Castration results in an elevated level of cortisol in plasma and although anesthetization reduces the level of cortisol concentration, it is still on a higher level than in calves only anaesthetized (Fisher *et al.*, 1996; Molony *et al.*, 1997). In several trials, where calves were castrated without anesthetization, it was concluded that castration resulted in pain for the animal (King *et al.*, 1991; Molony *et al.*, 1995; Murata, 1997).

One goal of organic farming, is to guarantee livestock high levels of welfare and ability to express natural behaviour. Another goal is to optimize the utilization of resources, and yet another is to provide the farmer safe and meaningful working environment. In steer and bull production, some of these goals may be conflicting. However, the questionnaire showed, that dairy farmers did not consider castration as unethical.

In Denmark, two methods for castration are used. Surgical castration that means a total removal of testis and epididymis or the Burdizzo method where the spermatic cord is crushed. In Denmark, castration has to be done by a veterinarian and anaesthesia is compulsory. The use of rubber bands is forbidden in cattle. The questionnaire survey showed, that the Burdizzo method was used on 59% of the organic farms with steer production and surgical castration was used on 37% of the farms (Nielsen, 2000). In England, a similar picture is seen on conventional farms, as 43% of the farms use Burdizzo and surgical castration is used on 39% of the farms (Kent *et al*., 1996).

Many trials comparing Burdizzo and surgical castration do not show any major difference between the methods concerning animal welfare, measured by cortisol concentrations in plasma and behavioural observations. However, it seems, that castration with the Burdizzo method results in the lowest level of stress hormone. A study showed an elevated cortisol concentration up to 6 hours after surgical castration, but only up to 1.5 hour after castration with the Burdizzo method (Fisher *et al*., 1996). However, many veterinarians are reluctant to use the Burdizzo method, due to the risk of unsuccessful castrations or due to swelling with possible reductions in animals welfare (Kent *et al*., 1996; Anon, 2000). With surgical castration there is a higher risk of complications due to infections.

Immunocastration, based on immunization against gonadotropin releasing hormone (GnRH), reduces castration stress compared to surgical castration (Hill *et al*., 1985). This method can delay the secretion of testosterone up to an age of 10-13 months (Jago *et al*., 1995; 1996; 1997). If steers are slaughtered at an age of 24 months, this castration method is not adequate. It is also unknown whether immunization complies with organic standards.

It appears that the age at castration has some influence of animal welfare as cortisol concentration was lower at the age at castration of 2.5 months rather than 5.5 months (King *et al*., 1991). However, the influence of age at castration on weight gain in the subsequent period is not unambiguous. Castration at the age of 1, 6 or 12 months (Brännäng, 1966), 7 to 17 months (Cosgrove *et al*., 1996; 1997) and 2-3 or 5-6 months (Törnquist *et al*., 2000) had no effect on the steers weight gain, when measured several months after castration. But Cohen *et al*. (1991) found reduced daily gain when castrating at 6 months compared to castration at 3 months.

Other health related issues

The farmers, participating in the questionnaire, were asked about health problems concerning the animals. Generally, there were few problems. As mentioned before, internal parasites in steer production were mentioned several times and lungworm was considered a greater problem in steer production than in the production of calves and bulls. The same tendency was seen with ringworm (dermatomycosis). Production of calves gave rise to minor problems with diarrhoea and pneumonia.

Finishing strategies

In the summer, finishing of steers has to be done on grass. Some farmers obtain the same classification when slaughtering steers directly from clover grass pastures compared to finishing in the stable. This result suggests grazing on clover grass pastures without finishing as a possibility of rearing steers with good carcass quality. However, more research in this area is needed. A trial with finishing steers on pasture with 4 kg barley/animal /day resulted in liver abscesses in 4 out of 11 steers (Andersen, pers. communication, 2000). It is possible that the combination of restricted amounts of barley fed two times a day and easily digestible clovergrass may have resulted in large fluctuations in rumen pH.

Feeding of organic steers in Denmark, as described in the survey, is based on about 300 kg cereals in the finishing period, i.e. minimal use of cereals. A finishing period for steers using 300-360 kg cereals or concentrates was found to be adequate to ensure a good meat quality (Flynn, 1985; Keane and Drennan, 1987; Grenet *et al*., 1997). However, other sources recommend finishing with cereals *ad libitum* (Griebenow *et al*., 1997). Meat quality will depend on daily gain in the fattening period and live weight at slaughter (Ender *et al*., 1995; Steen and Kilpatrick, 1995).

Product quality

Meat from steers versus bulls

Steers generally have a better eating quality than bulls (better tenderness, juiciness and taste) (Andersen and Ingvartsen, 1984; Steen and Kilpatrick, 1995). Reasons for the better eating quality are higher degree of marbling (intramuscular fat, IMF), lower collagen content and higher collagen solubility in steers compared to bulls (Temisan, 1989). Bulls often have a content of IMF below 2%, whereas steers have minimum 3% IMF (Temisan, 1989).

Conjugated linoleic acids

Beef and milk from cattle fed high amounts of roughage or on pasture have a higher content of conjugated linoleic acid (CLA). CLA is produced in the rumen by bacteria (*Butyrivibrio fibrisolvens*), and are expected to have anticarcinogenic and antiartherogenic properties. Grazing on marginal areas raised the CLA-content in milk with 500% compared to dairy cattle fed with TMR (Dhiman *et al*., 1999). Organic cows on pasture had higher content of CLA (0.80% of total methyl esters) compared to conventional cows on pasture (0.61% of total methyl esters), probably due to a high amount of roughage in the organic feed ration, having a positive effect on rumen flora (Jahreis *et al*., 1997).

Consequences of BSE-situation for organic beef production

The current BSE problem in Europe has resulted in a difficult market situation and low prices for beef. For some dairy farmers, this situation means the end of beef production. However in the large scale, the BSE-situation can result in an increased production of organic beef. It is not possible to claim that organic beef is safer than beef from conventionally fed cattle, as long as mode of transmission is not known completely and standards can only be enforced by inspection. However, some figures indicate, that organic production methods possibly mean lower risk of BSE infection. The ban of meat-and-bone meal was introduced earlier and was more restrictive in the organic sector than in conventional farming in Denmark. On the other hand, meat-and-bone meal has been permitted until the year 2000 for pigs and hens, allowing for cross-contamination with cattle feed. Furthermore, organic animals can be born and reared on conventional farms. As a consequence, the Danish organic certification body (LØJ) has recently decreed that only cattle born and raised their entire life on organic farms can be marketed as organic beef.

Conclusions

Problems and solutions

Organic beef production in Denmark is primarily based on cast cows from dairy farms. Only 26% of the bull calves born on organic dairy farms are reared and slaughtered as organic. This means that bull calves are a surplus for organic dairy production, i.e. a non-utilized resource. As a solution, it is suggested that arable farmers could be involved in rearing of bull calves, thereby utilizing clover cycle in their crop rotation and any potential non-utilized stall capacity.

Steer production is preferred by most farmers, due to the possibility to use roughage and marginal areas in the production. Production of organic calves and bulls is based on higher amounts of cereals than steer production.

The feeding strategies used in steer production appear to result in healthy animals. However, finishing conditions can mean metabolic disorders. Summer grazing can result in problems with weight loss just after turnout, especially for young calves. Grazing also increases the risk for parasite infections, especially on marginal areas. Management strategies in relation to turn-out, and to prevent parasite infections are important tools to secure healthy animals.

Future perspectives

The BSE-problem in Europe has resulted in problems for the beef market. However, the demand of organic beef has increased, as consumers obviously feel more secure in eating organic beef. This situation will probably continue, as new BSE-cases are found in Europe. But production economy in beef production cannot compete with organic milk production. However, for the dairy farmer beef production can be a supplement to the main production, if feed supply is available given.

Organic steer production appears to be a good option for Danish farms but the question of castration and its implications to animal welfare needs to be addressed. There is a need to investigate the best method of castration of bulls to prepare for a potential attempt to introduce legislation that could ban castration in organic production.

A more holistic view of organic milk production could result in a dual-purpose breed with more focus on beef, health, condition and roughage consumption. This approach could also result in an improved genetic material for beef production compared to the dairy breed, as it is used in Denmark today (Holstein Friesians).

Research needs

There is a market shortage of organic bulls and calves in Denmark. Whilst production from non-castrated animals is a better option in regard to growth rates and carcass quality, there are clear system level constraints to the introduction of this method in Denmark. Further research is needed to investigate the options.

Finishing of steers with roughage-based diets is another area deserving more interest. Research is needed to clarify, if finishing of steers grazing clover grass pasture is necessary and how much cereals are necessary during finishing in the stable.

Research is needed in relation to turn- out of young calves to pasture to minimize problems in this period and to give the calves a good start. To minimize parasite infections, usage of bioactive forages, having anti-parasitic properties should be investigated and introduced to organic farming.

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Influence of feed and feed structure on disease and welfare of pigs

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Introduction

In the classical nutrition theory, the feed has been regarded solely from the point of providing energy and essential nutrients to the pigs. Carbohydrates provide the bulk of energy, while the essential nutrients are provided as amino acids, fatty acids, vitamins and microminerals. However, this simplified view no longer persists. There is now increasing evidence that particularly the composition of the carbohydrate fraction has significant implications for the digestion and absorption processes, the composition of the microflora of the gastrointestinal tract as well as the animal's resistance to infections with porcine pathogens.

The feeding of pigs under organic farming conditions differs from that of conventional pig production in the sense that growing pigs and sows shall have access to roughage. This will have implications for the dietary composition as most roughages have a higher dietary fibre content than cereals (Bach Knudsen, 1997; Carlson *et al.*, 1998; Carlson *et al.*, 1999), which will inevitably raise the fibre level and reduce the digestibility of nutrients. The capacity of the gastrointestinal tract to handle roughage is limited and recent studies show that roughage's could contribute only 7% of the intake of net energy (Lærke *et al.*, 1999). Additional to the volume capacity of the gastrointestinal tract, the taste of the roughages could also play a role for the relatively low intake.

Pigs kept under organic farming conditions can be expected to be more exposed to parasites in particular *Ascaris suum, Trichuris suis* and *Oesophagostomum dentatum* and pathogenic bacteria than pigs kept under conventional farming conditions (Nansen

& Roepstorff, 1999; Pearce, 1999). Recent investigations point to the dietary composition as a factor controlling parasite and bacterial infections. Since the use of drugs in organic pig production is restricted there are obvious reasons to investigate the possibility of using the diet to improve the resistance against infection with porcine pathogens.

The gastrointestinal tract of pigs and its commensal microflora

The various gastrointestinal regions have different structure and functional elements that provide optimal conditions for the digestion and absorption processes of the tract. Largely dietary inputs and the secretion from the stomach, intestine, pancreas and gall bladder determine the composition of the digesta in stomach and the upper part of the small intestine (Johansen & Bach Knudsen, 1994; Johansen *et al.*, 1996). As the digesta moves distally, flow rate and oxygen content decline, and the composition changes as a result of digestive, secretory and microbial processes. The mucosa of the small intestine "traps" the nutrients released by the hydrolytic processes (glucose from starch; amino acids and peptide from proteins and fatty acids and glycerol from lipids) and absorbs them to the body (Gray, 1992).

The gastrointestinal tract of pigs is densely populated with bacteria. The population of bacteria increases from 10^7-10^9 viable counts in stomach to 10^9 viable counts in distal small intestine and further to 10^{10}-10^{11} viable counts per gram fresh materials in the colon and with an increasing proximal to distal abundance of obligate anaerobes (Bach Knudsen *et al.*, 1993; Jensen & Jørgensen, 1994). The majority of the culturable bacteria in the colon is gram-positive, strict anaerobic streptococci, lactobacilli, eubacteria, clostridia and peptosterptococci, while gram-negative organisms comprise about 10% of the total cultuable flora. The most common isolates in an extensive study of pig faecal bacteria by Moore *et al.* (1987) were in the *Streptococcus* genus representing 27.5% of all isolates. *Lactobacillus*, *Fusobacterium*, *Eubacterium*, *Bacteroides*, and *Peptostreptococcus* were the next most common bacteria. The bacterial composition is under the influence of dietary composition, which has a high impact on the population and activity of the commensal microflora.

Influence of dietary carbohydrates on the physiology of the gut

Dietary carbohydrates constitute a major fraction of the diets for pigs (Bach Knudsen & Jørgensen, 2001). The carbohydrate fraction consists of mono-, di- and oligosaccharides and two broad classes of polysaccharides – starch and non-starch polysaccharides (NSP; Theander *et al.*, 1989; Bach Knudsen, 1997). The carbohydrate fraction has a diverse composition in terms of constituent sugars (pentoses, hexoses, deoxysugars, etc.), glycosidic linkages (alfa or beta), size (degree of polymerisation from one to several thousand), and physical form (soluble in water, insoluble, cation and adsorbing binding properties; Theander *et al.*, 1989; Bach Knudsen, 2001).

The composition of the carbohydrate fraction influences the digestion and absorption processes of carbohydrates and other nutrients in the various parts of the gastrointestinal tract (Bach Knudsen & Jørgensen, 2001), it has a profound influence on the secretory response of the gut to feed intake (Low, 1989), the volume flow (Bach Knudsen *et al.*, 1993), the mucosal architecture (Jin *et al.*, 1994; Brunsgaard, 1998), composition of the gut flora (Jensen & Jørgensen, 1994) and the development of the gastrointestinal tract

(Jørgensen *et al.*, 1996). Digesta materials that are collected from the stomach resemble to a high degree the composition of the diets, while the endogenous materials become relatively more important as the digesta materials move distally in the small intestine. In ileal digesta, carbohydrates typically account 30-50% of the dry residue (Bach Knudsen & Canibe, 2000). In the large intestine, dietary carbohydrates are degraded to various degrees with insoluble lignified fibres (oat hull, wheat bran, etc.), usually resisting degradation to a high degree, while fibres characterised of being soluble are usually well degraded (sugar beet fibre etc.) (Bach Knudsen & Jørgensen, 2001).

The intestinal mucosa of the pig lacks the enzymes capable of cleaving a number of oligosaccharides that are naturally present in plant materials (i.e. raffinose-oligosaccharides, fructooligosaccharides) or used as feed additives (i.e. neosugar, transgalactooligosaccharides). Collectively these oligosaccharides are referred to as non-digestible oligosaccharides (NDO; Loo *et al.*, 1999). NDO were earlier considered as an antinutritional factor, which could potentially accumulate in the small intestine, cause osmotic diarrhoea, and because of their rapid fermentation and high gas production, cause discomfort for the animals. Recently, there has been a growing interest in NDO because of their possible prebiotic properties, i.e. stimulation of the growth and (or) activity of one or a limited number of desired bacteria in colon and, thus, exclude the pathogens (Gibson & Roberfroid, 1995; Loo *et al.*, 1999). In man, it has been demonstrated that inulin and oligofructose independent on chain length have significant prebiotic properties by selective stimulating of the growth of bifidobacteria in the colon. The results from studies with pigs are less convincing (Houdijk, 1998). In a study of Buddington (1998), it was found that the influence of oligofructose on bacterial population was more pronounced in the small intestine and proximal colon of suckling pigs compared with faecal samples. The reason for that is presumably that the NDO, at the low dose used, are metabolised by the flora colonising the stomach and small intestine (Houdijk, 1998). A synergic effect of fructooligosaccharide and *Lactobacillus paracasei* was recently reported in an experiment with weaning piglets (Nemcová *et al.*, 1999). Total number of anaerobes, aerobes, lactobacilli, and bifidobacteria increased while clostridia, *Enterobacteriaceae* and *E. coli* decreased.

Starch is the most abundant carbohydrate in diets for pigs. Starch is a mixture of the linear (1-4)- linked amylose and the branched (1-4), (1-6)- linked amylopectin. Most of the ingested starch is efficiently broken down by the combination of secreted -amylase and enzymes located on the intestinal surface membrane (Bach Knudsen & Jørgensen, 2001). A variable fraction of starch (resistant starch, RS), however, will be resistant against degradation in the small intestine and may have properties similar to NSP. For instance, a high amylose cornstarch diet fed together with *Bifidobacterium longum* increased the number of Bifidobacteria in the faeces compared to a low amylose cornstarch diet (Brown *et al.*, 1997).

NSP are the main carbohydrate fraction not digested by enzymes in the small intestine by pigs (Bach Knudsen, 2001). However, because of the microbial colonisation of the stomach and small intestine, some disappearance of NSP occurs in the upper intestinal tract. This degradation is caused by the microflora colonising these sites of the gastrointestinal tract. Based on results reported from 51 digestibility trials using ileal cannulated pigs, the average digestibility of NSP up to the end of the small intestine was found to be 24 % with large variations between experiments (range -10-+62%) (Bach Knudsen & Jørgensen, 2001). The results obtained with cereal diets consistently show a higher digestibility of the linear and relatively soluble mixed linked 1-3), (1-4)-D-glucan (-glucan) compared to the branched-chain arabinoxylans from wheat, rye and oats. -glucan rich diets i.e. barley and oats also seem to stimulate the formation of lactic acids in the small intestine (Bach Knudsen & Canibe, 2000) presumably because of prebiotic properties of -glucan. In a study of Graham *et al.* (1986), it was found that lactic acid producing microorganisms (Lactobacilli) were responsible for the significant degradation of -glucan in the upper intestine of pigs.

The main site for NSP degradation is the large intestine (Bach Knudsen & Jørgensen, 2001). At this site of the gastrointestinal tract, digesta is retained for prolonged periods of time (generally 20-40 h), which allows prolific bacterial growth. Several studies have shown that NSP is the carbohydrate source entering the large intestine in quantitatively the largest amount (Bach Knudsen & Jørgensen, 2001). It has also been shown that NSP has a strong influence on the activity and composition of the commensal microflora. However, NSP does not seem to have a selective influence on specific strains of microrganisms as has been identified for some NDO (i.e. various fructans) and very little is known about how the different groups of the residential microorganisms interact with pathogenic species of bacteria.

The outcome of fermentation of carbohydrates either as NDO, RS or NSP is production of short-chain fatty acids (SCFA), mainly acetate, propionate and butyrate, and the gasses H_2, CO_2, and CH_4. The production of SCFA and gas is under direct influence of the dietary carbohydrate composition as it increased in response to more carbohydrates entering the large intestine (Bach Knudsen *et al.*, 1993; Jensen & Jørgensen, 1994). Rapid generation of SCFA lowers the pH; a horizontal gradient is usually seen along the large intestine with the pH in caecum being significantly lower than in distal colon (Bach Knudsen *et al.*, 1991). The produced SCFA are rapidly absorbed from the gut lumen and the absorption rate is driven by the concentration gradient between the lumen and the portal vein.

The role of carbohydrates in the control of enteric bacterial infections of pigs

As discussed above, dietary carbohydrates play an important role for the function of the gastrointestinal tract of pigs. Australian works seem to suggest that the diet may help to control enteric bacterial infections. Swine dysentery is a major problem in many parts of the world. The disease is caused by the anaerobic intestinal spirochaete *Brachyspira (Serpulina) hyodysenteriae*, which colonise the crypts of the large intestine and induce severe mucohaemorrhagic colitis and dysentery (Hampson *et al.*, 1997).

Studies with gnotobiotics pigs have shown that colonisation by the spirochaete and lesion formation is enhanced by the presence of other species of anaerobic bacteria (Whipp *et al.*, 1979). Earlier field studies have indicated that a protective effect was obtained when pigs with swine dysentery were changed from a corn based diet to a diet based on corn silage (Prohaszka & Lukacs, 1984). The interpretation was that the corn silage lowered the pH in the digesta in the large intestine, thereby inhibiting the growth of *B. hyodesenteriae*.

A series of studies performed by an Australian group (Hampson and co-workers), however, could not confirm this. Rather, the Australian works identify a very digestible diet based on cooked white rice and animal protein to be protective against colonisation by the spirochaete or development of swine dysentery after experimental challenge (Pluske *et al.*, 1996; Siba *et al.*, 1996). When the cooked rice or the animal protein was mixed with either lupine or wheat, disease occurred after challenge. The authors identified the protective effect to be the low level of NSP and RS in cooked rice that limited the fermentation in the large intestine and in this way suppressed the commensal microflora, which normally facilitate colonisation with the spirochaete (Pluske *et al.*, 1998).

A direct physical effect of the limited amount of residues that is passed to the large intestine could also play a role. In a follow up study, maize and sorghum, when steam-flaked, also reduced the incidence of disease after experimental challenge and it was identified that soluble NSP (S-NSP) and RS were two important dietary components that promote fermentation in the large intestine and were associated with high incidence of swine dysentery (Durmic *et al.*, 1997; Durmic *et al.*, 1998). This hypothesis was further investigated in a follow up study in which either S-NSP in the form of guar gum or RS as retrograded maize starch was added to the protective cooked white rice plus animal protein diet (Pluske *et al.*, 1998). Pigs fed the diets supplemented with either S-NSP or RS became colonised and developed swine dysentery, while those on the control diet did not. In line with the hypothesis of the protective role of the limited fermentation in the large intestine, a diet with added insoluble NSP from oat chaff showed a protective effect in line with the rice diet (Pluske *et al.*, 1998). The potential of using exogenous enzymes to improve the digestibility of wheat and sorghum based diets and thereby to obtain a similar protective effect as of the cooked white rice diet has also been tested with variable results (Durmic *et al.*, 1997).

The Australian works have consistently shown the cooked white rice diet supplemented with animal protein to have a protective effect on the expression of swine dysentery after experimental challenge. However, it has been difficult to reproduce these findings outside Australia.

In a Danish study where the pigs were fed a standard diet based on wheat, barley, soybean meal and fish meal, cooked white rice plus animal protein and the rice diet supplemented with raw potato starch, wheat bran or sugar beet pulp, a fermented liquid standard diet or a standard diet supplemented with 2 % lactic acid, it was not possible by the rice diet to prevent the development of swine dysentery upon experimental infection (Lindecrona *et al.*, 2000). Increasing the level of NSP or RS did not result in any higher incidence of disease. However, clinical symptoms and pathological lesions were more severe when the level of NSP was increased. In the group that was fed the fermented liquid standard diet, the incidence and the severity of clinical signs were lower compared to the other feeding groups presumably reflecting an impaired colonisation of *B. hyodysenteriae* in the large intestine as a result of changes in the microflora (Leser *et al.*, 2000) and/or biochemical environment.

The reason for the failure in obtaining protection with the cooked white rice diet in Denmark compared to Australia is not easy to explain but could be due to differences in the way the rice is processed, and/or site differences in the commensal flora. Since colonisation with *B. hyodysenteria* requires a component of the anaerobic microflora to be expressed, it may be so that differences in the intestinal microflora at the study site can influence the outcome.

Carbohydrates to control parasite infections of pigs

Like enteric bacterial infections of pigs, parasites can have a major economical impact on the productivity in pig production through reductions in daily live-weight gain and feed conversion. As a result of a change finding Petkevicius *et al.* (1995) discovered that the dietary carbohydrate composition had a profound influence on the establishment, gut location and fecundity of *Oesophagostumum dentatum* in the large intestine of growing pigs.

The results of a series of studies with *O. dentatum* experimentally infected pigs fed on diets that provided different type and levels of dietary carbohydrates to the large intestine clearly demonstrated that diets that had a high content of resistant fibres (oat hull meal or wheat bran) provided favourable conditions for the establishment of *O. dentatum* and female worm fecundity, while the opposite was the case when the experimental diet contained fermentable carbohydrates as inulin and sugar beet fibre (Petkevicius *et al.*, 1997; Petkevicius *et al.*, 1999; Petkevicius *et al.*, 2001).

More recently, it was also documented that feeding the two contrasting diets could be used to reduce egg excretion and worm numbers (the diet containing fermentable carbohydrates) or to increase egg excretion and worm number (the diet containing the resistant carbohydrates) (Petkevicius *et al.*, 2001) of pigs with already established infection. The mechanisms behind the protective effect of diet with the high level of fermentable carbohydrates are not yet established but it appears to be related to the increased production of SCFA, which have direct and indirect effect on the large intestine by influencing epithelial cell proliferation, intestinal tissue mass, and the mucus secretion (S. Petkevicius, K.E. Bach Knudsen P. Nansen and K. D. Murrell, unpublished results). Thus, the dietary carbohydrate composition appears to have a significant influence in controlling *O. dentatum* infection not only on indoor pigs (Petkevicius *et al.*, 1995; Petkevicius *et al.*, 1997; Petkevicius *et al.*, 1999; Petkevicius *et al.*, 2001) but also on pigs on pasture (Petkevicius *et al.*, 1996).

These findings are in agreement with an epidemiological investigation that points to NSP as the most important factor controlling parasite infection particularly *Trichuris suis* in growing pigs in the UK (Pearce, 1999). Moreover, the study of Pearce (1999) further indicated that infection with *Trichuris suis* in many cases was followed by high incidence of *Lawsonia intracellularis*, which points to a synergism between the nematode and pathogenic microorganism. Such a synergism between the microbial flora and the *T. suis* has earlier been identified when comparing the clinical syndrome in conventionally reared pigs, specific pathogen-free pigs, and gnotobiotic pigs (Rutter & Beer, 1975). The disease in conventionally reared pigs was characterised by a severe mucohemorrhagic enteritis; in contrast, a mild catarrhal enteritis was observed in specific pathogen-free and gnotobiotic pigs. The authors concluded that a microbial component acts synergistically with *T. suis* infection to produce the severe clinical syndrome in conventionally reared pigs. It was further suggested that the mechanism could be that the emerging *T. suis* larvae stimulate the production of excessive mucus in which the microbial component of conventional pigs multiplies.

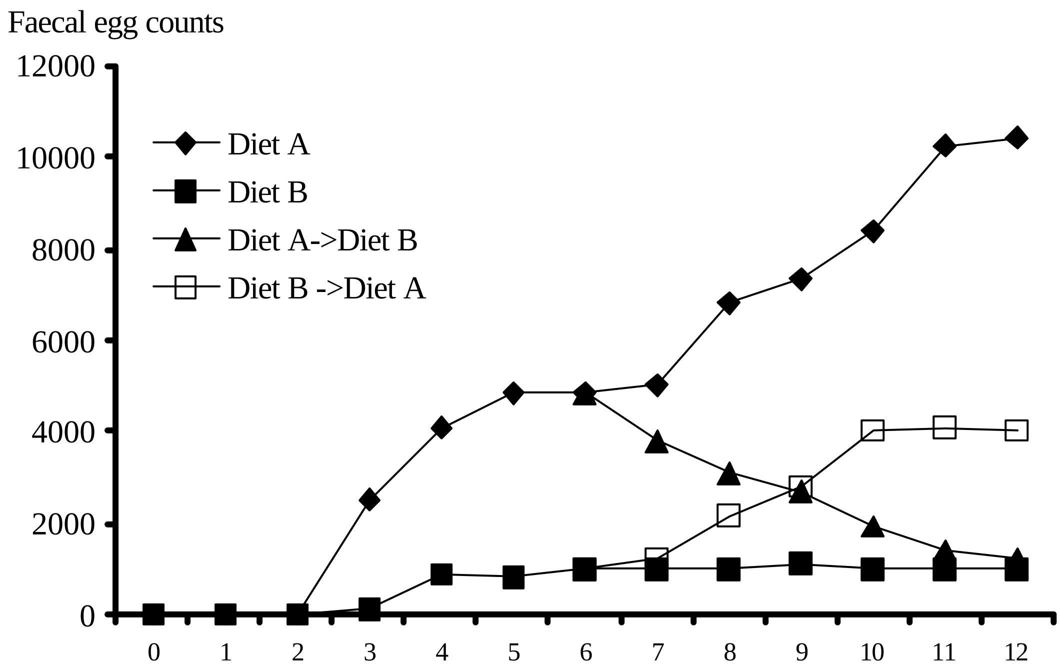

Figure 1. Faecal egg counts of pigs 0-12 weeks post infection with 6000 infective larvae from nodular worms when feeding a diet including resistant fibre (Diet A) or degradable fibre (Diet B). Data from Petkevicius *et al.* (2001).

Feed structure to control *Salmonella* prevalence of pigs and to improve gastric health

Several epidemiological investigations and reports from advisor practises in swine herds have independent of each other pointed to meal feeding relative to feeding with industrial produced pelleted feeds to reduce the risk of sub clinical infections with *Salmonella enterica* (Dahl, 1997; Stege *et al.*, 2000) and *Lawsonia intracellularis* and *Brachyspira pilosicoli* (Stege *et al.*, 2000). Results performed under practical conditions have shown that the prevalence of *Salmonella* is reduced when coarsely ground feeds rather than finely ground pelleted feeds are fed (Jørgensen *et al.*, 1999).

The feed structure is related to the carbohydrate composition in particular the fibre content of the raw material explicitly pointed out by barley producing a more coarse meal compared to wheat, when milled to pass the same screen size (Nielsen, 1998). In the digestive tract, coarsely ground feed or feed with a higher fibre content give rise to a digesta material that is more coherent with little separation between the solid and liquid phase of digesta and which in turn results in higher dry matter content and lower pH in the gastric content at slaughter compared to finely ground pelleted feed (Jørgensen *et al.*, 1999). This is seen of Figure 2 that shows the proportion of solid digesta in the stomach after feeding growing pigs either wheat or barley or wheat processed in different ways. It is likely that the more solid digesta after feeding the coarsely ground materials influences the microbial ecosystem in a way that provides *Salmonella* with poorer growing conditions compared with pelleted feeds. The results further document that coarsely ground materials have a positive influence on gastric health, which may be an ethical although not productive problem for the pigs industry (Simonsson & Björklund, 1978; Nielsen, 1998). The feed structure and dietary fibre composition also influence the morphology of the gastrointestinal tract, architecture, production and composition of mucus, which may possibly play a role against enteric infections (Brunsgaard, 1998).

Figure 2. Relative proportion of solid digesta in the stomach after precipitation in 16 hours or centrifugation when feeding expanded diets based on barley or wheat and a wheat-based feed provided as meal or pellets. Data from Bach Knudsen (2001), (unpublished).

The downside of the use of the feed structure to control *Salmonella* infection, however, is the negative impact it has on the performance (Jørgensen *et al.*, 1999). Because of the coherent properties of coarsely ground materials, there will be a bigger risk of incapsulation of otherwise available nutrients, which are then withhold from digestion by enzymes in the small intestine. In many cases, there has been a significant increase in the faecal excretion of starch (Jørgensen *et al.*, 1999). A factor that also may contribute to the negative influence of the coarse feed on animal performance may be because of stimulation of the gastric and pancreatic secretion, which also has been reported when increasing the fibre level (Low, 1989), and which from an energetic point of view is costly. Therefore, more work needs to be done to improve production economy without any adverse effects on gastric health and *Salmonella* prevalence.

Conclusions

Experiences from different studies indicate that the dietary carbohydrate composition influences the expression of swine dysentery and infection with nodular worms after experimental challenge with *B. hyodesenteriae* and *O. dentatum*, respectively. There is also increasing evidence that the feed structure can be used to reduce *Salmonella* prevalence at the herd level and to improve gastric health.

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Managing amino acids in organic pig diets

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Introduction

Pigs require amino acids for maintenance, growth, reproduction and locomotion. There are many reviews that discuss the response of pigs to variation in the daily supply of amino acids. Such response relationships are the basis of numerous recommendations for protein requirements. Field experiences constantly reinforce the importance of good quality proteins and amino acid availability, particularly during periods of stress, management change, and when the immune system is challenged.

The EC-Regulation (EC-No. 1804/1999) on organic livestock production restricts the availability of feed. Therefore the question arises, whether the regulation causes a shortage in the availability of amino acids in pig diets, and whether organic farming requires specific management efforts in order to meet the requirements of pigs in the different stages of production. The issue is discussed in relation to the feeding of sows, piglets and fattening pigs.

Amino acid requirements

There are approximately 22 amino acids, and whilst the pig can synthesise the majority of these, there are a number of amino acids that are required in its feed. The following are described as essential for normal health and metabolic process: arginine, isoleucine, histidine, leucine, lysine, methionine plus cystine, phenylalanine plus tyrosine, threonine, tryptophan and valine.

The quality of the protein in pigs` diet is a reflection of the amount and the availability of these essential amino acids. High quality protein contains all of the essential amino acids at acceptable levels, while poor quality protein is deficient in one or more. Where there is a deficiency of more essential amino acids in the diet, the metabolic functions of the pig are compromised leading to biological inefficiency and possibly disease (Muirhead and Alexander, 1997).

The major roles of the amino acids are in the production of muscle protein, digestive enzymes, haemoglobin in the blood, gamma globulins, milk protein and in hormone metabolism. If the diet is deficient in one ore more of these essential amino acids (lysine is the most likely, followed by methionine), then protein synthesis will only continue to the level associated with the first limiting amino acid. The amounts of each amino acid required in the diet are expressed generally as a percentage of the total lysine requirement. Recommendations in relation to amino acid supply of pigs at different stages of life are given in Table 1.

Table 1. A guide to protein and energy requirements for pigs at different stages of life in relation to final dietary levels (according to Muirhead and Alexander, 1997)

Type of Ration	Liveweight kg / *ad libitum* feeding					
	6 - 10 Creep	10 – 20 Weaner	20 – 50 Growner	50 – 100 Finisher	Dry Sow	Lactating Sow
MJ DE/kg	15-16	14.5-15	13.8-14.1	13.5-13.8	13.3-13.8	14.2-14.8
Crude protein %	23 - 25	19 - 22	18 - 20	16 - 17	13.5 - 13.8	17–18
Lysine %	1.3-1.5	1.25-1.35	1.0-1.1	0.85-0.95	0.6-0.7	1.0-1.15

While the requirements of dry sows and finishing pigs are low, lactating sows and especially piglets have a comparably high demand of amino acids. However, it has to be taken into account that demand in the different stages is not of an absolute quantity but varies within a range. For instance, requirements depend to a high degree on the performance that is expected from the pigs. Additionally, differences in the requirements are caused by genotype-environment interactions. Variation in protein metabolism accompanies genetic selection for a wide range of traits, including growth of lean tissue and feed intake. There are associated effects on cellular development, endocrine secretion, hormonal action at the tissue level, enzyme activity within tissues and supply of nutrients from digested feed, which would be expected to lead to changes in protein metabolism throughout the organism. Nutrition-environment interactions play an important role in regulating feed intake and hence daily growth rate (Ferguson, 1999). The prevailing environmental temperature will define the upper limit of the amount of heat the animal can produce, and hence the feed intake and growth responses of the animal.

Pigs fed amino acid deficient diets will increase their feed intake in an attempt to achieve daily amino acid intakes that will allow them to express their genetic potential. However, below a critical dietary amino acid concentration the animal can no longer compensate for the deficiency by consuming food at a higher rate, and voluntary feed intake will decline. Part of the variation in response to lysine observed in practice, and between experiments, is due to the different temperatures under which animals have been housed. Additionally, the availability of amino acids is often limited by the presence of anti-nutritional factors, which may act on the nutrients themselves or cause a deleterious physiological effect on the animal (Wareham *et al*., 1994).

Availability of amino acids in organic farming

According to the EC-Regulation, feed is intended to ensure quality production rather than maximizing production, while meeting the nutritional requirements of the livestock at various stages of their development. Natural milk has to be offered to the piglets for at least 40 days. Livestock must be reared preferably using feed from the unit or feed from other units subject to the provisions of the regulation. Purchased conventional feedstuffs are limited to 20% in relation to the total amount of dry matter feed intake. Additionally, roughage should be provided daily. Among others, soybean meal extracted with chemical solvents, synthetic amino acids and growth promoters are forbidden as feed ingredients.

The intrinsic amino acid source in organic farming is provided by grain legumes like faba beans, peas and lupines. Potato protein, maize gluten or rape cake are used as bought-in feedstuffs of conventional origin. There is a huge variation in the proportion of limited amino acids in the different feedstuffs. Additionally, digestibility of each amino acid is different between and within feedstuffs. The proportion of limiting amino acids of grain legumes and by-products in comparison to soybean meal are presented in Table 2.

Table 2. Availability of limiting amino acids in different grain legumes and by-products (g/kg, 88 % DM)

Feedstuffs	Crude Protein	Lysine	Ileal digest. Lysine	Methionine	Ileal digest. Methionine
Soybean	352	22.2	18.4* (83)*	5.3	4.3 (82)
Lupine	318	14.7	12.9 (88)	2.2	1.8 (82)
Faba bean	254	16.3	13.4 (82)	2.0	1.3 (66)
Peas	209	15.0	12.2 (81)	2.1	1.6 (74)
Potato Protein	738	58.3	52.5 (90)	16.8	15.3 (91)
Rape	348	19.5	14.4 (74)	7.1	5.8 (81)

* Digestibility in %

While soybean meal is the most favoured protein source in conventional production, it is rarely produced under organic conditions, except for some regions in the southern Europe. In comparison to soybean meal, the proportion of limiting amino acids in home-grown grain legumes is low, especially methionine in lupines, peas and faba beans. Potato protein provides a valuable protein concentrate and, therefore, it is often used as a supplementary source for amino acids in organic pig production.

Due to the low availability of limiting amino acids in home-grown feedstuffs, a major role for the stockperson on the farm is to formulate an adequate diet and to judge the interaction between the pig, its age and/or productive cycle against the quality, content and intake of feed.

Managing amino acids supply of lactating sows

Lactating sows have a high demand of amino acids, depending on the number of sucking piglets. A deficit in protein can be compensated to a certain extend by mobilisation of body substances. Investigations of Yang *et al*. (1989) showed that the loss of weight in sows of 16 kg during a lactation period of 28 days consisted of 3.5 kg of fat and 2.9 kg of protein. However, in order to prevent reproductive disorders, sows should not loose too much weight. King and Williams (1984) proved that additional supply with protein can prevent excessive weight loss in lactating sows. Furthermore, several studies describe the positive effect of the enrichment of the diet with protein on milk performance, crude protein content of the milk, number of weaned pigs and live weight before weaning (Burlacu *et al*., 1986; Kornblum *et al*., 1991). Additionally, adequate protein supply has a positive influence on the first occurrence of oestrus after weaning, on subsequent ovulation rate and early embryonic survival in the sow (Walker *et al.,* 1975; Hughes *et al*., 1984; Kirkwood *et al*., 1990).

Table 3: Diet formulation for lactating sows in organic pig production

	Diet based on home-grown feed	Diet supplemented with potato protein
Ingredients in (%)	34 Barley	35 Barley
	30 Triticale	34 Triticale
	30 Peas	20 Peas
	3 Rape seed oil	5 Potato protein
	3 Trace minerals	3 Rape seed oil
		3 Trace minerals
Composition		
Metabol. energy (MJ)	13.7	13.8
XP (g)	142	162
Digest. XP (%)	80	80
Lysine (g)	9.8	11.3
Digest. Lysine (g)	8.0	9.5
Methionine (g)	2.5	3.6
Digest. Methionine (g)	2.0	3.1

In Table 3, a diet primarily based on home-grown feed is compared with a diet supplemented with potato protein as a protein concentrate. Formulation of the diet shows that already a small portion of potato protein clearly improves the availability of amino acids. On the other hand, banning of bought-in feedstuffs in organic systems is expected to lead to an insufficient supply of amino acids, especially in the case where the sow has a high number of sucking piglets. As the EC-Regulation allows supplementing the diet with specific protein sources of conventional origin, the requirements of lactating sows can be met properly under the framework of organic farming.

Managing amino acid supply of piglets

For piglets, milk is the best available source of amino acids, providing a high digestibility. This source dries up at weaning. While in conventional production, weaning of pigs currently takes place between 3 and 5 weeks of age, with the majority of producers opting for "early" weaning (19-25 days), the EC Regulation requires organic pig producers to provide natural milk at least for 40 days.

At weaning, the young pig is subjected to myriad of stressors (e.g. change in nutrition, separation from mother and littermates, new environment), which cause reduced growth. This post-weaning "growth-check" continues to represent a major source of production loss in many commercial pig farms. Various explanations and hypotheses have been forwarded to account for the variable growth check and loss of health experienced by many piglets at weaning and some have been summarised in the Table 4.

Table 4. Principal factors assumed to be associated with the growth check experienced by young, newly weaned pigs, given an adequate thermal environment and low disease challenge (Partridge and Gill, 1993)

1. Insufficient digestive enzymes for new food substrates
2. Reduced absorptive capacity due to changes in villus architecture
3. Poorly developed gastric secretions
4. Removal of beneficial factors in sow`s milk (e.g. antibacterials, immunoglobulins)
5. Inadequate feed intake
6. Form of post-weaning diet offered, dry meal/pellet cf. liquid (sow`s milk)
7. Environmental changes, "stress"

The primary objective at weaning is to ensure that the transition from sow`s milk, to post-weaning diet is as smooth as possible, without compromising growth or predisposing the young animal to disease. In an ideal world of pig production, weaning would be a gradual process rather than an abrupt event in the piglet's life. Successful rearing of piglets depends on the development of the digestive potential and on nutrient digestibility. These relations are determined by digestive juice and enzyme secretion, morphological development and microbial colonization of the digestive tract as well as by the absorption capacity of the latter. Substrate induction of the activities of different enzymes for digestion are influenced by the time of the first introduction of creep feed, the quantity of diet consumed, dietary composition and age of weaning (Pluske *et al.*, 1997). Creep feed intake is notoriously variable both within and between litters. Factors such as weaning age, sow milk output, palatability and digestibility of the creep feed offered, wet or dry feeding, form of feed, access to the creep (e.g. floor fed or in hoppers) are all likely to influence the quantities consumed and thereby the degree of induction of digestive enzymes (Cera *et al.*, 1988; Kelly *et al.*, 1990). This is relevant also in the post-weaning period where high feed intake stimulates gut development and enzyme levels in the small intestine. Indeed it appears numerically that the small intestine still has spare capacity in terms of enzyme complement, to deal with cereal-based weaner diets (Kelly *et al.*, 1991).

If the nutritional stress of interrupted intake at weaning could be overcome, then the transition from sow´s milk to solid food would be less traumatic and piglet growth would increase. Pigs dying after weaning from herds having diarrhoea had shorter villi and deeper crypts than in pigs of those herds without deaths. From these data, Nabuurs *et al.* (1993) suggested that villous height and crypt depth might influence the pathogenesis of diarrhoea after weaning. Since shorter villi and deeper crypts have fewer absorptive and more secretory cells that cause decrease absorption but increased secretion. A reduction in digestion and absorption would encourage the development of an osmotic diarrhoea, whilst unabsorbed dietary material may act as a substrate for enterotoxigenic *E. coli* in the gut (Hampson, 1994). On the other hand, enteric diseases in the sucking pig, transmissible gastro enteritis, colitis and swine dysentery, which severely damage the lining of the intestine and its capacity to absorb nutrients can have a profound effect on the absorption of amino acids and exacerbate the effects of the disease. It is important when dealing with such disease to ensure that the diet has a high level of amino acids during the recovery period.

Table 5. Diet formulation for creep feed as found in organic farms in comparison to recommendations

	Creep feed often found in practice	Recommendation for a creep diet
Ingredients in (%)	41 Barley	22 Wheat
	25 Triticale	30 Oat flakes
	20 Peas	25 Skim milk
	6 Potato protein	8 Potato protein
	3 Yeast	5 Faba beans
	2 Rape seed oil	2 Rape seed oil
	3 Trace minerals	3 Trace minerals
Composition		
Metabol. energy (MJ)	13.4	14.6
Crude protein CP (g)	144	220
Digest. CP (%)	86.6	90.2
Lysine (g)	9.1	14.4
Digest. Lysine (g)	7.4	12.9
Methionine (g)	5.3	7.5
Digest. Methionine (g)	4.4	6.8
Price ***(Euro/100kg)***	33	88

Table 5 shows 2 organic creep diets for piglets, one with a moderate supplement of potato protein and the other with a further supplementation of skim milk powder.

Especially, the latter provides a high digestibility and a high portion of limiting amino acids, markedly improving the diet. However, there is a high difference in price between the two diets. However, the amount of creep feed consumed by piglets is very low during the sucking period so that the price should not play a relevant role. Currently, an investigation is carried out to assess the intake of an improved creep diet by the piglets and the implications on the incidence of diarrhoea.

Managing amino acids for fattening pigs

While lactating sows and piglets have a high demand of limiting amino acids and deficiencies can cause severe nutritional stress, the requirements of fattening pigs are primarily a function of the performance and the carcass characteristics that are expected by the farmer. In organic farming, the restriction to a moderate level of performance therefore clearly reduces the requirement for limited amino acids in comparison to conventional pig production.

To evaluate the effects of a restriction to home-grown feedstuffs and abstinence from supplementation with synthetic amino acids, as ideal objectives in organic pig production according to the EC-Regulation standards, an experiment was conducted on growth performance and carcass characteristics (Sundrum *et al.,* 2000). One hundred individually housed pigs were allocated to four dietary treatments and fed from growing through finishing to compare three organic barley/wheat-based diets with an isocaloric conventional diet supplemented with synthetic amino acids. Protein sources in the organic treatments were either faba beans, supplemented with potato protein to the same amino acid level as the control diet, peas and lupines or faba beans and lupines, both without further supplementation, leading to a lower level of limited amino acids. The ingredients and the composition of the diet in the different treatments is presented in Table 6 while performance, carcass and longissimus muscle characteristics are shown in Table 7.

Amino acid supplementation with potato protein showed the same performance compared with the conventional diet, supplemented with synthetic amino acids, although crude protein levels differed markedly. Pigs fed the organic diets without amino acid supplementation grew more slowly, had a decreased feed intake in the grower period but nearly the same feed efficiency compared to conventional or organic diets with amino acid supplementation. Carcass characteristics differed in percentage of lean meat and longissimus area, being lower in the treatments without amino acid supplementation. However, the intramuscular fat was higher without amino acid supplementation (2.9% fat) than with supplementation (1.2% fat). The data show that the exclusion of amino acid supplementation resulted in a reduction in pig performance but in an increase in intramuscular fat content, the latter being an important aspect of eating quality characteristics (Fernandez *et al.,* 1999).

Table 6. Ingredients and Composition of the grower and finisher diets (% dry matter)

	Grower diet				Finisher diet			
	CON[a]	FA+PO[b]	PE+LU[c]	FA+LU[d]	CON[a]	FA+PO[b]	PE+LU[c]	FA+LU[d]
Ingredient								
Wheat	--	5	20	45	--	11	24	40
Barley	85	62	28	2	89	62	38	22
Protein concentrate	15	--	--	--	11	--	--	--
Faba beans	--	20	--	30	--	16		14
Peas	--	--	25		--	--	14	--
Lupines	--	--	22	18	--	--	19	19
Potato protein	--	8	--	--	--	6	--	--
Trace minerals	--	3	3	3	--	3	3	3
Sunflower oil	--	2	2	2	--	2	2	2
Composition								
ME, kcal/kg	3,129	3,249	3,129	3,153	3,082	3,177	3,082	3,177
Crude protein	15.6	18.1	17.6	18.6	14.0	16.6	15.5	16.2
Lysine	0.99	1.09	0.90	0.93	0.79	0.86	0.70	0.70
Methionine+Cystine	0.62	0.64	0.49	0.48	0.52	0.53	0.44	0.43

[a]CON = conventionally treatment, [b]FA+PO = faba beans + potato protein, [c]PE+LU = peas and lupines, [d]FA+LU = faba beans and lupines.

Table 7. Performance, carcass and longissimus muscle characteristics of pigs fed different levels of crude protein and amino acids

	Dietary treatment			
Response criteria	CON[a]	FA+PO[b]	PE+LU[c]	FA+LU[d]
Days to 120 kg	103.4[e] ± 9.8	99.8[e] ± 5.9	115.6[f] ± 14.7	116.8[f] ± 11.3
Daily weight gain [g]	858.6[e] ± 60.8	890.5[e] ± 56.5	769.5[f] ± 90.0	766.6[f] ± 66.9
Feed efficiency	2.71 ± 0.15	2.58 ± 0.16	2.78 ± 0.19	2.81 ± 0.15
Carcass yield [(%)]	77.9[e] ± 1.5	76.9[e,f] ± 1.0	76.7[e,f] ± 2.0	76.5[f] ± 1.8
Lean meat (FOM) [%]	56.0[e] ± 2.3	55.6[e,f] ± 1.6	54.3[f,g] ± 2.0	53.6[g] ± 2.4
M. longissimus dorsi area [cm^2]	56.8[e] ± 5.1	54.3[e] ± 4.0	48.8[f] ± 4.9	48.0[f] ± 4.5
Lean : fat – ratio	0.33[e] ± 0.05	0.33[e] ± 0.04	0.39[f] ± 0.06	0.39[f] ± 0.07
Intramuscular fat [%]	1.20[e] ± 0.41	1.25[e] ± 0.37	2.90[f] ± 0.87	2.95[f] ± 0.97

[a]CON = conventionally treatment, [b]FA+PO = faba beans + potato protein, [c]PE+LU = peas and lupines, [d]FA+LU = faba beans and lupines,
[e,f,g] Values within a row with different letters are different ($P < .05$).

Current situation on organic pig farms

Organic pig farming still plays a minor role in organic livestock production. Information about the feeding situation in different countries is scarce. In a field study in Austria, only 12 of 48 farms had data where the diets for lactating sows could be determined (Wagner *et al*., 2001). Calculations of the rations for the lactating sows indicated that the diets on 10 of the 12 farms were lower in energy (<13 MJ metabolizable energy) and protein (<16.5%) than recommended. Sources of crude protein were: potato, sunflower cake, pumpkin cake, soybeans, peas and rape cake and some protein concentrate, all organically produced.

A questionnaire survey in Germany on 21 pig farms showed that none of the farmers has carried out regular analysis of feedstuffs (Rubelowski and Sundrum, 1999). As a consequence, predictability of the diet in relation to the bio-availability of amino acids is very low. This is especially the case when the knowledge of the crude protein content of the diet is missing.

Conclusions

Organic pig farming requires increased efforts of the management in order to ensure appropriate supply with amino acids according to the specific requirements of the pig. The preference of home-grown feedstuffs and limitations in the choice of bought-in feedstuffs can be a cause to a huge variation in the composition of the diets and increase the demand of analysis of the ingredients and calculation of the diet. The high variation in breeds and housing conditions in organic farming in comparison to the more and more standardized conditions in conventional production impairs the predictability of the specific requirements and the rate of utilisation of the nutrient potential (e.g. digestibility).

The framework of organic agriculture provides sufficient possibilities for an adequate availability of limiting amino acids. The exclusion of synthetic amino acids and chemically solved soybean meal can be compensated for by other protein sources like skim milk powder, potato protein or rape cake. However, problems can be expected in the future when the derogation for a transitional period which allows buying feedstuffs of conventional origin expires on August 2005. Possible alternatives are soybean meal and skim milk powder from organic origin.

Piglets have the highest demand for limited amino acids. Their requirements should be covered in order to prevent predisposition for diseases, especially for diarrhea. Farmers have a considerable responsibility for safeguarding the welfare of the newly weaned piglet by constructing diets that will not stress the physiology of the immature gut and therefore compromise health. Mismanagement, i.e. a huge discrepancy between nutrient requirements and supply is the cause of different diseases, e.g. diarrhoea in piglets and reproductive disorders in sows and a suppression of the immune reaction. In practice, options for producing the “ideal” baby pig diet are constrained by cost and the farmer must explore alternative strategies that will maintain piglets in satisfactory health.

The emphasis on creep feed of high quality should favour the development of a market place for relatively high cost, specialised creep diets that almost invariably, rely on a significant use of milk products and highly processed raw materials (e.g. denatured skimmed milk powder; whey powder and derivatives). Such diets are, of necessity, a compromise between what is nutritionally desirable for the young pig and what is economically justifiable to the pig farmer. Nutrition is not routinely regarded as a primary welfare issue but in the case of the young pig separated from the sow at weaning it assumes major importance.

While grain legumes provide a disadvantage in the feeding of sows and piglets due to the low content of limiting amino acids, there seems to be an advantage in the case of fattening pigs in relation to meat quality. In diets for fattening pigs, the avoidance of supplementation with limiting amino acids favors the production of meat with high intramuscular fat without causing an overly fat pig. In this case, the organic approach provides a tool for producers to manipulate intramuscular fat levels to meet specific market requirements with limited impact of on-farm performance. However, the strategy to increase intramuscular fat by a reduced supply of limited amino acids requires further studies, e.g. in relation to the impact on the palatability.

It is suggested that feeding management in organic pig farming has a high potential for improvements. Stimuli should be provided to persuade the farmers to pay more attention to feeding. In the future, farmers should be given help with regard to the composition of their feedstuffs and analysis of the diets they plan to feed to their pigs.

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Nutrition issues in organic poultry systems

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Introduction

It should be borne in mind by practical nutritionists, and by those seeking advice from them, that the established principles of nutrition and metabolism apply both to conventional (i.e. intensive indoor or standard free range) and organic poultry production. Although it may be necessary for political and regulatory reasons to treat organic poultry differently, we should remember that we are dealing with the same biological entity. The regulatory framework within which nutritionists must operate does impose some constraints upon their freedom of choice of both raw material ingredients and formulation. The challenge which the nutritionist faces is to produce a balanced diet for poultry within these constraints.

Regulatory and certification constraints

For regulatory reasons, there must be a minimum proportion of organic ingredients in an organic ration. These ingredients must be drawn from a limited, approved range, and some classes of ingredients are prohibited. For example, no genetically modified (GM) material is allowed; neither is meat and bone meal. However, it might be pointed out that these ingredients are sometimes prohibited from non-organic rations for reasons of consumer unacceptability or other concerns, and so these constraints are not necessarily exclusive to the organic sector. The issue of synthetic amino acids has recently been contended, and the debate will no doubt develop further. I will discuss this issue in more detail later in this paper. In the egg sector, a further constraint is the prohibition of synthetic yolk pigments. This normally results in paler yolks, but in addition it may also lead to more variability in yolk colour intensity.

In the organic poultry meat sector, birds must be grown for a minimum period of time – usually 81 days of age – and in this time some strains of table chicken will reach weights well beyond those of commercial broilers. Are there welfare issues associated with this?

Raw material constraints

Probably the most significant factor dictating raw material limitations for organic poultry rations is the requirement to use non-GM soya. The uncertainty surrounding the provenance of North American sourced soya means that to be certain of its status, buyers must obtain soya from South America or from Europe, where it is in relatively short supply. However the largest component of any organic poultry diet will be cereal, and there is a question over the availability of organic cereals and the ability of the organic cereal growing area to keep pace with the growth in the market.

Gordon (1999), in a MAFF funded literature review, studied the possible sources of home grown proteins for organic poultry feed. Her review suggested that several materials offered some potential, including peas, beans, lupines, linseed, rapeseed and naked oats. Of these, it seems that peas offer the most scope. Peas have certainly been used successfully in large quantities in the French poultry industry, but in the UK they tend to be used more sparingly and usually in a blended or extruded form with some other pulse. The limiting factor applying to all these alternative proteins is their anti-nutritive factor (ANF) content. Gordon produced tables showing the nutrient contents, ANF contents and suggested maximum inclusion levels of these ingredients in poultry diets. Some of them may lend themselves to being grown organically.

Examples of coping with antinutritional factors

Where a raw material is known to contain antinutritive factors, there is usually a palliative measure or option, which can be taken. In the case of peas, micronisation ameliorates the effect of the protease inhibitors; in the case of beans, heat treatment ameliorates the impact of trypsin inhibitors. For lupines and rapeseed, the choice of cultivars low in alkaloid and glucosinolate content is important. With careful treatment and formulation, it may be possible to include peas in organic poultry rations at inclusions of between 250 and 300 g/kg for table chickens and 150 to 200 g/kg for laying hens.

All the materials reviewed have lower lysine concentrations than full fat soya. Whilst rappelled meal and sunflower meal have higher concentrations of methionine plus cystine than full fat soya, their inclusion rates are limited because of the presence of toxins and ANFs, and because of low metabolisable energy/high fibre content values respectively.

Oily fishmeal is allowed in organic rations and it has a higher essential amino acid content than full fat soya. Its use in poultry rations is limited partly by cost, by restrictions on the source of the fish, by the fact that some customers require the birds to be fed on a vegetable based diet and by concerns about fishy taints to the product.

Amino acid nutrition – the key to growth

A considerable part of this paper is devoted to the subject of amino acid nutrition because it is so important in the growth and product yield of poultry. Organic chickens are no different from any others when it comes to their requirement for amino acids. The systems in which they are grown, however, require us to think of them differently.

Amino acids are protein molecules containing an amino group (H_2N), a carboxyl group (COOH), and a carbon chain. The carbon chain incorporates the distinctive features of each amino acid, sometimes including one or more carbon rings, and sometimes including sulphur. Animals can synthesise some amino acids themselves, and these are the non-essential amino acids. However some amino acids are called essential amino acids either because they cannot be synthesised by the animal at all, or they are synthesised too slowly, and must be supplied through the diet. For the chicken the essential amino acids are: arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine and glycine (McDonald *et al*., 1995).

Poultry require amino acids both for maintenance and for growth. The proportion of the amino acid supply, which the bird's metabolism will allocate for each purpose, will depend upon a number of factors. Some of these factors will be the same for organic poultry as for non-organic, while others may differ. If we assume that the environmental constraints placed upon the organic chicken are equivalent to those affecting non-organic birds, then we may say that all other things being equal, the bird's maintenance requirement will be similar.

However, all other things may not be equal. The bird's maintenance requirement will also be a function of genotype and age. The latter may have a different effect upon maintenance needs depending on whether we think of it as chronological or metabolic (see below). We may require specific strains of bird to grow in organic systems. In meat production systems, these birds may be slower growing than their commercial cousins. The way they partition energy and protein from their diet may differ. It is certain that we will require them to reach market weight at a far greater age than intensively reared broilers. All these factors dictate that poultry nutritionists should be paying particular attention to the way they formulate feeds for organic poultry.

A concept with which nutritionists will be familiar is that of the "balanced diet". In amino acid terms, this means that the first limiting amino acids are provided first, with the less essential ones accounted for further down the order of priority. In this way the over supply of amino acids is avoided. Once the requirement for lysine and methionine is met, the nutritionist can turn his or her attention to the secondary amino acids. The availability of raw materials, which are good sources of lysine and methionine, helps the nutritionist to formulate a diet without over-supplying crude protein, and consequently, other amino acids.

Inadequate supply of amino acids is not simply a production problem. If the bird's diet is deficient in a specific component, a "hunger" for that component can arise. In the case of methionine for example, there is circumstantial evidence (Owen, 2000) that birds may peck each others' feathers in search of this amino acid when it is deficient in the diet. This in turn presents a welfare problem.

One question, which should be asked when considering poultry nutrition is whether it is "natural" to feed an omnivorous bird a vegetarian diet. Does the concept of a vegetarian diet sit comfortably with the ethos of organic poultry production, with its image of being closer to nature's intention? There is a risk of adopting a standpoint of perceiving a vegetarian diet as inherently wholesome, whereas an objective approach might lead us to a different conclusion.

Some practical feeding problems

Organic chickens will spend a proportion of their lives outdoors, and even when indoors they may be in small houses with poor environmental control. In controlled environment systems, nutritionists can rely on the assumption that ambient temperature will be within a certain relatively narrow range, and they can therefore formulate diets on the basis that the birds will have a predictable feed intake and therefore energy intake. The *ad libitum* intake of the diet is driven by energy need, and this in turn dictates the consumption of the non-energy nutrients.

What happens in a system where ambient temperature, and hence *ad libitum* energy intake, is unpredictable? The main effect will be that protein content of the diet is difficult to optimise. Over consumption of protein will be a risk if low temperatures stimulate high feed intakes; conversely in hot weather feed intake can be depressed. Either way, growth and/or carcass conformation can potentially be affected detrimentally. An unbalanced diet puts stress on the bird's metabolism. Excess protein has to be de-animated and excreted as uric acid (Larbier and Leclercq, 1994) and this process uses up additional metabolic energy and requires the liver and the kidneys to work harder. Birds may over-consume water in an attempt to de-aminate protein, and this, in turn, causes environmental and litter quality problems (Tucker and Walker, 1992).

Inadequate protein, as mentioned above, leads to both production and welfare problems. Variability in feed intake will also lead to difficulty in predicting carotenoid intakes in laying hens and this may lead to variable yolk colour. This is in addition to the issue of synthetic yolk colourants mentioned above.

Feed formulators often work on the concept of the "space" within a ration. What they mean by this is the scope for including certain quantities of raw material ingredients. Say, for example, that a diet is required to contain 650 kg of cereal per tonne - this means that only 350 kg of "space" remains for the nutritionist to fit all the other ingredients needed to balance the diet - the protein sources, the oil if any, the minerals and the vitamins. This is a practical challenge.

Biosecurity and hygiene

Consumers may believe that organic poultry products are intrinsically safer to eat than conventionally produced poultry products. Organic suggests natural wholesomeness, quality and a degree of purity, which may be perceived as lacking in conventional intensive systems. In 1999, a survey in the UK (MORI) found that consumers buy organic food because they believe it to be healthier, free of chemicals, better tasting, GM free, better for the environment and better for animal welfare.

The environmental and animal welfare aspects are not for debate here, but there are biosecurity risks in organic production, and product hygiene may be compromised. These risks are inherent in all outdoor systems whether organic or not, but nevertheless they exist. Two particular risks come to mind; firstly the risk of pathogens being introduced by the wild bird population, which cannot be excluded from outdoor paddocks and runs, and secondly the risk of disease transmission by the rodent population. The latter can be excluded if very robust precautions are taken, but these will have a high cost. We should bear in mind that some hygiene measures, which the conventional industry might employ (certain vaccines, antibiotics, feed additives and so on) may not be permissible under organic rules.

Growing to 81 days - special problems

The formulation of feeds for what we know as fast growing commercial broiler hybrids is a well established science. But when formulating for breeds or hybrids, which may take up to 81 days to reach a similar bodyweight (and a similar carcass conformation) to a Ross or Cobb broiler, one is dealing with a different metabolic phenomenon. Two birds may have the same bodyweight, and the same proportion of breast meat, but one may be twice the age. Do we compare them on the basis of their chronological age, their physical weight, or on some other basis? Recent work by Gordon *et al.* (2001) suggests that a comparison on the basis of metabolic age may be an appropriate approach. The criterion of comparison is the point which the birds have reached on their respective growth curves as they grow towards their own specific mature weight.

In work at ADAS Gleadthorpe, Gordon showed that different breeds exhibited a range of metabolic ages and degrees of maturity for given chronological ages. It is therefore recommended that carcass characteristics be defined as those for given metabolic ages, in order to compare breeds on a biologically consistent basis. It is possible that commercial broiler hybrids, even when fed “Label Rouge” type formulations with low energy and low essential amino acid content, may grow to weights in excess of market requirements by 81 days of age. The choice of hybrid, and the formulation of diets, both require careful consideration.

Methodology and marketing

The modern European poultry industry has, in the author’s view, exemplified the principle that successful agriculture should be science driven. The methodology we adopt in driving forward technological advances in organic livestock production should be inductive (evidence and hypothesis driven), not deductive and driven by subjective or political perception. The criteria for decision making will not always match across the two approaches, and occasionally there will be a conflict between perceived and objective naturalness. Organic regulations provide the framework within which marketing activity takes place, and there is a danger that badly drawn rules will lead to unsubstantiated claims, and subsequently to a loss of credibility for the organic label. The UK House of Commons Agriculture Committee, in its second report on Organic Farming, said “It is vital that the organic industry develops its ability to market its products effectively so that they appeal not to sentiment but to proven benefits”.

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Discussion report

Feeding for health and welfare

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Feeding of livestock in organic production systems was discussed in four different groups: beef production, dairy production, pig production and poultry production.

A. Beef production

Whilst feeding to achieve good health status in organic beef production was generally considered unproblematic, the following key problem areas were identified:

- Finishing of beef cattle for slaughter was considered problematic in areas where home-grown cereal production is difficult or impossible and of organic cereals is expensive. This problem was considered particularly pertinent in beef production areas in Scottish highlands, where traditionally local, slow-maturing breeds have been used. The problem has been exacerbated by the 30 Month Rule that requires that all cattle destined for human consumption have to be killed before 30 months of age (due to BSE precautions).
- Some EU areas with low summer rainfall have traditionally practiced zero/buffer grazing (cut and carry systems) during the dry summer season. The requirement to maximise pasturage in organic standards may limit conversion to organic production in these areas.
- Maximisation of pasturage was seen as a problem in young cows due to increased parasite burdens.

- The preference for permanent pastures and the popularity of organic production systems in upland areas may cause problems with trace element provision, as farmers often do not carry out routine supplementation.
- Killing of dairy bull calves at birth, practised both in conventional and organic systems, was considered to have serious animal welfare implications.
- The difficulty of clover management was considered a potential health risk for cattle. Too high levels of clover in the sward has been shown to lead to increased risk of bloat and poor absorption of certain minerals and trace elements.
- The effect of castration on welfare, growth rates, meat quality and husbandry systems on organic farms should be examined to avoid unnecessary castrations.
- It was felt that there was a certain amount of incompatibility between consumers' perceptions about local breeds and their actual buying habits. The consumers were seen to desire the use of local breeds but were not often happy with the type of end product these breeds produced (e.g. marbled, fatty beef).
- In some countries (e.g. Denmark), organic beef production on marginal, ecologically sensitive areas was seen to be conflicting with the environmental objectives of organic farming.

The general consensus was that most of these problems require <u>solutions</u> on management and systems level, rather than further nutritional research. The following suggestions were made:

- The breed and animal type needs to be taken into careful consideration at conversion stage. Types and breeds that mature poorly on grass-based diets should not be kept in organic systems.
- The standards on the extent of buffer grazing/cut-and-carry practices should be set. It was pointed out that the Soil Association in the UK had recently set a limit of 20% of daily DM intake to cut-and-carry systems during the grazing season.
- It was suggested that there is adequate information on good clover management available, and that this information needs to be implemented better on organic farms. Strip grazing swards that are too heavy on clover was also suggested as a management system for organic beef farms.
- The following suggestions were made to solve the problem of unwanted dairy bull calves: use of dual purpose breeds for dairying, organic veal production, communal/co-operative fattening system for dairy farms, collaboration between organic arable farms and dairy farms.
- It was also felt that there was adequate information on the influence of castration on growth rates, meat quality and other aspects of beef production. It was considered important to weigh the animal welfare implications of castration against other welfare-related aspects of management on individual farm basis (e.g. if castration would make finishing by grazing possible, whereas entire animals would need to be kept housed, castration might be considered a lesser breech of welfare than housing).
- Mineral deficiencies were not considered a particular problem as the EU Regulation 1804/99 allows routine supplementation in organic beef systems. There is, however, a need to emphasise an evidence-based approach on organic farms with appropriate soil, forage and blood analyses in order to avoid deficiencies.

- Unrelated to the health and welfare issues, it was concluded that organic beef production needs higher profile and more emphasis on ensuring good quality to justify higher prices for organic beef to reflect the higher production costs. Simultaneously, environmental problems related to the use of marginal land for beef production on organic farms need to be solved in order to maintain customer demands.

Research and development needs:

- Identification of suitable crosses for "production" of desirable dairy bull calves. This research would need to take into consideration the varying conditions in different production systems and individual farms.
- Identification of constraints to collaborative approach to fattening of store cattle (including dairy bull calves) and development of systems that have minimal impact on health and welfare (e.g. minimal travelling time and distances, herd health safety procedures).
- Research into the practicalities of producing non-castrated bulls for organic beef.
- Consumer education on organic beef production with the emphasis on understanding welfare and quality.

B. Dairy production

The discussion on health and welfare related problems in dairy feeding focused on the following issues:

- Selenium and copper deficiencies were seen as a problem in some countries (e.g. Finland) or regions as a result of no routine supplementation in bought-in concentrates or discontinuation of Se-containing artificial fertiliser use on deficient soils.
- Energy deficiency in early lactation in high-yielding dairy cows was considered a potential problem due to poor adaptation of milk performance and poor energy quality of home-grown feedstuffs.
- Diets with high clover content and without additional supply of energy-rich forage or concentrates was seen as a potential problem on dairy farms due to the high protein content leading to excess urea levels and potential fertility problems.

The following management solutions were suggested:

- To avoid the restrictions of the requirement for the production to be land based (i.e. for the concentrates to be home-grown), it was suggested that collaboration between arable and dairy farms could help in solving the regional shortages of home-grown concentrates on organic dairy farms. It was, however, pointed out that such collaboration might require large inputs in form of transport of manure from the dairy farm to the arable farm and of feed from the arable farm to the dairy farm.
- It was suggested that full utilisation of existing know-how on grassland management and conservation of forage combined with 24-hour access to forage at *ad libitum*-basis should be the basis of organic milk production. Data from Austria and Sweden suggest that relatively high yields are possible on forage-based diets without any concentrates (see papers by Knaus and Jonsson in these proceedings).
- A discussion on the acceptability of energy deficiency during the first 6 to 8 weeks of lactation in organic cows was discussed. It was pointed out that, whilst relatively

high yields are obtained from apparently healthy cows, monitoring of potential long-term effects (poor fertility, fatty liver syndrome, subclinical ketosis, early culling due to all these problems etc.) of such energy deficit should be carried out. Monitoring of the environmental consequences of high clover-based forage diets in terms of excess N, should also be carried out.

- In Germany, organic farmers are advised to increase the amount of crude protein to a level that is acceptable with regard to animal health in order to increase nitrogen content in the manure. At the same time, they are advised in minimising nitrogen losses to the environment by appropriate housing, storage and distribution measures.

Research and development needs:

- Research into the long-term effect of early lactation energy deficit in organic dairy cows: health and welfare (culling) monitoring.
- Research into the biological efficiency and environmental impact of feeding systems in organic dairy herd.
- Development of advice based on existing information on clover management, grassland management and forage conservation adapted to organic system.
- Development of advice based on existing knowledge on the formulation of feeding rations adapted to organic systems.

C. Pig production

The following problem areas were discussed:

Nutritional problems:

- It was agreed that energy and trace element deficiencies were not likely problems in organic pig systems, but deficiency in limited amino acids was considered a potential problem due to the difficulty of sourcing high quality feeding stuffs (home-grown protein sources, like corn legumes, have a low level of essential amino acids, and conventional sources, like potato protein, maize gluten or skim milk powder, are expansive).
- When home-grown grain is used, best grain is often sold and poor quality grain is used as feed: nutritional deficiencies and mycotoxins may become problems.
- Weaning management:
- Increasing the weaning age (six weeks required by organic standards) may be complicated by the sow's inability to suckle long enough in hybrid breeds and with large litters. This can result to exhausted sows with an energy deficit leading to impaired fertility.
- Early weaning, even at six weeks, requires careful feeding management, especially with regard to the creep diet in order to avoid diarrhoea in piglets.

Research and development needs:

- Identification of optimal weaning age for the health and welfare of piglets under specific farm conditions and identification of sow breeds that are capable of suckling to this period.
- Development of optimised system at weaning: adequate control of parasite burdens, management of salmonella etc.
- Identification of feasible alternatives to artificial amino acids.

- Development of pig health plans that include a complete feeding plan for organic farms.

D. Poultry production

The following problem areas were identified:

- The control of intestinal parasites, and coccidiosis in particular, was identified as a potential problem in free range systems and with rations free of in-feed prophylactic medications.
- Potential problems arising from increased use of home-grown and home-mixed rations were discussed.
- Home-grown and home-mixed rations are more likely to be of low nutrient density, leading to thin intestinal contents and poor absorption of nutrients in the short digestive tract of poultry.
- The farmers have poor understanding of ration formulation, leading to potentially serious deficiencies in home-mixed rations.
- The EU regulation banning the use of artificial amino acids was considered to cause a potential problem in the provision of essential amino acids.

Potential solutions to these problems were suggested:

- The acceptability of coccidial water-administered vaccines in organic poultry hatcheries should be clarified. In layer systems, serious coccidiosis is unlikely to be a problem in adult birds that have acquired immunity, as long as hygiene standards are good, stocking densities are not too high and site rotation is practiced.
- Training and advisory materials on poultry ration formulation for home-mixing should be developed. It was also suggested that poultry could be allowed to practice choice feeding where they choose their own rations.
- It was pointed out that high levels of limited amino acids in poultry diets are needed because of high performance levels required from the birds. The need to adjust the production levels to available diet should be considered, rather than a change of feeding standards. In Germany, the artificial amino acids have been successfully replaced by potato protein in broiler diets, but the availability of GM-free potato protein is under threat. In Scandinavian countries, soured milk powder has been used in both broiler and layer diets to replace artificial amino acids. In the future, soya bean expeller of organic origin will probably be available.

Research and development needs:

- There is a need to carry out research in order to identify alternatives to artificial amino acids (potato protein, soured milk powder, organic soya bean meal). The research should focus on establishing appropriate production levels without the use of artificial amino acids and ensuring that no welfare problems arise from organic poultry diets.
- Training materials on home-mixing poultry diets need to be developed for farmers.

Part C:

Posters and additional papers

The measurement of quality of stockmanship for dairy farm assurance schemes

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Introduction

Consumer concern for animal welfare in the UK has increased in recent years. This is perhaps a result of high-profile media and pressure-group campaigns that have drawn attention to issues such as export of live animals, intensive pig production and slaughter of young male dairy calves. There has been a parallel surge of public interest in human food safety, following the BSE-CJD link, deaths from *E. coli* infection, worries about Organo-phosphate toxicity and antibiotic residues in food.

The result of these concerns has been the emergence quality assurance schemes. Farm Assurance has been described as “a process of quality assurance that is intended to reassure consumers that a product is derived from a farm working to specified production standards” (Sibley, 2000). Farm Assurance Schemes (FAS) provide assurance on food safety and environmental issues as well as an assessment of animal welfare (Main and Cartledge, 2000). The details of the schemes are many and various, and welfare assessment methods range from a tick in the box in answer to the self-report question: “Is the welfare of animals on your farm good?” to a detailed analysis carried out by trained assessors.

The FAS provides a potentially valuable tool for driving up standards of animal welfare, but will be effective only if it measures ALL the key factors involved in animal welfare, and if the FAS measurements are accurate. We can probably all agree that every aspect of the welfare of the dairy cow is influenced by the quality of stockmanship she enjoys. No matter how good the facilities, housing and nutritional planning, it is the stockperson who ensures (for example) that the cow is adequately fed, kept comfortable, and cared for when she is sick. Therefore, if a FAS is to provide an accurate estimate of the welfare of the dairy cow, it must include an assessment of quality of stockmanship.

However, it is not so easy to measure quality of stockmanship as to measure trough size or stocking density or dimensions of the bull's pen. This paper describes a pilot study carried out with two veterinary students. The aim was to identify objective measures of quality of stockmanship that might be suitable for inclusion into FAS.

Method

The first job was to identify potential methods from work carried out elsewhere. These included methods developed for studies exploring the effect of stockperson behaviour on animal fear and productivity, comprehensively reviewed by Hemsworth and Coleman in 1998 (Table 1). The results of other research work provided methods for measurement of further aspects of stockmanship (see Table 2). Veterinarians attending a British Cattle Veterinary Association (BCVA) conference were invited to suggest the two questions they would ask dairy stockpersons in order to assess the quality of dairy stockmanship. The results identified the range of stockperson responsibilities, and provided 65 potential questions.

Table 1 The effect on livestock of negative interactions (smacks or prods, angry words etc.) compared to positive interactions (stroking, fondling, etc.) (reviewed by Hemsworth and Coleman, 1998).

Correlation examined	**Outcome**
Dairy cow behaviour at milking: Restlessness Defaecations Delay to enter parlour	All increased following negative interactions
Time to interact with humans, and/or flight distance: • Pigs • Farmed foxes • First lactation cows • Calves • Poultry • Sheep and goats	Increased with negative interactions (e.g. slaps), decreased with positive interactions (eg stroking)
Production levels: • milk yield (dairy cows) • growth (pigs, poultry) • fertility (pigs)	All reduced following negative interactions
Heart rate and blood cortisol levels in cattle, sheep goats and pigs	Higher increases in cortisol and heart rate following negative interactions

Table 2 Other research that might provide useful methods for assessment of quality of dairy stockmanship

Stockperson trait	**Measurement**	**Welfare outcome for stock**	**References**
Personality profile	"Good stockpersons" identified by peers	All aspects of care	Seabrook M.F., 1997
Relationship with stock	Behaviour of stock and behaviour of stockperson	Distress and discomfort	Seabrook M.F. 1989
Agricultural training level	Incidence of lameness (dairy cattle)	Pain and disease	Mill J.M. and Ward W.R., 1994.
Recognition of lameness lesions	Incidence of lameness (dairy cattle)	Pain and disease	Mill J.M. and Ward W.R., 1994
Early observation of disease/injury	Mortality (finishing pigs)	Injury and disease	Duran O. (1996)
Abusive or ignorant stockmanship	Bruising in cattle carcasses	Fear, distress and injury	Tarrant P.V. (1990).
Individual anxiety	Injuries in spent laying hens pulled out of cages	Pain and injury	RSPCA, 1993

"Stockmanship" includes a variety of facets that may impact on animal welfare, including technical knowledge (Mill and Ward, 1994), early observation of disease and injury (Duran, 1996), good handling (Tarrant, 1990) and empathetic behaviour (Seabrook, 1991). For the purpose of this study, the aspects of stockmanship have been classified as management ability, technical skill and knowledge, observation skills and empathy with stock. This study explored technical skills and knowledge, observation and empathy. The various methods outlined above were reviewed. Fourteen potential tests were chosen and modified for this study, including a questionnaire, observations of cattle behaviour and observations of stockperson behaviour and attitude. Each test was evaluated for practicality and ease of use, acceptability to the stockperson and effectiveness at separating individual stockpersons (variation/spread of test results between different stockpersons).

A pilot protocol was carried out on the University of Bristol dairy farm, and amended in the light of problems identified. Each test was carried out on 12 dairy herds in SW England, with 16 stockpersons (men and women, farmers and employees). Each assessment involved a short interview with the stockperson. Initial questions established details of the herd and personnel, and were designed to put the stockperson at ease. Questions were then asked about animal disease. The assessors then accompanied the stockperson into the yard, where further questions were asked around the stock to test familiarity and observation. A measurement of flight distance was made for both stockperson and assessor to test fear of humans. The process of rounding up, and aspects of the milking routine were then observed and recorded. Each part of the assessment was carried out by the same assessor on the different farms to ensure standardisation of results. (see Table 3 for a summary of the method.)

Table 3 Methods evaluated as potentially useful for FAS assessment of quality of dairy stockmanship.

Aspect of Stockmanship	Quality evaluated	Method	Measure
Technical skill and knowledge	Years' experience with cattle	Questionnaire	Number
	Agricultural training	Questionnaire	
	Knowledge about cattle diseases	"How many clinical signs can you identify (milk fever, LDA, calf diseases)?" "What would you do if you had an animal suffering from Milk Fever?"…	Score
	Recognition and knowledge about lameness	Questions based around photos of foot lesions.	Score
	Understanding about welfare	Questions about Five Freedoms.	Score
Observation skills	Recognition and knowledge about lameness	Questions based around photos of lesions	Score
	Facts known about individual cows	Questions in the yard. "Tell me about that animal…", "Which is the highest yielding cow, tell me about her."	Score
Empathy - cow behaviour	Avoidance	Flight distance for stockperson and for observer	Measured
	Speed to enter yard	Measured using timer and trundle wheel	Measured
	Readiness to enter parlour	Measured using timer	Measured
	Restlessness within parlour	Number of flinches, steps and kicks as cluster was applied counted for each cow	Number
	Defaecations in parlour	Counted	Number
Empathy – stockperson behaviour	Interaction with cows during rounding up for milking	Number of positive and negative interactions with cows counted Use of stick and dog	% positive
	Kick bar	Use of kick bar during milking	Number
	Introduction of heifers into herd	Questions around routine to identify special care for heifers	Score
Empathy – stockperson attitude	Job satisfaction	Stockperson evaluated their satisfaction	Score
	Ability to feel like a cow	"What extra things could be provided to make a cow happy?"	Score

Results

Some tests were well tolerated by stockpersons, practical to use and effectively separated between different individuals. Questions about cattle diseases that were familiar to all, (for example calf disease and cow lameness were better than questions about conditions such as milk fever). Questions based around photos were well received. In general, stockpersons preferred talking around individual animals while moving among cattle in the yard, and these effectively separated individuals. Flight distance of cows when approached by the assessor or the stockperson provided an objective measurement that was different in different herds and with different stockpersons. Restlessness in the parlour was readily measured. The percentage of positive interactions with cows (touching, encouraging, talking with cattle) did not separate this group of stockperson.

Some measurements were not so useful. The results of some tests were confounded by factors other than that under investigation (number of defaecations, for example, was influenced by diet, and one herd of thin cows was particularly eager to enter the parlour because they were hungry.) Some tests proved too time-consuming or awkward to measure (restlessness in the parlour). Some questions proved to be ambiguous ("What extra things would make your cows happy?"), and a small number were not well received by stockpersons (questions about cattle disease without photos caused them to feel that they were undergoing an exam).

Discussion

The results identified a group of simple, objective tests that are easily used, well tolerated by the stockperson and effectively distinguished between individual stockpersons. The assessment of stockmanship could be fitted within the routine of the main FAS assessment, adding little to overall time taken, if questions were posed in an informal way during other investigations around the farm. The study had certain limitations. No really bad stockpersons were tested, so the spread of results for some tests was less than could be expected from a more representative group of stockpersons. Most herds have more than one person milking, and cow behaviour is influenced by all the people who deal with them (not just the person being tested). Two of the stockpersons had only worked for a very short time in the herd. Stockperson responses will depend upon their personality, confidence etc. as well as their knowledge and enthusiasm, so the assessor must put the stockperson at ease, and choose tests that do not make the him/her feel threatened. There has been no external validation of results.

The authors believe that there is a real difference between good and bad stockpersons and it can be measured. Although none has yet formally been incorporated into Farm Assurance Schemes in the UK, quality of stockmanship is included within the BCVA's Herd Health Plan and into other dairy FAS. These methods are also discussed as part of the Animal Welfare Assessors' Course, where they have been well received. It is hoped that this study will form the basis for a wider exploration of these measures of quality of stockmanship.

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The Maremmana, a rustic breed ideal for organic production - Experimental experiences

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Introduction

In EU Regulation No. 1804/99 (supplementing EU Regulation No. 2092/91) at the point 3.1, it is said 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. In addition, breeds or strains of animals shall be selected to avoid specific diseases or health problems associated with some breeds or strains used in intensive production. Preference is to be given to indigenous breeds and strains". Moreover, the animal breeds and varieties have to be selected in a way to avoid diseases or sanitary problems linked to specific breeds and strains used; preference should be given to autochthonous breeds and strains (Martini, 2000).

The Maremmana breed is the direct descendant of the Grey Steppe cattle breed brought to Italy by the Goths after the fall of the Roman Empire. The Maremmana has a grey coat that is darker in males and lighter-coloured in females, with white apical pigmentation. As seen in other breeds descending from the Podolica cattle, calves are red-coloured at birth and then at around three months they turn into the characteristic colour of the breed. The horns are long and have typical half-moon shape in the males, whereas the females have lyre-shaped horns.

The Maremmana has an impressive skeletal structure that gives the adult a very solid and robust appearance. This very large sized cattle has solid legs with hard hooves that, in general, are perfectly perpendicular. The cows have a well-shaped udder and an abundant supply of milk that ensures daily weight gains of over 1 kg of the calves. The Maremmana is a very rustic and long-lived breed that can reach an age of 15-16 years. Selection has always been directed towards disease resistance and adaptation to the harsh environment, where the Maremmana cattle lives (Martini, 2000). In fact, generally these cattle are not treated against parasites.

Calving is spontaneous and the calves weigh 30-40 kg at birth. They reach a weight of 180-220 kg by the age of six months, thus confirming the cow's milk-producing capacity. Adult females weigh about 600-800 kg, whereas the males reach a weight of 1000-1200 kg. This breed is widespread in the Italian regions of Tuscany and Latium and around 5000 head are enrolled in the Herd Book (ANABIC, 2001).

Material and methods

The trials were carried out at the Filetto organic farm (controlled by AIAB) property of Metallifere Hills Mountain Community (Massa Marittima), and at the Alberese organic farm (controlled by CCPB) property of Tuscany Region. The realisation of this research has been possible thanks to the financial support of Tuscany Region, Metallifere Hills Mountain Community and the Regional Agency for the Improvement and Innovation in Agriculture (ARSIA).

Results and discussion

In a first trial (Filetto Farm) we considered Maremmana calves slaughtered at 12 e 18 months of age (Giorgetti *et al.*, 1995A; Giorgetti *et al.*, 1995B; Sargentini *et al.*, 1996A; Giorgetti *et al.*, 1996A; Poli *et al.*, 1996; Sargentini *et al.*, 1996B; Giorgetti *et al.*, 1996B; Sargentini *et al.*, 1998A; Bozzi *et al.*, 1998). This research showed the very good physiochemical characteristics of meat, and it indicated the need for a thorough study on the calves breeding systems and the qualitative characteristics of meat (Tables 1 and 2).

Table 1: Slaughtering parameters of young bulls (Sargentini et al., 1996B; Giorgetti et al., 1996A).

	12 months	**18 months**	**sign.**
Live weight (kg)	373,5	528,6	***
Dressing %	51	52,88	
Net dressing %	58,38	58,65	
Conformation score	R-	R	**
Fatness score	2	3	***
1st quality cuts %	33,59	34,37	
2nd quality cuts %	9,94	10,76	**
3rd quality cuts %	35,59	35,56	
Bones %	15,42	14,51	
Fat %	5	4,44	
Carcass value (Euro/kg)	5,66	5,76	**

Table 2: Meat characteristics of young bulls (Giorgetti *et al.*, 1995A; Sargentini *et al.*, 1996A; Giorgetti *et al.*, 1996A; Poli *et al.*, 1996; Giorgetti *et al.*, 1996B).

	12 months	**18 months**	**sign.**
Cooking loss (%)			
M. longissimus thoracis	30,8	32,1	
M. triceps brachii	32,4	34,4	
M. semimembranosus	36,4	35,5	
W.B. shear force (kg)			
M. longissimus thoracis	6,7	9,3	*
M. triceps brachii	7,6	8,4	
M. semimembranosus	9,5	11	
Chemical composition of M. longissimus thoracis			
Water %	75,25	75,23	
Protein %	22,39	22,29	
Ash %	1,15	1,16	
Total lipids %	1,21	1,32	
Cholesterol mg/100g	71,85	70,93	

Maremmana meat was characterised by good physical parameters at both ages tested. The low lipid rate and its fatty acid composition have shown the high meat quality (Table 3).

In a second trial (at "Filetto" Farm) (Sargentini *et al.*, 2000) heifers were slaughtered at about 18 months of age to value the physiochemical meat characteristics (Table 4). The female meats showed a higher tenderness and lightness. The M. Logissimus thoracis monounsaturated fatty acids percentage resulted higher than in males. The C14+C16 incidence resulted similar, and the n-6 lower (Table 5). Presently we can't find easily the meat of Maremmana heifers on the market, because the interest of the breeders for this breed is growing, and therefore, most of the young females are used to improve or to create new herds.

Table 3: Fatty acid composition of meat of young bulls (Bozzi *et al.*, 1998).

	12 months	**18 months**	**sign**
(g/100g of fatty acids)			
Saturated	39,76	40,41	
Monounsaturated	28,77	33,14	*
n-6 polyunsaturated	26,57	22,98	
n-3 polyunsaturated	4,89	3,46	*
C14+C16	20,97	22,55	

Table 4: Meat characteristics of 18 months old heifers (Sargentini et al., 2000A).

	LT	**SM**	**TB**	**sign**
Physical characteristics				
Cooking loss (%)	32,97b	38,76a	32,57b	**
W.B. shear force (kg)	7,46b	12,63a	8,85b	**
Chemical composition				
Water %	74,33b	74,28b	75,58a	**
Protein %	22,92a	23,08a	21,86b	**
Ash %	1,17ab	1,22a	1,15b	*
Total fat %	1,44	1,5	1,67	ns

Table 5: Fatty acid composition of meat from 18 months old heifers (Sargentini *et al.*, 2000A).

	LT	**SM**	**TB**	**sign**
(g/100g fatty acids)				
Saturated	43,57a	41,96ab	39,79	**
Monounsaturated	38,84	41,54	39,89	ns
n-6 polyunsaturated	14,27	13,6	17,14	ns
n-3 polyunsaturated	3,29	2,95	3,15	ns
C14+C16	25,95a	25,68a	23,21b	*

In a third trial realised at "Filetto" Farm (Sargentini *et al.*, 1998B; Rondina *et al.*, 1999; Sargentini *et al.*, 1999A; Sargentini *et al.*, 1999B). Maremmana young bulls were slaughtered at 12, 14, 16, 18 and 20 months of age to investigate the meat quality at different ages. Moreover, the growth curves, average daily gain, dressing % and carcass scores were calculated. The animals were fed a diet of medium energy concentration, composed by ad libitum hay, barley and organic protein supplementation. During the fattening period they were weighted and measured every 45-60 days (Figures 1 and 2).

Figure 1: Live weight of males (Sargentini *et al*., 1998B)

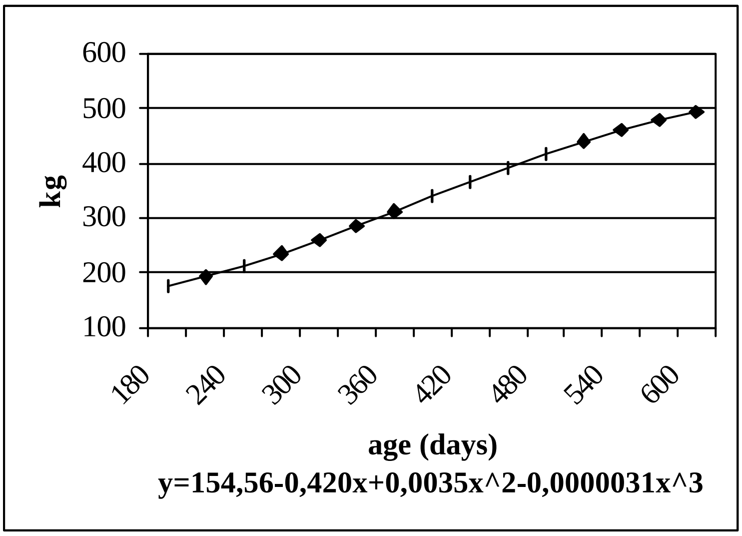
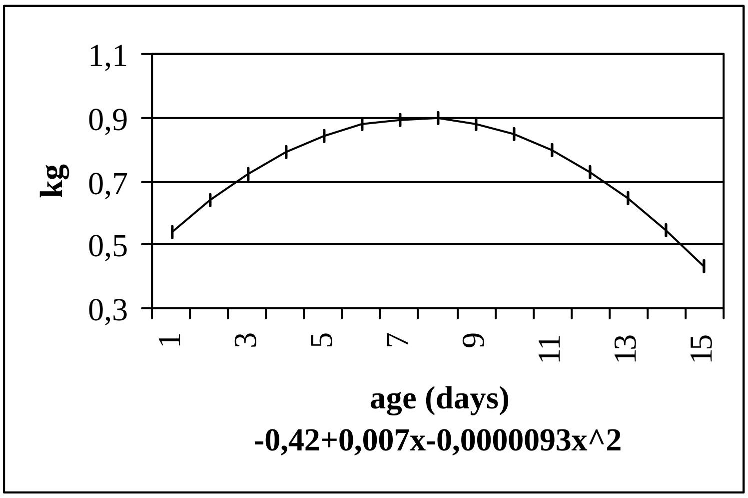


Figure 2: Average daily gain of males (Sargentini et al., 1998B)



Maremmana young bulls showed productions that were similar to that of other rustic breeds, as concerned quality and quantity. Table 6 shows the equations for the evaluation of dressing percentage, conformation and fatness scores. These two parameters appear in linear relation with slaughter age, with a lower “b” coefficient for fatness. At one year of age the conformation score was 4,82 (class O) and reached 7,34 (class R-) at 18 months, whereas fatness ranged from 4,67 (class 2) to 6,29 (class 2+). In the 4th trial carried out at “Filetto” Farm we compared Maremmana young bulls fattened in feedlot vs. pasture (Sargentini *et al*., 2000B).

Table 6: Regressions for relationship between dressing percentage and conformation and fatness scores on age (days) of males (Rondina, 1999).

Parameters	Regressions	sign.	R^2
Dressing %	y=34,706+0,031x	***	2,09
Net dressing %	y=48,2999+0,019x	***	0,44
Conformation score	y=-0,225+0,014x	***	0,59
Fatness score	y=1,434+0,009x	***	0,66

The second group received only little feed supplementation. When comparing the price of the meat sold in different years on the same local markets (see 1st trial), it can be noticed that the Maremmana meat is sold actually (year 2000, see Table 7) at a higher price than before (1996) (also see Table 1).

Table 7: Slaughtering parameters of males reared at feedlot vs. the pasture (Sargentini *et al*., 2000B).

	Feedlot	Pasture	sign
Slaughtering age (months)	15,47	15,5	
Slaughtering weight (kg)	351,8	310,6	**
Dressing %	49,22	45,87	**
Net dressing %	56,08	52,59	**
Conformation score	O	O	
Fatness score	2+	2	*
1st quality cuts %	35,31	34,87	
2nd quality cuts %	10,91	10,49	
3rd quality cuts %	34,1	33,61	
Bone %	14,76	16,33	**
Fat %	4,54	4,24	
Carcass value (Euro/kg)	6,71	6,59	

An analogous trial (5th) was carried out in a plain close to the sea at the “Alberese” Farm. This Farm shows very different characteristics from the “Filetto” which is situated in a hilly area. The animals, which are fed on pasture, received 1 kg/100 kg body weight as supplementation to the diet (Rondina *et al*., 2000). The 4th and 5th trials were realised to adjust a more extensive breeding system, following the philosophy of the EU Regulation No. 1804/99. This breeding system is not easy to realise in the environment of the Maremma (Tuscany and Latium regions), particularly in the hilly areas, where available pasture is very scarce from May/June to October/November (Table 8).

Table 8: Live weight of males calculated at different ages (Rondina *et al.*, 2000).
AF = feedlot at the "Alberese" farm; AP = pasture at the "Alberese" farm;
FF = feedlot at the "Filetto" farm; FP = pasture at the "Filetto" farm

	240 days	300 days	360 days	420 days	480 days
AF	202,37	220,25[a]	262,65[a]	321,71[a]	389,58[a]
AP	196,38	216,71[a]	269,62[a]	338,66[b]	407,36[b]
FF	231,84	265,85[b]	293,13[b]	339,12[b]	428,85[c]
FP	213,13	238,25[c]	256,39[a]	292,38[c]	371,05[d]

[a,b,c] $P \leq 0{,}01$ on the same column

Further research was carried out regarding:

1. Genetic characterisation of this breed,
2. Study of the principal hormone variation patterns in females from weaning to 2 years of age, with the aim of monitoring the physiological characteristics of reproduction in the Maremmana breed,
3. Studies on reproduction biotechnology with the aim to create a germplasm bank of local breeds.

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Growth and development of young stock on organic dairy farms

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Intoduction

Rearing young stock on organic farms in the Netherlands has to deal with extensive grazing and limited amounts of concentrates on the one hand, and the economical drive to shorten the rearing period on the other hand. On conventional dairy farms, age at first calving is on average 25 months with a tendency to reduce that age for economic reasons. On a number of organic farms, young stock grazes under extensive conditions in summer. In winter heifers are fed roughage from extensively farmed grassland, poor in energy and protein. Till August 2000, in organic farming the amount of concentrates per cow (young stock included) was limited because of the regulations in the Netherlands. Since EU-regulations have been accepted, the price of concentrates will be the factor limiting the amount of concentrates fed to young stock.

Material and methods

On 10 organic farms chest circumference of all young stock was measured, while age at first calving, diseases and milk yields were recorded. From the chest circumference weight has been calculated by following equation:

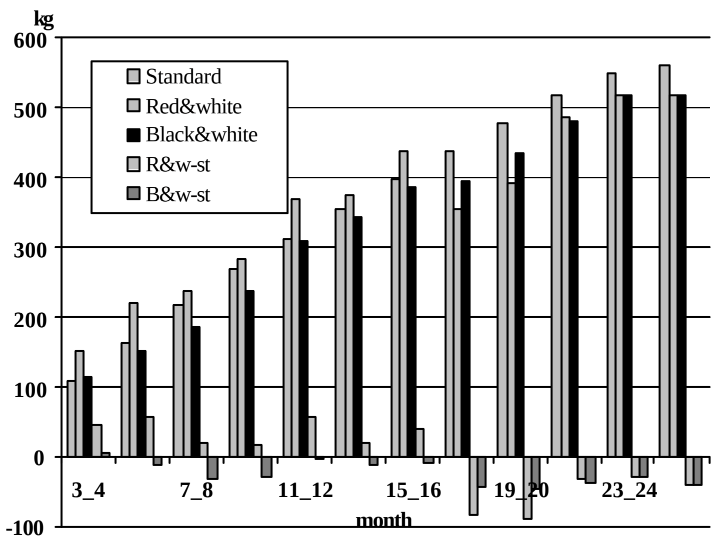
HF, FH (Black&White (B&W) cattle): weight = $2.75*10^{-4}*x^{2.76}$
MRIJ, Montbeliarde, Fleckvieh (Red&White (R&W) cattle): weight = $6.6*10^{-4}*x^{2.76}$,
where x is chest circumference in cm.

Results

Results are compared with the average weight of HF- and MRY-heifers on 9 conventional experimental farms (standard). Rearing intensity of young stock aims at a body weight of about 350 kg at the time of first insemination and of about 560 kg after first calving.

The average number of animals on the farms was 27, ranging from 8 to 53. In Figure 1, the average calculated body weights of B&W and R&W young stock on organic farms are compared with the average weights of young stock on conventional experimental farms for two-month periods. Also differences in weights between young stock on organic farms and on conventional farms are shown.

Figure 1: Mean body weight of youngstock in 2-month periods



In the first year, the R&W heifers on organic farms, on average, met the standard easily while the B&W heifers just met the standard. In the second year, both groups on organic farms underlay the conventional heifers. At the end of the second year there was a difference in body weight of about 40 kg in favour of the standard. On organic farms, the ideal weight for mating has been reached at an age of 13-14 months on average. The main health problems were lung problems (pneumonia and lung worm) in the first 6 months of age.

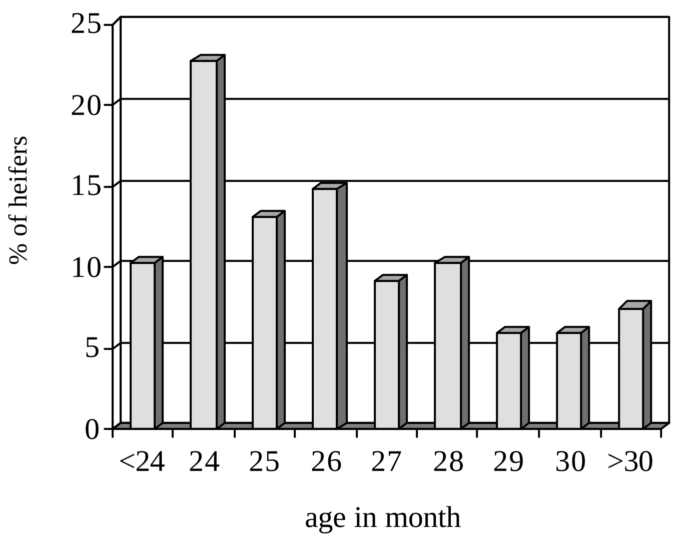
In Table 1, more information on the heifers is given, including: age at desired weight for 1st insemination (AIW), age at calving (AC) and fat and protein corrected milk yield (FPCM) in the first lactation as percentage of older cows. A body weight of 350 kg was reached in month 13 and the mean age at 1st calving was 2 years plus 2 months. The mean fat and protein corrected milk yield of the heifers was about 82% of the yield of the older cows. On farms where heifers reached the desired body weight for insemination at a relatively low age, relative FPCM-yield tended to be higher. On those farms, there was a larger interval between AIW and AC and hence a more developed animal at calving.

Table 1: Age reaching 350 kg BW (insemination) and 1st calving and milk yield 1st calvers in % of yield (FPCM) and standardised production (LW) of older cows

Farm Number	*9*	*11*	*1*	*6*	*4*	*8*	*5*	*7*	*10*	*3*	*mean*
AIW in month (1)	11	11	13	13	13	14	14	15	15	15	13
Age at calving (2)	25	25	26	27	28	25	26	26	27	30	26.5
Interval (2) – (1)	14	14	13	14	15	11	12	11	12	15	13
%FPCM	83	80	84	84	91	81	77	81	79	81	82

The age at first calving of the heifers over the last two years is given in Figure 2. It shows that about half of the heifers gave birth before the age of 2 years and 2 months. About 15% of the heifers were 2 years and 6 months or older at first calving.

Figure 2: Percentage of heifers and calving age



Conclusions

1) Mean growth of organic young stock is comparable with growth on conventional farms in the 1st year and lower in the 2nd year.

2) Main diseases are pneumonia and lung worm in young calves.

3) First calving at an older age is no guarantee for more milk; yields tend to be higher on farms where growth rates of young stock are higher in the first year.

4) Management (feeding, feedstuffs, time of 1st insemination) should meet the aims of rearing young stock.

Feeding of dairy cattle on organic farms in the Netherlands

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Introduction

Organic dairy farming is a forage based production system. Farmers aim to be self supporting. Like in conventional dairy farming in the Netherlands, grass and forage maize are the main important fodder crops. Sometimes also fodder beet, lucerne and (triticale) whole crop silage are fed. The amount of concentratess is limited, about 1200 kg/year. On conventional farms cows are fed about 2000 kg of concentrates a year. The way Dutch farmers deal with these basic principles in feeding of dairy cows was studied on 10 organic dairy farms.

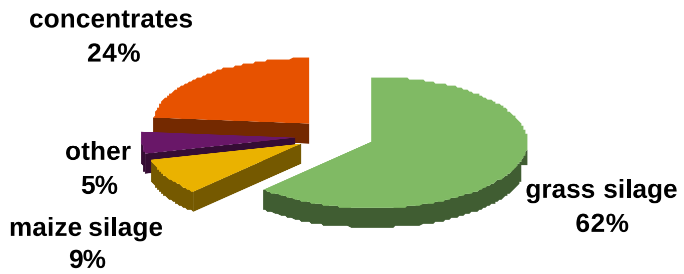
Material and methods

In both housing periods 1998/1999 and 1999/2000 on 10 organic dairy farms taking part in the 'Bioveem' project total feed consumption was measured during 3-5 days on 2 or 3 occasions. The composition of the ration and total milk production were calculated. The breed of most cattle was HF (black & white) or Dutch Red & White.

Results

During the housing period, the ration for dairy cattle contained mainly grass silage (on average 62%) (see Figure 1). On most farms also maize silage was fed (9%). Concentratess amounted to 24%. On a few farms the ration contained other fodder crops like lucerne, (triticale) whole crop silage, fodder beet or potatoes (5%). In conventional dairy farms cows were fed more concentrates (± 40%), more maize silage (± 20%) and less grass silage (± 40%).

Figure 1: Average composition of ration



The feeding value of the ration was very different between farms. Due to a varying percentage of concentrates and different quality of grass silage the energy content varied between 5.8 and 6.7 MJ/kg DM (Table 1).

Table 1: Feeding value of rations

	Avg.	Max.	Min.
NEL (MJ/kg DM)	6.1	6.7	5.8
Protein (DVE/kg DM)[1]	74	81	62
Concentrates (%)	24	30	18

[1)] Thamminga, S., W.M. van Straalen, W.M., A.P.J. Subnel, R.G.M. Meijer, A. Steg, C.J.G. Wever and M.C. Blok, 1994. The Dutch protein evaluation system: The DVE/OEB- System. Livestock Production Science, 40: 139-155.

Average feed intake measured 19.2 kg DM of which 4.5 kg concentrates (Figure 2). Substantial differences between farms were found. The minimum intake was 16.1 kg whereas the maximum intake was 22.7 kg DM. Logically, a higher feed/energy intake generally resulted in a higher milk yield.

Figure 2: Feed intake and production

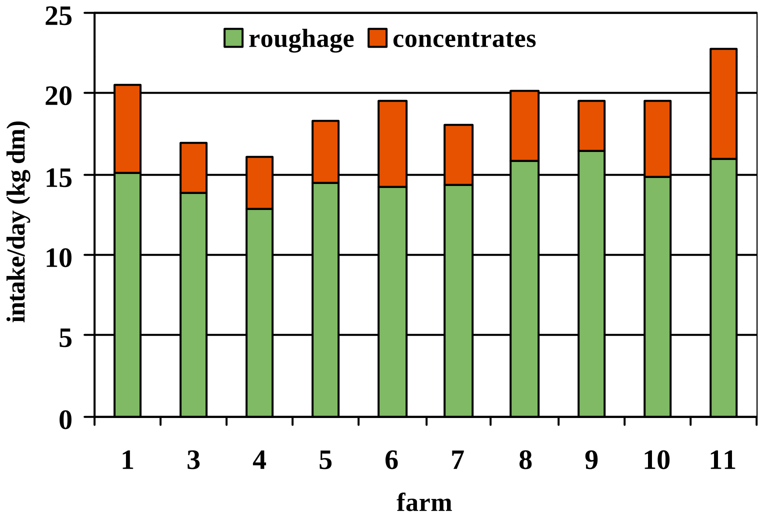


Table 2: Intake and nitrogen efficiency

	Avg.	Max.	Min.
Intake (kg DM/day)			
Roughage	14.8	16.1	12.2
Concentrates	4.5	6.9	3.8
Total	19.2	22.7	16.1
FPCM (kg/day)	23.5	35.5	18.8
Nitrogen effeciency (%)	25	35	21

Nitrogen efficiency was 25% on average (Table 2). This is a good result, although there were substantial differences between farms. Nitrogen efficiency is an important measure for utilization of nitrogen for milk production.

Conclusions

- In organic farming, the ration for dairy cattle during the housing period mainly consists of grass silage;
- Quality and yield of grass (silage) are very important;
- Substantial between farms differences in composition of ration, feed intake, milk production and nitrogen efficiency were found;
- With well balanced rations high nitrogen efficiency is possible in organic dairy farming.

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