Ecological Animal Husbandry in the Nordic Countries

Proceedings from NJF-seminar No. 303
Horsens, Denmark 16-17 September 1999

John E. Hermansen,
Vonne Lund &
Erling Thuen (Eds.)

Danish Research Centre for Organic Farming

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DARCOF Report no. 2
Printed from www.foejo.dk

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Danish Research Centre for Organic Farming 2000

DARCOF Report No. 2/2000

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Layout

Cover: Enggaardens Tegnestue
Content: Rikke-Kirstine Villadsen and Grethe Hansen, DARCOF

Photos at cover: E. Keller Nielsen

Print: Repro & Tryk, Skive, Denmark

Paper: 90 g. Cyklus print

Paginated pages: 202

First published: April 2000

Publisher: Danish Research Centre for Organic Agriculture, DARCOF

ISSN: 1399-915X

Price: 100 DKK incl. consignment

To be bought at

Danish Research Centre for Organic Agriculture, DARCOF
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Preface

During the last decade there has been a rapid development and a great increase in the area of organic farming, both in the Nordic countries and in the rest of Europe. This development is due to an increased marked, but also due to an increased interest in society because organic farming contributes to a better environment and a more healthy animal husbandry.

During this development it is a great challenge for research to give explanations and to follow up and provide the knowledge that is needed in society, i.e. research is an important factor to secure quality, health and sustainability in the production.

Often, research and practical agriculture in the Nordic countries face the same problems. The aim of the NJF/DARCOF seminar at Horsens was thus to present current research projects from the different countries. Through a presentation of research projects it is possible to learn from experience obtained in the different countries and it becomes possible to create a far more extensive collaboration across the frontiers.

In this report the various presentations are collected and elaborated. The desire is to contribute to the development of research in organic animal husbandry, and to promote both Nordic and international co-operation in the area.

This would not have been possible without the efforts of the individual authors, the editorial group and the organisers of the workshop. Our sincere thanks are therefore extended to all those involved in the workshop and in the creation of this book.

Erik Steen Kristensen
Research Centre for Organic Farming
Foulum, April 2000

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What is ecological animal husbandry?

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In Sweden there is an expression: "A beloved child has many names." This applies to ecological animal husbandry as well. In the Scandinavian countries, together with the German speaking countries and Spain, we have chosen the name "ecological" for what in English usually is called "organic". In other countries such as Italy or the Netherlands, the same thing is called "biological", and in Finland it is "luonnonmukainen" (Table 1). The selection of the term "ecological" for this conference may be seen as a sign of Nordic stubborness: We feel that the term ecological makes much more sense than the word "organic". All the terms in Table 1 denote a production performed according to the IFOAM basic standards. From August 2000 it must also be performed according to the EC regulation no. 1804/1999 of 19 July 1999, supplementing "Regulation (EEC) No 2092/91 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs to include livestock production."

Before getting deeper into what the new EU regulation means to the Nordic ecological animal husbandry, I will present a short review of what has happened before we came this far. The origin of the animal husbandry of today stems from several lines of ideas. Most of these have to do with the care of the soil and soil fertility. Here we find important names like Sir Albert Howard and Lady Eve Balfour who have initiated organic farming in England, and Hans and Maria Müller and Peter Rusch who developed the organic-biologic cropping method.

Table 1 The term for "ecological agriculture" in different European languages, according to Article 2 in the EEC regulation No 2092/91.

Language	Term
Danish	økologisk
Dutch	biologisch
English	organic
Finnish	luonnonmukainen
French	biologique
German	ökologisch, biologisch
Italian	biologico
Portugese	biológico
Swedish	ekologisk
Spanish	ecológico

The first one to fully include farm animals in an alternative outlook on agricultural production was Rudolf Steiner, the founder of biodynamic farming. He had an idea of the farm as an independent organism where plants, animals and humans were equally important corner-stones of the farming system. The first alternative farms in the Nordic countries were biodynamic, and they were established already in the 1930's. The big development of alternative agriculture came with the growing environmental concerns in the late 1960's and 1970's. It was a "grass-root" movement, with the ideas coming from people dealing with practical farming. This is shown by the fact that the ecological farmers' organizations (with one exception) were founded long before the universities started "ecological" activities (Table 2). Generally speaking the development of animal husbandry has been behind already from the start, compared to the plant production. This is especially true for the universities. There is for example only one chair in organic animal husbandry systems (and this is not financed by the university).

Table 2. An overview of the development of ecological agriculture in the Nordic countries.

	Denmark	**Finland**	**Iceland**	**Norway**	**Sweden**
First ecol. farms (biodynamic)	1930's	1930's	1930	1932	1934
Ecol. Farmers' organizations	1981 *Landsforeningen økologisk jordbrug (LØJ)*	1985 *Luonnonmukaisen Viljelyn Liitto*	1993 VOR	1971 *NØLL* 1987 *Øko-produsentane*	1985 *Alternativ-odlarnas riksförbund*
National standards for ecol. agriculture	1981 LØJ 1987 Gvt.	1987 1994 Gvt.	1995 Gvt.	1986 and 1987 1995 Gvt. "connected"	1985 1995 Gvt. "connected"
National standards for ecol. animal husbandry	1981 LØJ 1987 Gvt.	1988	1995 Gvt.	1989 1995 Gvt. "connected"	1987
Government support	1987	1990	1999	1990	1989
First dissertation: in plant production in anim. husbandry	 1985 (PhD) 1995 (PhD)	 1998	 1995 (B.Sc.)	 1993	 1981
University chairs	1994-(99) Agroecology 1997-2002 Organic animal husbandry systems 1998-2003 Organic plant production	1993-1997 Organic farming 1997-2002 Agroecology	–	1998 Agroecology	1990 Organic Farming

The new EU regulation is confronting us with a number of challenges. One example is the paragraph stating that animals can have a maximum of three courses of treatment within one year, or only one when the "productive lifecycle" of the animal is shorter than one year. This could have serious animal welfare implications, if it means that the farmer hesitates to treat sick animals properly. The paragraph B 5.4 (a) in Annex I is advocating use of homeopathic products in preference to chemically synthesised allopathic veterinary medicinal products or antibiotics. However, in Sweden it is prohibited for veterinarians to use homeopathic methods since these are considered contrary to scientific knowledge and well-tried experience. Another problem is that most homeopathic products can't be sold as veterinary medical products, thus there can be difficulties in controlling the quality of these products. This leaves us of course with a strong urge to create optimal animal living conditions to avoid diseases.

However the regulation appears to create different problems in the different Nordic countries, much depending on animal husbandry traditions. For example: In Sweden a major issue is the requirement to give tethered cattle regular exercise. There are no such traditions in Sweden, in addition there are relatively big herds in tethered systems. In Denmark and Finland this requirement is already part of the national standards. In Denmark most big herds are kept in loose housing systems, and in Finland the average size of the herds is smaller. This might be one explanation why the paragraph is experienced as less difficult in these countries.

Another example is the rule that at least half of the total floor area must be solid. It is not much talked about in Sweden, while causing annoyance in Denmark where a number of buildings for organic livestock have been raised lately with slatted floors. In Iceland it is considered a disaster for the organic production, since there are really no alternatives available to slatted floors in Icelandic sheep production. The cold and rainy climate does not allow much straw production. The same is true for parts of Norway.

The Nordic climate combined with the paragraph stating that 100% of the feed must be organic raise a challenge for parts of the Nordic countries. In some parts it is difficult to grow even grain to maturity, and in even more parts there are problems to grow high quality protein feed. At present there is not much organic feed on the market to buy, especially not in Finland, Iceland and Norway, and if there is, prices are high. In a longer perspective the market situation can be changed, but the paragraph still puts the organic farmers under increased riskiness compared to their conventional colleagues.

As for research, the EU regulation clearly points at some urgent research issues:

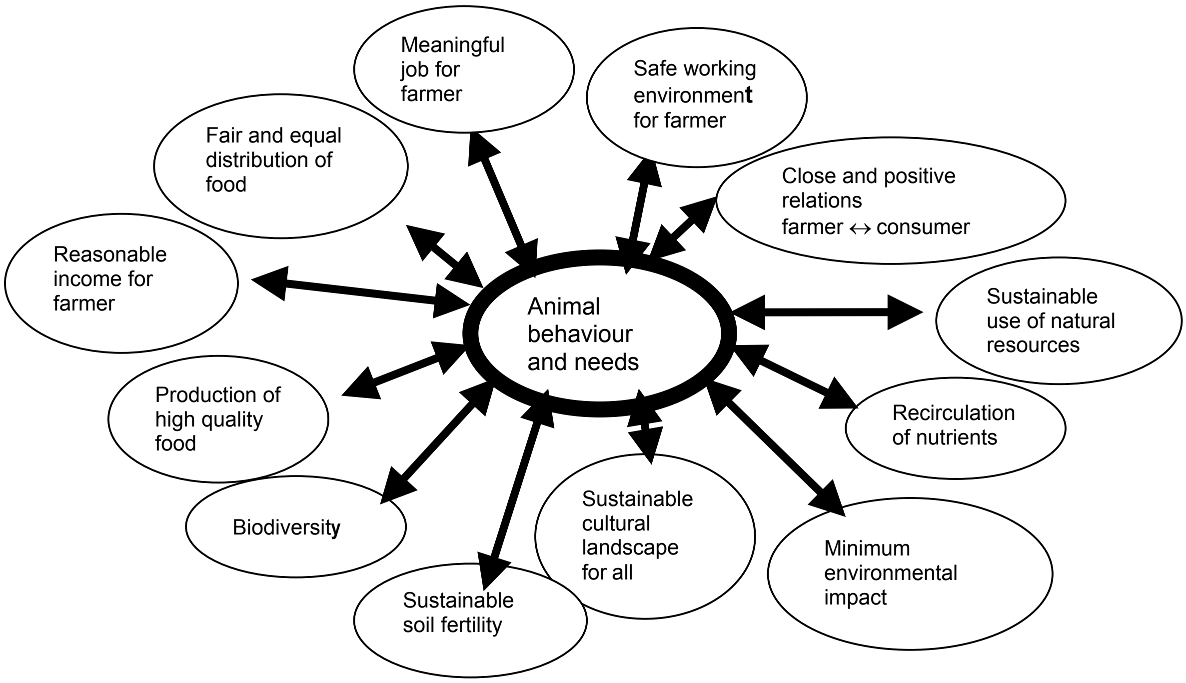
Preventive health is already mentioned. A fast developing of systems for organic poultry and pig production is necessary since these differ so much from what is practiced in conventional animal husbandry. A very basic question to be answered is: What do farm animals actually need for better welfare? (Will it for example significantly increase poultry welfare to have exit/entry pop-holes of a combined length of at least 4 meters per 100 m^2 area of the house, as prescribed in the new regulation?)

Coming back to the opening question of what ecological animal husbandry is: It is not sufficient just to look at the EU regulation to get an understanding of the phenomena. It is actually much more than just a set of rules.

Ecological animal husbandry is based on a vision of a sustainable society and a more sensible way of doing agriculture: The animals should be part of an agricultural system that is environmentally sound, and it should be animal and human friendly as well. It calls for a holistic approach, which is considering the whole system rather than only optimizing its parts (Fig. 1). It is a big challenge to develop an agricultural system along these lines, not least since there is an abundance of conflicting interests and goals involved in this vision. But working on the task, we should not let our thinking be limited by today's frameworks. The aim is to have high animal welfare in a sustainable system. We must continuously ask the question if the suggested measures actually imply this, and if it is to lowest possible cost.

It should be the biological and ethological needs of the animals, together with the ecological, economical and social sustainability of the system, that make up the restraints rather than present regulations or standards for organic/ecological farming.

Figure 1 Goals for organic farming according to the Nordic platform (Nordic IFOAM group 1989).



The status of research and development in organic farming in Iceland

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Background

Organic agriculture is in its early stages of development in Iceland. The progress made during this decade is based on the initiative of a few pioneers ever since Sesselja Sigmundsdóttir paved the way at Sólheimar Farm after 1930. In recent years several steps have been taken to establish a necessary, formal and institutional framework for organic agricultural production, such as special legislation and the establishment of inspection and certification services in 1994 and the foundation of a science council in 1997 with the aim of increasing and improving technical development in organic farming through research, teaching and advisory services.

The number of farms and companies involved in the production, processing and distribution of organic has grown from 6 in 1993, when VOR, the National Association of Organic Farmers was founded, to 33 farmers and 9 processers, certified and in-conversion, in 1999. Although this is only a small proportion of the total number of 4000 farms in Iceland a steady progress is being witnessed in several enterprises. Organic produce is approximately 0,6% of the total agricultural production with premium prices normally ranging from 15 - 30%. In the early stages vegetable growing predominated while livestock production, mainly of sheep and cattle, is gradually gaining a share in the market. As far as livestock production is concerned the greatest potential is in lamb followed by milk.

Prospects

It is clear that the main research priorities are in the production of certified organic fodder for winter-feeding. This rests on the facts that legume growing is difficult in the cold Icelandic climate and that there is a lack of plant nutrients of organic origin on most farms to replace artificial fertilizers for hay-fields and other cultivated land in order to maintain acceptable and sustainable yields. Thus the progress of organic livestock production in Iceland will depend heavily on research and dissemination of the results obtained.

An important step was taken in November 1997 with the foundation of the Council for Science and Technology in Organic Agriculture which links together organic farmers, advisors, researchers, teachers and officials from the Ministry of Agriculture. Six meetings have already been held where fruitful discussions have taken place on priorities in research, teaching and advisory work aimed at strengthening the scientific foundations of organic farming in Iceland. The meetings have been rotated between the institutes mainly involved in this development, i.e. the Agricultural Research Institute, Hvanneyri Agricultural University College, Reykir Horticultural College and the Farmers Association of

Iceland, the last one being responsible for transfer of information to farmers which in these early stages of development mainly concerns conversion to organic farming.

Research priorities

Already in 1995 a committee appointed by the Minister of Agriculture identified the main areas of research and development needed and highlighted scientific and technical prospects of organic farming under Icelandic conditions (Dýrmundsson et al., 1995). Both advantages and restrictions were addressed in an objective way in co-operation with organic farmers. The Council for Science and Technology in Organic Agriculture subsequently studied in more detail the research needs and proposed the following research priorities last winter:

- Supply and utilization of organic fertilizers for crop production, including glasshouse growing.
- Breeding and growing of legumes suitable for Icelandic climatic conditions.
- Control of pests and diseases in both crops and livestock.
- Development and adaptation of suitable machinery and buildings for organic farms.
- Economic aspects of organic farming, including marketing.

It is hoped that the establishment of research priorities will serve as guidelines for the preparation and funding of both short- and long-term experimental projects. They open new challenges to scientist in several disciplines and the Council for Science and Technology in Organic Agriculture is, for example, urging the Hvanneyri Agricultural University College to convert its sheep unit to organic farming. This would strengthen efforts to promote organic principles amongst sheep farmers and generate new research (Dýrmundsson, 1996a).

Conclusions

So far no research projects have been initiated directly addressing organic animal husbandry. However, several past and present studies provide valuable information, which is relevant to and may be applied in organic farming under Icelandic conditions (Dýrmundsson, 1996b). Thus a great deal of knowledge is already available together with considerable useful experience such as on the use of farmyard manure and the growing of legumes. Results from, for example, research on rangeland utilization (Guðmundsson et al., 1989; Guðmundsson et al., 1994), grazing of cultivated pastures and parasitism (Dýrmundsson et al., 1996) and fish meal feeding (Dýrmundsson, 1996c), provide much useful background information on which further work can be based. Much will depend on the market demand for organic produce and the priority given by funding bodies willing to give financial support to both short- and long-term projects aimed at strengthening the scientific foundations of organic growing and organic animal production. A special research effort is clearly needed.

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Research within ecological animal husbandry in Norway

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The history of research within ecological animal husbandry in Norway is only about ten years old, and involves mainly Norwegian Red Cattle (NRF) and milk production. No research projects with other farm animals and productions have been conducted so far. Ongoing projects indicated that this would also be the general trend in the years to come. The focus on dairy cattle reflects the dominant role that milk production has on the majority of ecological farms.

The main institutions involved in ecological animal research are; Norwegian Centre for Ecological Agriculture (NORSØK), Agricultural University of Norway (NLH), and Norwegian School of Veterinary Science (NVC).

NORSØK has conducted two whole farm studies, the first from 1989 -92 with 30 farms (Ebbesvik, 1993) and the second in 1993 -97 with 13 farms (Strøm, 1997; Strøm & Olesen 1998). An objective in both studies was to register feeds, feeding, milk yield and quality, and different health parameters on these farms, that was either converted or under convertion to ecological milk production.

In the period 1992-96 Dept.of Animal Science at NLH got a research project entitled: «Milk production in an ecological farming system», with the aim to develop systems for milk production within ecological farming, and to study the effects of different feeding regimes on feed intake and utilization, and different production and health parameters. During the project period it was built up a separate ecological unit with a defined crop and pasture areas and a dairy herd (Thuen & Kollberg, 1994; Thuen, 1996, Thuen, 1998; Thuen & Steinshamn, 1999). The ecological unit is now an important part of a new comprehensive five year (1998-2002) research project at NLH entitled: «Resource utilization in organic and conventional systems with crop and dairy production» (Thuen et.al., 1998, Thuen et al., 1999; Steinshamn & Thuen, 1999). This ongoing project is a co-operation between Dept. of Horticulture and Crop Science and Dept. of Animal Science at NLH, with the aim to improve resource utilization in organic and conventional systems with crop and dairy production by studying the flow of energy and matter along the production chain.

NVC has been and is involved in some of the mentioned research projects, but are also conducting some interesting projects themselves. The project: «Health and fertility in cattle related to environmental factors- with special emphasis on ecological farming» is running from 1995 to 2001 and includes issues like (i) feeding and reproduction (ii) the effects of light and management factors on the reproduction of dairy cattle, and (iii) epidemiological studies to compare reproduction in ecological and conventional milk production (NORSØK, 1999). The project: «Production diseases in Norwegian organic herds compared to conventional dairy herds» that was running from1994-97, was investigating total frequency of diseases as well as the three main diseases in Norway: mastitis, ketosis and milk fever

(Hardeng,1998). A newly started project (1998-2002): «Alternative veterinary medicine» includes as one part a scientific testing of homeopathic treatment against infection diseases on production animals. NORSØK is involved in this new project (NORSØK, 1999).

The main conclusion from the research projects so far is that within an ecological framework with low levels of concentrates, one can achieve acceptable milk yields (5000-6000 kg), good milk quality, and a generally high standard of health with low frequencies of ketosis and milk fever and few reproduction disturbances. The preconditions for this is to have a good strategy for feeding both in the lactation and dry period and to maximise roughage intake through enough roughage of good quality in a many-sided roughage ration.

Future challenges in ecological animal husbandry in Norway is, to initiate research within ecological production systems for pigs and poultry, to look closer into the field of animal welfare and behaviour, and into the concept of product quality. An important aspect in any research project with ecological animal husbandry is to increase the knowledge of resource utilization, to be able to make improvements in the different systems.

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Swedish research in ecological animal husbandry: Extent, issues, priorities

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Extent of research

In Sweden, research in ecological agriculture is conducted primarily at the Swedish University of Agricultural Sciences (SUAS), but also at other national institutes, universities and in the regional extension service. Today in total about 40 projects are dealing with ecological animal husbandry. SUAS has about 160 projects on ecological agriculture, not only in Uppsala, but also at research centres at Alnarp, Röbäcksdalen and Skara. About 20% deal with animal husbandry / animal health and welfare. As a comparison about 66% concerns plant production / plant protection / soil science.

Table 1 shows the funding from the main bodies.

Table 1 Funding of research in organic farming in Sweden. (In addition there have been minor fundings from other funding bodies.)

Organization	Period	million SEK	million US$
Swedish Council for Forestry and Agricultural Research	1986-96	~ 100	~ 11,9
	1996-98	46	5,5
Swedish Board of Agriculture	1988-95	26	3
	1997-99	39	4,6

Between 1986 and 1996 the Swedish Council for Forestry and Agricultural Research (Skogs- och jordbrukets forskningsråd, SJFR) invested somewhere in the range of SEK 10 millions annually in projects related to ecological production. Between 1988 and 1995 the Swedish Board of Agriculture (Jordbruksverket, SJV) contributed a total of approximately SEK 26 millions to research and development projects in the field of organic agriculture. Smaller amounts of funding have also come from the Swedish farmer's co-operative. In December 1996 the Parliament decided to set aside SEK 46.5 millions for research in ecological agriculture and horticulture during 1996 to 1998. In addition, the state has contributed with approximately SEK 39 millions for applied research and development projects from 1997-1999 through SJV.

In 1994 the Swedish parliament set the goal that 10% of Swedish arable land should be grown organically. This goal is almost reached today, with 9% converted in 1998. However, the animal husbandry has not been converted at the same pace. Now the parliament has decided about a new goal, stating that a minimum of 20% of Swedish arable land should be converted before the year of 2005. It can be expected that this decision will be followed by further support for research in organic farming (including animal production) during the years to come.

Issues and priorities

No overall planning of priorities or research issues has been made but a diversity of projects have been funded. Some priorities have however been stated in different contexts.

In 1996 the Swedish Council for Forestry and Agricultural Research (SJFR) was commissioned by the government to organize a comprehensive program for ecological agriculture including research projects and co-operative international research support services. Prioritized research topics dealing with animal husbandry in this program were animal health and welfare, genetic resources including animal breeding, integration of animal husbandry and plant production/horticulture and ethical issues.

In 1997 a Centre for Sustainable Agriculture (CUL) was founded at SUAS as a forum for inspiration, co-operation and co-ordination of research and education within ecological agriculture. The center is now in the process of adopting a platform for future research and formulating research priorities. Preliminary animal husbandry is mentioned as one out of nine scientific areas of priority. Another of these areas is "sustainable, multifunctional agricultural systems", including the close integration of animal husbandry and plant production. Egg and poultry production, pig production, systems research involving several species of farm animals integrated with the plant production, animal health issues and ethics are areas preliminary mentioned as particularly important for future research.

It is difficult to classify current research projects according to issues since some projects span over several issues. Also, it has unfortunately been difficult to estimate the extent (size) of the different projects. However, a rough classification of projects is made in table 2.

Table 2 Swedish research projects dealing with ecological animal husbandry, roughly divided on issues.

Issue	No. of projects
Dairy	10
Beef	2
Pig	7
Egg and poultry	9
Sheep	1
Bee keeping	1
Health and diseases	4
Production systems and animal welfare	5
Ethics	1
Systems studies (research farms)	3

Danish research in organic animal husbandry – extent, issues and priorities

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Background

Until now there has been a close link between research and development activities and the present development in the different sectors of organic animal production in Denmark. The organic movement has played a central role in stimulating research activities. The Danish Association of Organic Farming was established in 1981 and in the following years the societal and political interest for organic farming increased rapidly. This resulted in 1987 in the establishment of "The Council on Organic Agriculture" appointed by the Ministry of Food, Agriculture and Fisheries as part of the first Danish law on organic agriculture. The Council, with its majority of members from the organic movement, had the role to stimulate and evaluate the development possibilities for organic farming and to advise the Minister on proposals and initiatives that could stimulate the development. This included advice on extension and research activities and there is no doubt that the Council, and thus the organic movement, has had a major influence in this respect.

In 1987, a combined research and demonstration project with organic milk production, which was the first organic enterprise of economic importance, was initiated. This project was based on recordings on and co-operation with private organic farms, and the purpose was primarily to study organic farming practise, to document overall farm results to be obtained and to identify the most critical obstacles to an efficient organic milk production in a broad sense. The project is described in more detail in Anon. 1999, which includes a list of references. Some major results are in given in Mogensen et al. (1999). After the potential had been established and documented, more specific research projects were carried out concerning animal health (c.f. Vaarst & Enevoldsen, 1997; Vaarst et al., 1998), feed supply (c.f. Kristensen & Kristensen, 1998), environmental effects (c.f. Halberg et al., 1995) and milk quality. At a later stage (1994), a similar approach was used for organic egg production (Kristensen, 1999). Although organic egg production is clearly a realistic alternative, it is much more difficult to handle than organic milk production, especially in relation to animal health and welfare, and the need for improvement in this respect was identified at an early stage.

So, until 1996 the main focus of research in organic milk and egg production was put on observational studies on private farms with a major emphasis on issues, which could immediately be recognized on farms. This period was also characterized as a period with few researchers involved. In 1996, however, as a consequence of the establishment of the first action plan for promoting organic food production in Denmark, a new, extended and wider research effort on organic animal husbandry was initiated, allowing also strategic research and classical comparative hypotheses testing experiments to be performed. This included the establishment of the Danish Research Centre for Organic Farming (DARCOF) heading two major research programmes, which also included organic animal husbandry.

The research in animal husbandry was supported by the establishment of Rugballegaard, an organic experimental station suitable for experiments with cattle and pigs (c.f. Hermansen, 1996; Hermansen & Kristensen, 1998), and smaller facilities for organic poultry experiments at Research Centre Foulum. Today's status of focus on research activities can be summarized as follows:

Present priorities

Cattle – milk production ***(2-3 mill. per year)***

- Feeding strategy for obtaining a high degree of home-grown organic feed including effect on animal health, reproduction and milk quality.
- Cattle in the farming system as dynamos for other organic productions through soil fertility maintained.

Pigs – pork production ***(5-6 mill. per year)***

- Diagnostic surveys of obstacles with a focus on health aspects
- Housing of slaughter pigs
- Roughage including grass as feed for sows and slaughter pigs

Poultry – egg production **(*1-2 mill. per year)***

- Rearing in relation to later behaviour and production
- Genotype effects in relation to behaviour and health
- Surveys in production systems

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Emergy analysis of two pig production systems

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Abstract

In order to estimate the direct and indirect natural resource needs and environmental impact on a farm system level, emergy analysis was used to evaluate a conventional Swedish pig production system (PH) and a production system with pigs integrated in the crop rotation (PC). The unit of measurement is the solar emjoule (sej). The solar emergy for raising one pig to 110 kg liveweight was 4.1 x 10^{14} sej in the PC and 5.8 x10^{14} sej in the PH and the transformity was 3.6 x 10^{5} sej/J and 5.1 x 10^{5} sej/J respectively. The results indicate that the PC is a more sustainable and economical strategy to produce pork than the PH from a natural resource perspective. However, the future of pig production depends on whether agricultural systems are optimized with an externalization strategy driven by purchased non-renewable resources or an internalization strategy based on local renewable resources.

Introduction

Animal husbandry in the Western world has in the past decades been focused on the optimization of feed utilization in primary production. This efficiency is defined as feed amount per amount meat retained (or other animal products for human consumption). This might be useful as long as the system in which the animals are produced is ecologically, ethically and economically acceptable. However, this concept of efficiency may not optimize the whole system, because environmental loading and resource needs further back in the feed chain are externalized and excluded from the analysis. Furthermore, the welfare of the animals can be forgotten and extreme production systems developed, where the behavioural needs of the animals are neglected and high levels of antibiotics are needed to keep the system functioning. Therefore methods for evaluation of the production in a broader context are needed, which include resource demands and environmental consequences of feed production and preparation, veterinary treatments and animal health, resource use for construction and operation of the buildings etc.

The objective of the study was to identify and quantify the internal and external resources needed in two different ways to produce pork; a conventional Swedish production system and a production system in which the pigs are integrated in crop production. In the latter system, the pigs forage on different parts of the crop rotation and their rooting activity and production of manure are used in the crop management programme of the farm. To be able to compare resources and services with different qualities, emergy analysis was used.

Materials and methods

The emergy approach recognizes the ability of different forms of energy to perform different types of work. In the analysis all energy and material flows are evaluated on a common basis by the solar energy used up directly and indirectly to make a service or a product (Odum 1996). The unit of measurement is the solar emjoule (sej). The solar transformity is defined as the solar emergy required to make one joule of a product or a service and is expressed as solar emjoules per joule (sej/J). To evaluate the service involved in making a product or an input, we used an emergy to money ratio to trace the environmental work needed. It was calculated from the total emergy flow to the national economy, divided by the GNP (Lagerberg et al., Manuscript). Emergy investment ratio measures the intensity of the economic development and in this case, with no identified use of local non-renewable resources, also the loading of the local environment (Odum, 1996). The macroeconomic value of the yield is emergy yield divided by the emergy/money ratio for the economy. It can be used to estimate the emergy exchange ratio, which is the macroeconomic value divided by the market price, and expresses the relationship between the economic system and the resources withdrawn from a system. The emergy analysis is further described in Odum (1983) and Odum (1996).

Two pig production systems

The Pig in Housing System (PH) is a typical Swedish production system for specialized pig production (Table 1). Pigs are kept in a housing system based on recently published information on building a confined pig production unit (Olsson et al., 1993). The production is assumed to follow a mean level for Swedish pig production according to Grant (1996). Mineral fertilizers are applied and pesticides are used when needed in the cropping system. All cereals produced leave the farm and ready mixed feed is purchased, but straw is used as litter material in pig production.

Table 1 Key factors for one pig produced in the Pig in Housing System (PH) and the Pig in Cropping System (PC).

	Pigs in Housing system (PH)	Pigs in Cropping system (PC)
Area demand/pig produced (ha)	0.054	0.137
Feed consumption of mixed feed (PH) or cereals/peas (PC)		
* 0-25 kg liveweight (kg air dry)	100	137
* 25-110 kg liveweight (kg air dry)	240	264
Silage (kg DM)	0	54
Working time/porker produced (hours)	1.5	3.0
Building and machinery costs (SEK)	573	251
Soil tillage effect (tractor hours)[1]	0	0.22
Oil (litres diesel)[2]	0.6	9.0
Electricity (kWh)	70.5	6.0
Area lost for harvest (direct foraged) (ha)	0	0.021

[1] Soil tillage effect is calculated as the substitution of tractor hours, if the same work is done mechanically with tractor and aggregate instead of using the work of the pigs.
[2] Diesel consumption for pig husbandry (diesel consumption in the cropping system not included)

The Pig in Cropping System (PC) is based on the farming system at Ekhaga Research Farm (SLU). Pigs are kept outside in the crop rotation with small huts as shelter, and their foraging behavior is used in the management of the crop production system, where ploughing is excluded on the areas treated by the pigs (Andresen, 1999). The sows farrow once a year and are kept in a simple uninsulated housing system in the winter period. In this period the sows are fed mainly on silage. A lactation period of 10 weeks is applied in the suckling period to compensate the piglets for a simple feed ration. The growing pigs are assumed to consume 10% more than in indoor production due to higher activity and a simple feed ration based on 80% cereals and 20% peas. All supplementary feed is produced in the crop production system on the farm, where no mineral fertilizers, herbicides or fungicides are used. The two systems have large differences in area demand, feed consumption, working load, consumption of external resources etc. (Table 1).

Results

The two systems are shown in Figure 1 and Figure 2.

The diagrams have been aggregated to show the main flows of emergy in the pig production systems on a farm scale level based on Björklund et al. (Manuscript). In the PC system there is a direct feedback of manure and work on the crop rotation and the pigs are fed on the crops produced in the system. The limiting factor for pig production on the farm is the capacity of the crop rotation to produce feed for the pigs. The PH system has a flow of manure to the cropping system after storing it on the farm. The production of manure is the limiting factor for the production level on the farm, regulated by legislation on area demands for manure application. The feeds for the pigs are purchased, but straw from the cereal production is used for the pigs as litter material.

The solar emergy for raising one pig to 110 kg live weight was 4.1×10^{14} sej in the PC system and 5.8×10^{14} sej in the PH system with a transformity of 3.6×10^{5}sej/J and 5.1×10^{5}sej/J respectively (Figures 1 and 2). The free environmental input to the PH was 3.0×10^{13}sej or 5% of the total emergy in the porker produced. Emergy in purchased feed and services was 50.0×10^{14} sej or 86% of the emergy consumption in the PH system and the emergy investment ratio (F/R) was 18.3. The free environmental emergy was 7.7×10^{13}sej for the PC or 18.9% of the total emergy used**,** which is larger than the PH due to a larger area demand per pig produced. Emergy in on-farm produced feed was 58% of the total emergy consumed. The emergy in depreciation and maintenance of machines and the services and labour connected with this activity was 9.5×10^{13}sej or 60% of the purchased inputs for feed production. The emergy investment ratio was 4.3.

The macroeconomic value for the PH was 3246 emSEK per porker, which should be compared to the market price of around 900 SEK, making an emergy exchange ratio of 3.6. The macroeconomic value for the PC was 2274 emSEK per porker, which should be compared to the market price of around 1700 SEK for an ecologically produced porker, making an emergy exchange ratio of 1.4.

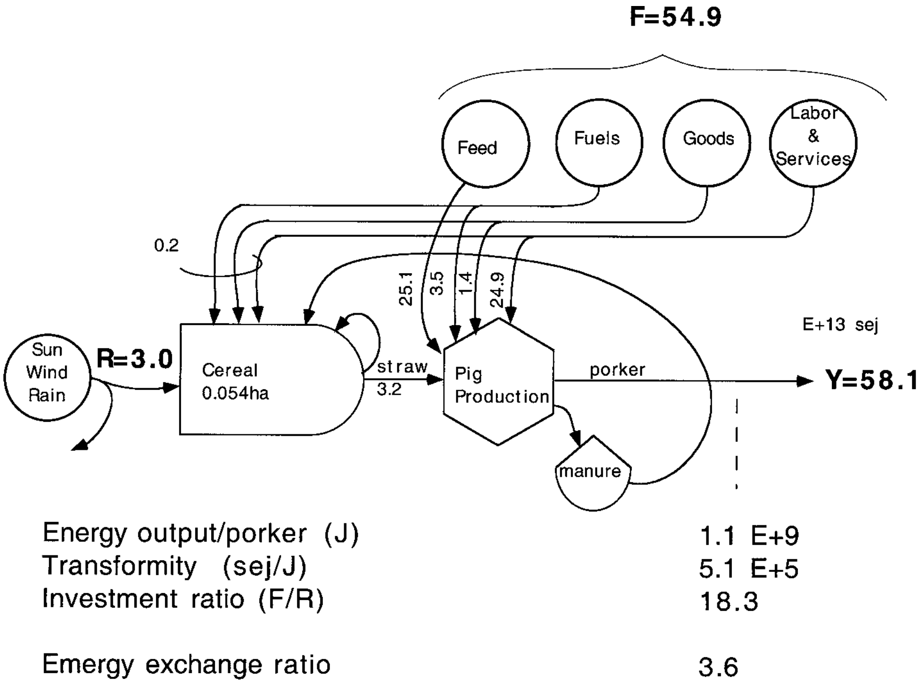

Figure 1 Emergy diagram for the Pig in Housing System (PH) with emergy flows,(sej x 10^{13}), transformity and investment ratio per pig produced. Environmental inputs are labelled (R), purchased inputs are labelled (F) and the yield is labelled (Y).

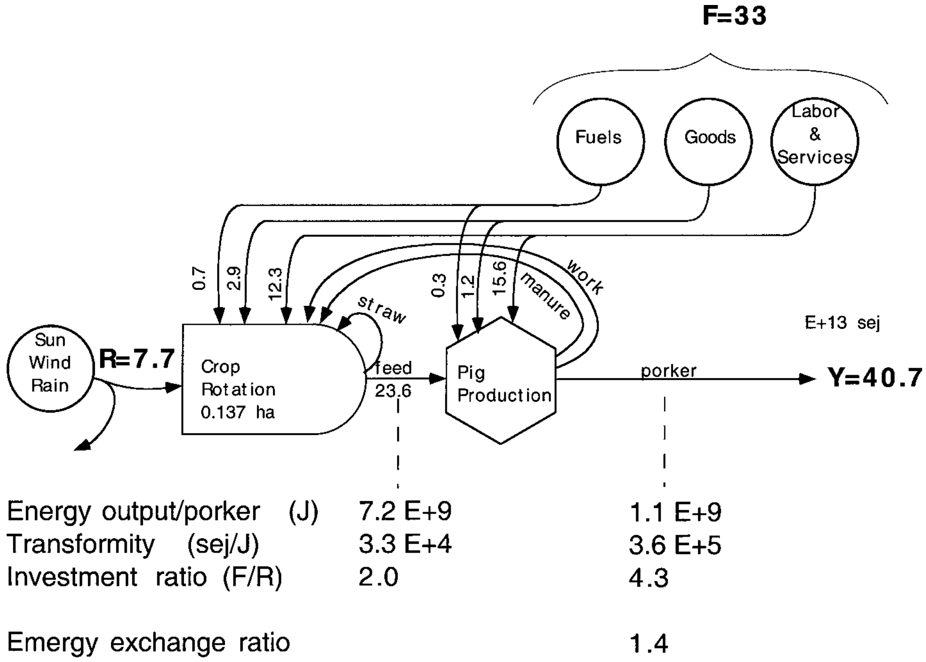

Figure 2 Emergy diagram for the Pig in Cropping System (PC) with emergy flows, (sej x 10^{13}), transformity and investment ratio per pig produced. Environmental inputs are labelled (R), purchased inputs are labelled (F) and the yield is labelled (Y).

Discussion

This analysis shows that integrating pigs in an ecological cropping system (PC) lowers the consumption of purchased resources even though the feed efficiency is lower than in a common housing system (PH). The PC is based on a bigger proportion of local renewable resources (R), whereas the PH relies to a bigger extend upon inputs from the economy outside the farm (F). The emergy ratio (F/R) for the PH was 18.3 compared with 4.3 for the PC, which indicates that the PC is a more sustainable and economical strategy to produce pork than the PH system. The high ratio for the PH implies that the system puts high pressure on the surrounding ecosystems, because the high emergy import from the rest of the economy has to be assimilated in the farming system. This is for instance practically recognized in a high nutritional surplus on a farm scale level in industrialized pig production.

Feed efficiency is a central concept for optimization of animal production in confined housing systems. This is reasonable according to this study because the emergy in feed is the dominating resource component for the PH system. One of the reasons for the high emergy in purchased feed is that the cereals on the farm are exported out of the system and bought in again highly processed. The other inputs for the system are more or less fixed, for example interests and capital costs for the buildings have to be paid to parties outside the farm (Table 1), which puts pressure on the system to produce as much pork per square metre as possible to create profits for the financial markets.

Feed production is a resource-consuming activity in the PC system, where the purchased inputs are dominated by depreciation and maintenance of machines. A high feed utilization is therefore implicated in lowering the resource use for feed production. However, lowering the use of machinery by increasing the tillage work of the pigs would lower purchased inputs and decrease the investment rate, which is economically interesting from a natural resource perspective. Another way would be to change the crop rotation or the habitat, making it possible for the pigs to forage to a greater extend directly in the cropping system and thus lowering the need for supplementary feeding.

Why are ecological pig production systems not popular among farmers today? To understand that one has to look at the system level above the pig producing systems, such as slaughterhouses, distribution systems and supermarkets, which have an industrial structure (linear production). This influences the farmers to produce pigs in systems which are easy to scale up and with a low working time per pig produced, which are dominating factors for industrial production. Furthermore the conventional pig production system offers continued flows of low price pork, which is appreciated by the consumers. However, this study show that environmental loading is high for the PH system, which indicates that society may have to invest in the ecosystems surrounding these units for pig production to keep a good balance between agricultural and natural ecosystems.

The future will decide whether pig production should be optimized with an externalization strategy, driven by purchased inputs based mainly on non-renewable resources or an internalization strategy, where pig production is optimized in relation to local renewable resources. In the latter perspective, the direct feed-intake in the field (foraging) and the tillage effect of pigs are interesting possibilities to lower the consumption of non-renewable resources in pig production.

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Barley as catchcrop of soil nitrogen after grazing sows

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Abstract

When sows are kept on grassland they graze and root. At the same time, the area is fertilized by the excretion from the grazing and the extra feed that is fed to the animals. The magnitude of the loss of soil N from such an area is of interest to keep low. If the area is left for regrowth of the ley when the sows have left, it will be most probably be difficult to harvest the crop for silage. Even a firm rooting activity by unrung sows makes the soil surface so uneven that the risk for soil contamination, and thereby the quality of the silage, will be too big. There is also a risk that the presence of faeces on the ground increases the risk for a bad silage quality (Rammer et al., 1994).

Hypothesis

A crop of spring barley can significantly increase the value of the harvest and decrease the risk for soil N loss from a ley where sows have grazed, compared with the situation when the area is left for harvest of the ley.

Grazing period

At the beginning of April 1998 six Large White sows, without nose ring, farrowed in individual pens on totally 0.2 ha of a clover-grass ley. They had a hut and were fed in a trough. The trough was moved at some occasions in order to spread the manure evenly. The sows were fed a diet based on barley, wheat, oats, peas, rapeseed meal and minerals. At this early time of the season the ley did not contribute much to the feeding of the sows, but about 15% of the area for each sow was grown with Jerusalem Artichoke, which they were allowed to harvest.

Three weeks after the last sow had furrowed, the electric fences between the pens were removed, and a fresh ley area of the same size was offered in addition to the first. The huts remained on the first area, but the troughs and water supply were moved to the new area. At the end of May, the sows and their 46 piglets were moved from the area and the piglets were separated from the sows. The animal density corresponded to 2.5 sows with piglets per ha and year. The amount of nitrogen imported to the field by feeds for the pigs corresponded to 172 kg ha^{-1}, and the amount exported by the growth of the piglets corresponded to 62 kg ha^{-1}, which means that the net supply by urine and manure corresponded to 110 kg N ha^{-1}.

Experimental design and evaluation

The two areas, where the sows and litters had been, plus an adjacent area with the ley intact (0.1 ha) were all in a row. These areas were divided into six stripes across them, and every second stripe was sown with barley on the 6^{th} of June. On the other three stripes, the ley was left to grow or regrow respectively. This design gave 18 plots, 9 with barley and 9 with ley. Three plots with barley and three with ley had not been offered to pigs (zero plots), whereas 6 of each had. The soil had a very high organic content (about 40%) on 0-20 cm, and under that the clay content was high. On the 20^{th} of June, two weeks after sowing, soil samples were taken at 0-30 and 30-60 cm depth. Three spots per plot and level were sampled by three subsamples, and the nine subsamples were merged into one per plot and level. Due to weed problems, all ley plots were cut once during the early summer, and the cut weed crop was left on its plot. Immediately after the harvest of the barley, on the 10^{th} of October, new soil samples were taken in the same way as before, on the same spots. The same day, three crop samples from 0.25 m^2 each were taken from each plot with ley, weighed as one sample per plot and analyzed for nitrogen, dry matter content and botanical composition. The harvest of barley grain for each plot was determined from 40-100 m^2 per plot, and samples were analyzed for nitrogen and dry matter content. The soil samples were analyzed for content of NO_3-N, NH_4-N at both levels.

The difference in soil content of N and in harvest between plots was evaluated by analysis of variance (SAS, 1995).

The model used for soil was
*soil N = level sows crop level*sows level*crop*

where:
soil N = NO_3-N, NH_4-N
level = 0-30 cm, 30-60 cm
sows = yes, no
crop = ley, barley grain

Interactions not shown in the model were tested but did never significantly explain the variation in soil N.

The model used for harvest was
*harvest = sows crop sows*crop*
where:
harvest = crop and N from ley and barley grain
sows = yes, no
crop = ley, barley grain

Interactions not shown in the model were tested but did never significantly explain the variation in harvest.

Results

Soil nitrogen

The amounts of mineralized nitrogen in the plots are shown in Table 1.

Table 1 Amount of mineralized nitrogen in the soil at two levels after ley (n=3 per level) and after sows (n=6 per level). Mean ± standard error.

	Without sows		With sows	
	0-30 cm Kg ha^{-1}	30-60 cm Kg ha^{-1}	0-30 cm Kg ha^{-1}	30-60 cm Kg ha^{-1}
June				
NO_3-N	54.3±2.5	31.9±2.1	88.5±5.8	24.2±1.8
NH_4-N	9.2±0.6	36.1±6.2	9.9±1.2	61.7±4.2
October				
NO_3-N	27.3±4.0	24.0±3.4	40.2±4.6	12.7±1.4
NH_4-N	6.9±0.5	42.3±7.7	8.6±0.6	84.9±6.1

In June, the plots after sows had significantly more NO_3-N on the 0-30 cm level (34.2±6.4 (s.e.) kg ha^{-1}) and significantly more NH_4-N on the 30-60 level (25.6±5.3(s.e.) kg ha^{-1}) compared with zero plots ($P<0.001$). At this time, there was no significant difference between the N-profiles of the soil samples taken from plots sown with barley and plots left with ley.

In October, the plots with barley had significantly more NH_4-N than plots with ley on the 30-60 cm level (18.0±6.6 kg ha^{-1}, $P<0.01$) after correction for sows. The general effect of sows on NH_4-N at this level had increased from June (42.5±6.7 (s.e.) kg; ha^{-1} $P<0.001$), whereas the level of significance for higher NO_3-N in the 0-30 cm profile in plots after sows was lower than in June (12.9±5.5 kg ha^{-1}, $p<0.05$). In addition, the zero plots had a significantly higher content of NO_3-N on the 30-60 cm level (11.3±5.5 kg ha^{-1}, $p<0.05$) than the sow plots. Samples from the two stripes in the middle of the areas available for sows showed significantly higher concentrations of NO_3-N on the 0-30 level than the other four stripes in June ($P<0.01$). In October this had changed to a significant difference between the same sets of stripes for NH_4-N on the 30-60 cm level ($P<0.01$).

Harvest

The amounts harvested were

Ley on zero plots: The harvest was 3048±244 (s.e.) kg dry matter (DM) ha^{-1} and 91 kg N ha^{-1}.

Barley grain on zero plots: The harvest was 2002±174 (s.e.) kg ha^{-1} with 15% water content, and 37 kg N ha^{-1}.

Ley after sows: The harvest was 1652±330 (s.e.) kg DM ha^{-1} and 51 kg N ha^{-1}.

Barley grain after sows: The harvest was 2251±137 (s.e.) kg ha^{-1} with 15% water content, and 42 kg N ha^{-1}.

"Ley on zero plots" differed significantly from the other three groups ($P<0.001$) in the analysis of variance, concerning harvest of N.

Discussion

The risk for loss of soil N after grazing sows has been assessed by comparing the soil content of mineralized N on two occasions. Higher levels of mineralized N were found after sows than on zero plots both times. The higher amounts after sows were most probably caused by the urine of the pigs and by their rooting. The effect of rooting on N mineralization was indirectly studied by Edwards et al. (1998), who showed that unrung sows destroyed the vegetation cover significantly more than rung sows, and this caused significantly more inorganic N in the soil level 0-45 cm than with rung sows. Wejfeldt & Gustafson (1997) showed that a light surface soil cultivation, comparable with the rooting of sows, increased the content of NO_3-N in the soil fluids. The net import of N by feeds corresponds well with the calculations made by Worthington & Danks (1994) if correction is made for the number of sows per hectare. They had 14 sows per hectare and year. The number in this study corresponded to 2.5 sows per hectare and year, which is 0.3 above the density allowed in Sweden. The harvest of barley grain in terms of kg grain and kg N in the grain per hectare was the same, whether the barley was grown on zero plots, where the ley was used as green manure, or on plots where the sows and piglets fertilized the soil. At harvest the amount of NH_4-N found on the 30-60 cm level was higher after sows than on zero plots (43 kg ha^{-1}, $P<0.001$). So, if the task were to grow barley ecologically on this kind of soil, it seems best to use the ley as green manure with respect to nitrogen efficiency.

However, the main task for this study was to compare two strategies for land use after grazing sows. The harvest of N in ley or barley grain after sows was not significantly different, but the NH_4-N content on the 30-60 cm level was 17 kg/ha higher after barley than after ley ($P<0.01$). For pigs, the nutritive value of the nitrogen in grass and clover has a good potential as source of essential amino acids (Reverter et al., 1999), but the regrowth of the ley after sows would be difficult to harvest for silage due to the rooting activities and risk of contamination by manure and soil. The quantity and quality of the roughage would be better from another field. If the task were to have sows on a ley in the early spring, it would be a better economic and nutritive outcome of the field to grow spring barley after the sows than to let the ley grow for silage. The surplus of inorganic nitrogen in the soil profile after barley should be compared with the risk of loosing N after breaking the ley (Ulén, 1999). The dynamics of N flow and storage also has to be studied on the farm level.

Conclusions

- Spring barley after sows with piglets cannot reduce the risk for N leakage from the soil compared with the situation when the ley is left to regrow.

- Spring barley after sows with piglets produces the same amount of N in the harvested crop as if the ley is left to regrow, but the quantity and quality of the roughage would be better if taken from a field that has not been grazed by pigs.

Acknowledgement

The Swedish Board of Agriculture kindly financed the study.

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Mixed grazing with sows and heifers: effects on animal performance and pasture

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Abstract

Preliminary results of separate or mixed grazing with sows or heifers on the performance of the animals and quality of the pasture are presented. The daily live weight gain of the sows (500-550 g) or estimated grass DM intake (2.4-3.7 kg) were not different between grazing regime. Heifers gained more weight in the mixed grazing regime compared to separate grazing. The accumulation of waste-grass around heifer dung was avoided when grazing sows and heifers together.

Introduction

The project is based on the fact that it is difficult to utilise the desired amounts of clover grass in specialised organic pig production. A combination of cattle and pig production might solve this problem.

This paper will focus on:

- performance of heifers and pregnant sows grazing separately or mixed
- effect of the grazing system on the pasture

Data are only based on one grazing season, 1998, and are therefore to be considered as preliminary. Effect of grazing system on parasitological aspects is presented in a separate paper (Roepstorff et al., 1999).

Materials and methods

The experiments were carried out at the organic research station "Rugballegaard" during the grazing season 1998. The white clover grass was established in 1997. Three grazing systems were studied:

- heifers grazing alone - 5 heifers per ha
- pregnant sows grazing alone - 14 sows per ha
- mixed grazing with heifers and sows - 3.4 heifers + 4.7 sows per ha

Eight heifers and/or ten pregnant sows grazed each system. Continuous grazing was practised in paddocks regulated in area according to herbage allowance/sward height. Heifers and sows were weighed every 14 days.

The aim for sows was to achieve a weight gain of approximately 500 g per day. The sows were supplemented with approximately one FU (Feed Unit, equal to 7.72 MJ NE, see Just, 1982) less than their expected requirement to obtain this goal, i.e. the sows were expected to graze equivalent to 1 FU. Herbage dry matter (DM) intake in sows was estimated in five sows in each system during five days in both June and August by means of the alkane method (Sehested et al., 1999). Least square means of daily gain for sows in each group has been weighted by number of grazing days for the individual sow and calculated with starting weight of the sow as co-variable.

Sward height was measured by a plate raising-meter every 14 days. Samples of herbage were cut three times during the season at mean grazing height, which was measured by a ruler. The botanical composition was determined by hand separation.

Results

Table 1 shows daily weight gain and grass intake of pregnant sows grazing in the period 1 May till 30 September 1998. The weight gains are the average of 22 and 20 observations for system A and B, respectively, during the season. Estimates of grass intake are averages from five sows.The average daily weight gain of the groups was not different. Daily weight gain indicated a grass intake corresponding to the value of 1 FU. Grass dry matter intake was 2.4 - 3.7 kg estimated by means of the alkane method.

Table 1 Daily weight gain and grass intake in pregnant sows.

System		Daily weight gain g	Estimated daily grass intake DM, kg	
			June	August
A:	Sows grazing alone			
	- 14 sows per ha	515 ± 54	2.4 ± 0.6	3.7 ± 2.1
B:	Mixed grazing with heifers			
	- 3.4 heifers + 4.7 sows per ha	550 ± 54	2.5 ± 0.3	3.4 ± 0.6

Figure 1 shows the development in the average body weight (least square means) and S.E.M. of heifers grazing alone or grazing mixed with sows during the grazing season 1998. The groups were significantly different from around 1 July. The average daily weight gain during the whole season was 934±46 g in the mixed grazing group as compared with 808±46 g in the control group, with P=0.07. Parasitological aspects are reported by Roepstorff et al. (1999)

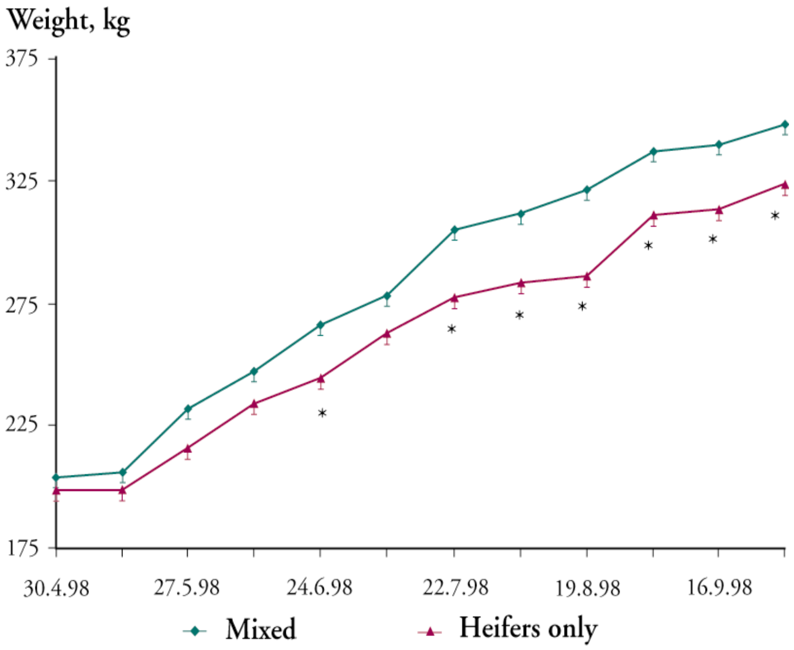

Figure 1 Weight gain in heifers during the grazing season. Asterisk "*" indicates a significant difference between the groups, with P<=0.05.

Figure 2 shows the sward structure of the paddocks. The heifer paddock had the typical look with the rejected area around the dung pats. In the paddock with mixed grazing there were no rejected areas around the heifer's dung pats and the sward were more evenly grazed. The sows ate the grass around the pats. In paddocks with sows grazing alone, the swards were much higher, because of more dirty and stem-rich sward.

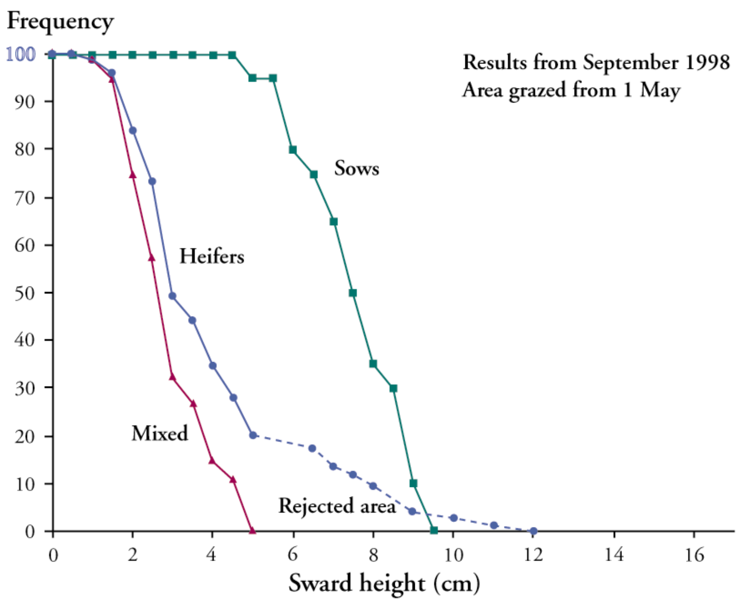

Figure 2 Sward structure based on 100 sward height measurements per paddock in paddocks grazed by heifers, sows or mixed heifers and sows.

Table 2 Herbage allowance and quality in the area with grazing during the whole grazing season. Means of three measurements.

Grazing animals		Allowance (g DM/m^2)	Clover (% of DM)	Clover flowers (% of clover DM)	[3]EFOS$_s$ (% of OM)	Crude protein (% of DM)	Ca (% of DM)
Sows		74	13	4	52	19	0.5
Mixed		83	23	5	54	21	0.6
Heifers	b.r.a.[1]	23	29	21	49	17	0.7
	r.a.[2]	161	26	18	49	18	0.7

1) Between rejected areas around dung pats
2) Rejected areas
3) Grazed digestible organic matter, see Boisen & Fernández (1992)

Table 2 shows the herbage allowance and quality on the areas grazed by sows a heifers.

The mean allowance (herbage above grazing height) during 1998 was nearly the same in sows pastures as in the pasture with mixed grazing. In the pasture with heifers the allowance between the rejected areas was very low, as the heifers grazed these areas very severely.

The content of white clover in the herbage above grazing height was lower with sows on the pasture. The sows seemed to select clover at grazing. They also seemed to like the flowers of white clover, as the content of flowers of white clover dry matter was lower with sows on the pasture. The herbage quality in pasture with mixed grazing seemed to be a little higher than in the other pastures. The clover content affected the Ca content.

Table 3 shows, that there was a large difference in herbage quality between different parts of the pastures. The herbage in the buffer area, which was grazed from the last part of June, was of better quality, had a higher EFOS$_S$, crude protein and clover content.

Table 3 Effect of grazing time on the herbage quality.

Grazing system	Grazing area	Clover content (% of DM)	[1]EFOS$_S$ (% of OM)	Crude protein (% of DM)	Ca (% of DM)
Mixed	Total 2)	24	54	22	0.6
	Buffer 3)	40	58	24	0.8
Heifers	Total	29	47	17	0.6
	Buffer	54	53	23	0.8

1) Enzyme digestible organic matter, see Boisen & Fernández (1992)
2) grazed from spring (mid May).
3) grazed from last part of June.

Conclusions

Based on this first year results the following preliminary conclusions can be drawn:

- Pregnant sows grazed up to approx. 4 kg DM/day in clover grass
- The performance of sows grazing mixed with heifers was unchanged compared with sows grazing alone.
- The weight gain in heifers grazing mixed with sows was significantly better compared with heifers grazing alone.
- The grass swards and pasture production can be maintained during grazing with sows.
- Accumulation of waste-grass around heifer dung was avoided when grazing sows and heifers together.
- The proportion of clover in the pasture decreased when grazing with sows compared with grazing with heifers.

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Mixed grazing with sows and heifers: parasitological aspects

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Abstract

Preliminary results of an experiment set up to elucidate whether mixed grazing can help controlling helminths in pigs and heifers are presented. No clinical symptoms were observed either in sows or in heifers. The mixed grazing had no detectable effect on the *O. dentatum* infections of the sow, where as the *O. ostertagi* infection level of susceptible first year grazing heifers was reduced

Introduction

Gastro-intestinal helminths are commonly found in both cattle and pigs in the temperates, and the infections may cause severe production losses, especially when the animals are kept under traditional housing conditions or on pastures (see Foldager *et al.*, 1981; Nansen & Roepstorff, 1999). One of the most important GI helminths of first-year grazing heifers is *Ostertagia ostertagi*, which lives in the abomasum. At the start of a normal Danish grazing season, a low number of overwintered larvae will give rise to the initial infections in susceptible first-year grazing heifers and thereby result in new larvae on the pastures. Thus, there is a gradual build-up of pasture contamination during the grazing season, normally peaking with high numbers of infective larvae in the grass in August and September (e.g. Foldager *et al.*, 1981). During the summer, the heifers will gradually acquire resistance against the infection, for which reason the faecal excretion of *O.ostertagi* eggs may decline even despite heavy reinfection. However, the infective larvae obtained from the grass may still invade the abomasal mucosa and cause damage to the HCl producing parietal cells, and a high uptake of infective larvae may thus cause an increase in abomasal pH, resulting in diarrhoea, reduced weight gain, protein loss and poor body condition (reviewed by Armour & Ogbourne, 1982). Therefore, this parasite has to be controlled to subclinical levels in the young animals, although a low level of infection is desirable in order to induce immunity.

The most common helminth in adult sows in Denmark is *Oesophagostomum dentatum*, which lives in the large intestine. Although the infections normally are subclinical, *O.dentatum* has been suspected to contribute to the "thin sow syndrome" of grazing sows (Stevens, 1967).

Most helminths, including the two above-mentioned species, are strictly host specific, and therefore mixed grazing is welknown in helminth control, as it may reduce the parasite transmission to each of the animal species involved (e.g. Thamsborg *et al.*, 1999). Despite mixed grazing as a non-medical control strategy is in accordance with the organic husbandry principles, there have been no reports on mixed grazing of heifers and sows. The present experiment was set-up to elucidate whether mixed grazing can help controlling helminths in these two production animal species. The experiment was started in 1997 and has not yet been finished, and the present preliminary report will only be dealing with some of the 1998 results. Other results of the experiment are reported elsewhere (Sehested *et al.*, 1999).

Materials and methods

A pasture was grazed by either sows alone (approx. 10 nose-ringed dry sows and one boar) on 8,000 m², heifers alone (8 first-year heifers) on 16,000 m² and the combination of the two animal groups (approx. 10 nose-ringed dry sow and one boar plus 8 first-year heifers) on 24,000 m². On all 3 pastures, the animals started on core areas at turn out in May, wherefore the areas were gradually extended until the total areas were grazed before turn-in in early October. The same pastures were utilized both in 1997, when they were totally new, and again in 1998.

To introduce parasites, both groups of heifers were inoculated with 10,000 infective *O.ostertagi* larvae per individual at turn-out in 1997, while the new groups of heifers in 1998 were not artificially infected but took up overwintering larvae from the pastures. Similarly, the two groups of sows were given 1000 infective *O.dentatum* larvae per head in 1997, while not in 1998, as the majority of sows were identical in the two years.

Heifers and sows were followed parasitologically by numbers of worm eggs in faeces, numbers of infective larvae in the grass, and the concentration of pepsinogen in serum, which reflects the actual damage of the abomasum of the heifers.

Results and discussion

No clinical symptoms were observed neither in the sows nor the heifers.

The mixed grazing with heifers had no detectable effect on the *O.dentatum* infections of the sows (results not shown).

The faecal egg output of the mixed grazing heifers was low during the whole grazing season, while the faecal egg counts of the control heifers increased steeply after turnout (Fig.1). Due to a gradual build-up of immunity, the faecal egg counts decreased in both groups of heifers during the grazing season.

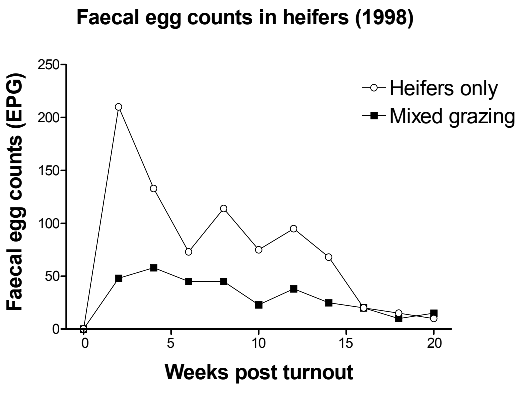

Figure 1 Mean faecal egg counts (eggs per gram) of the heifers.

The number of infective *O.ostertagi* larvae in the herbage was somewhat higher on the control pasture (Fig.2). However, the values were in general low to moderate, presumably because the sampled areas were gradually extended by including clean areas.

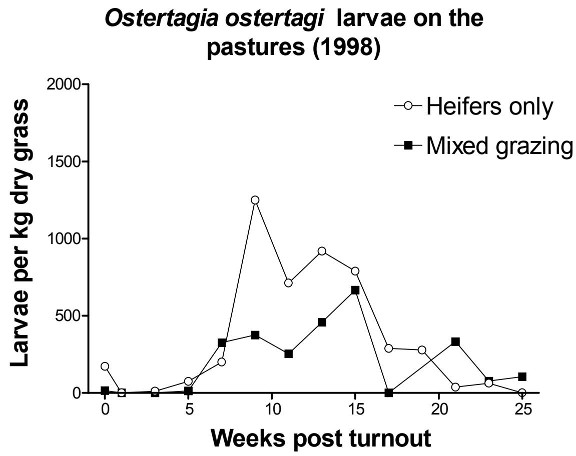

Figure 2 Numbers of infective *O.ostertagi* larvae per kg dry grass on the two pastures.

Gradually, the serum pepsinogen levels of the control heifers became higher than that of the mixed grazing heifers (Fig. 3), which hardly had pepsinogen values exceeding the normal values.

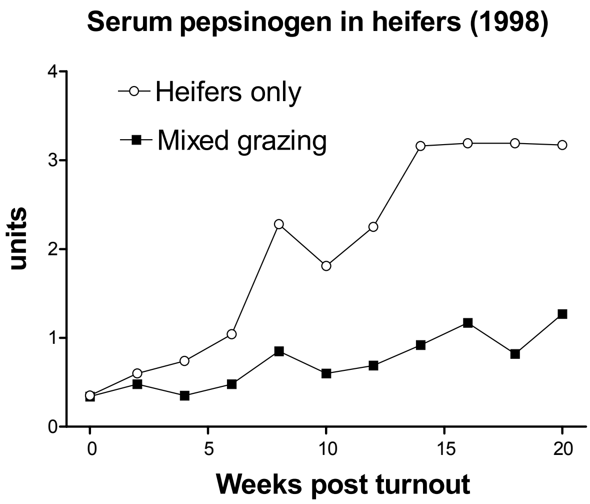

Figure 3 Mean serum pepsinogen levels of the heifers. (Values of 0.5 to 1.0 are considered normal, values of 1.0 to 5.0 are elevated, while values above 5 indicate clinical affected animals, which deserve anthelmintic treatment.)

The overall higher *O.ostertagi* level of the control heifers compared to the mixed grazing heifers indicates that the higher weight gains of the latter by the end of the grazing season (Sehested *et al.*, 1999) may be caused by the helminth infections.

Heifers graze selectively, omitting the herbage around the deposited cow pats, and thereby avoiding the most heavily infective grass. The most possible explanation of the parasite-controlling effect of mixed grazing is that the sows tended to eat this lush bush grass, thereby directly eliminating a large proportion of the *O.ostertagi* larvae and indirectly exposing the cow pats to dessication and UV-light. Furthermore, the sows were observed to turn around cow pats when searching for insects, causing an extraordinary high dessication of the faeces.

Conclusion

Mixed grazing of sows and heifers was shown to reduce the *O.ostertagi* infection levels of susceptible first-year grazing heifers.

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Management of Laying Hens in Mobile Houses - A review of experiences

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Abstract

The idea of mobile houses for laying hens in organic farming is elaborated in relation to parasite pressure, feed supply and management strategies, and examples of experience are given.

Introduction

Mobile houses for layers contain basically perches for the night and nests and are - during the vegetation period - moved over the farmland. Mobile housing for layers, cockerells and growing pullets was quite common in the first half of this century: The complete mash with balanced nutrients, minerals and vitamins was still under development and high performing birds depended on fresh pasture as a feed supplement.

The purpose of keeping laying hens in mobile houses today is to integrate the animals in the farm ecosystem. The farm-own resources shall be utilized most efficiently and in a sustainable way by placing the hens in their (agro-) ecological niche. By moving the houses, three effects can be achieved:

- A concentration of parasites in the land around the house (e.g. roundworms or coccidia) is prevented, the land does not become "fowl sick".

- The farmer can manage the stocking density in time and thus avoid damage to the pasture by overgrazing, scratching and digging holes.

- The farmer can regularly bring the hens to fresh pasture and by this, optimize a feed source, consisting of herbage, worms and arthropodes. This can also reduce the risk of featherpecking and cannibalism by preventing nutritional deficiencies and boredom (Kennard & Chamberlain 1945).

In most cases the pastures' main production is utilized by cattle while the birds follow afterwards. The cattle provides a short sward (keeps the birds dry, ground predators cannot hide, sunlight can disinfect and dry up the birds droppings) and dung pats which subsequently provide worms and fly larvae. But even the fresh dung as such seems to be appreciated by the hens, which raises the question whether cattle dung has a dietetic value for hens. The hens on the other side scratch apart the dung pats which spreads its nutrients more evenly over the pasture. The scratching is not limited to the dung and can have a harrowing effect that benefits the sward. In addition, ranging hens have the potential to reduce cattle- respectively pasture parasites like for example flies (e.g. *Hypoderma bovis, Stomoxys calcitrans*), liverfluke (*Fasciola hepatica*) (Worden et al., 1963, Notion, 1996) and probably also *Tipula*.

Predators

Goundpredators like foxes can effectively be kept away from the flock by an one-wire electric fence, pp. five cm above the ground, in front of a fence net or by an electrified fence net. It is, however, more difficult to control the impact of birds of prey: Cocks are instinctively scanning the sky and warning in case of danger. The hens then need quick access to shelter from attacks (e.g. under the house or small satellite shelters).

A peacock, ranging together with the chickens, might impress purely by his size and keep birds of prey away. A big glass jar on top of the house reflects sunlight, which might irritate the eyes of the bird of prey (Arthofer, 1996).

Feeding

The herbage as well as the animalic part of the pasture (worms and arthropodes) are both potential feed sources for the hens. Greenfeed contains the vitamins A, E and riboflavin plus minerals (McArdle 1972). It further appears that the range can be a protein- more than an energy source (Table 1).

Table 1 Nutritional value of worms, arthropodes and green feed for layers, examples

Feedstuff, dried	DM [%]	per kg DM: ME [MJ]	Cp [g]	LYS[1] [g]	MET&CYS[1] [g]	Reference (data partly recalculated from:)
Earthworms[2]	93	12.6	610	42	12	Yoshida & Hoshii 1978
Grasshoppers	90	12.4	780	36	13	Sugimura *et al.* 1984
House-fly pupae	83	12.8	740	22	10	Teotia & Miller 1974
Coleoptera	56	-	250	-	-	Wu Leung 1968
Grass meal	91	6.4	230	6.7	3.6	CVB 1995
Lucerne meal	91	5.6	210	6.7	3.6	CVB 1995
Layers' concentrate[3]	88	13.8	165	6.1	5.3	NRC 1984

[1] digestible; if a total value is given, digestibility was assumed 80 % (NRC 1984)
[1] digestible; if a total value is given, digestibility was assumed 80 % (NRC 1984)
[2] mainly *Eisenia foetia* (Savigny)
[3] assumed average intake: 110 g feed / hen and day

How much of a flocks' nutritional requirement can be covered by the range differs widely and depends mainly of the time of the year, stocking rate, the quality and utilization of the range and the flocks' level of production. A laying hen seems to have the capacity to daily consume up to 30 to 40 g of dry matter herbage plus small animals, in addition to more than 100 g dry matter of concentrate (Hughes & Dun, 1983).

It might be of economical as well as of ecological relevance to adapt the composition of the given feed to the nutrients offered by the range. Free choice feeding is a strategy that offers the feed components like for example wheat, oats, oyster shells and a protein concentrate separately and allows the hens to combine their own daily menu according to their individual demand. Ciszuk and Charpentier (1996) have shown that domestic laying hens are able to combine a complete ration from separate feedstuffs.

This support the observations of the Virginian farmer Salatin, that hens can adapt their intake of feedstuffs offered in the house to the feed found on the range (Salatin, 1993).

Stocking rate

To prevent contamination of the land with parasites, laying hens must not be kept permanently on one piece of land. Without scientific studies to refer to, two to three years between land use with poultry seems to be a recommendation to begin with. This can be achieved when the hens are kept on grass/clover ley, integrated in the crop rotation. Laying hens do not utilize a given piece of land as evenly as for example cattle or sheep. Although ranging distance can be 200 m from the house, the flocks' major activity will be in a radius of 10 to 20 m.

Another factor that is related to the stocking rate is the question, *when* the grazing occurs: Cowlishaw (1960) found that grazing in the autumn had an especially depressing effect on white clover which he explained with the reduction of the carbohydrate reserves in the stolones and roots. On permanent pasture, a dense sward can carry 50 - 100 free ranging layers for *ca.* seven days without the birds starting damage the sward around the house mainly by scratching. The house should then be moved some 20 mtrs. Bigger flocks must be moved more often, if the creation of bare ground spots shall be prevented.

According to these data (a fresh 20 m radius every 7 days) and assuming a six months vegetation period and a two seasons rest period, a flock of 50 layers would require *ca.* 10 hectares of land over three years (3,3 ha per year, 15 hens per hectare per year). - Compared with the European Economic Community standards for free range egg production (EEC 1991: 1000 hens per ha, without time dimension), this seems to be extremely extensive. Still it should be noted that in the example given above:

- The hens are given just an ecological niche in an agro-ecosystem. They just "fit in" while the pasture is mainly used by ruminants: Assumed each hen "removes" 50 g dry matter herbage per day, 15 hens would remove not more than 300 kg dry matter herbage per growing season. Assumed a dry matter production of 15 tons herbage per hectare, this equals only *ca.* 2 percent of the total production. A pasture (re-) growth-lag after hen grazing is not taken into account here.

- Two thirds of the "required area" can be used for other crops or animals in the meantime and even in the same year, ruminants can graze ahead and after the poultry.

- The lower the stocking rate, the higher the ranges' value as a feed supply for poultry. If that is not found important, hygienic considerations will determine the maximum stocking rate. In that case, 1000 to 4000 birds per hectare per year might be acceptable, depending on the interval length between land use with poultry.

The farmer Sjelin (Ciszuk & Sjelin, 1996) keeps layers in mobile houses with attached run (see Fig.1). The construction covers 117 m². Holding 200 layers and moving them weekly all summer results in a stocking rate of ca. 1000 hens per ha with this "high density / short duration" technique on second year grass clover ley. Within a week, the hens consume roughly all herbage above ground which equals ca. 10 g dry matter per hen per day (Danielsson *et al.*, 1994). Still, there is a regrowth of mainly grass and some clover. The hens reduce the first cut by ca. 30 and the second by ca. 50 percent with considerable variations between different years.

Figure 1 Mobile house with fixed run (Hånsta Östergärde, Vattholma, Sweden). Photo: K. Sjelin

Design

Mobile hen houses may be designed simple and light so that a house for 50 layers can be moved by one person by hand. A house for 100 layers can still easily be drawn with a tractor. Several hen flocks living in their own houses can be combined in a common pasture area, as practiced by Charpentier (1999), a commercial organic egg producer south of Uppsala. This practice allows a total flock size of several hundreds of hens.

It might be advisable to have the feed trough inside the house so that wild birds are not attracted and transmit diseases.During winter, at least the water- and nest area need to be frost protected. The hens seem to do well also at temperatures below zero but the combs, especially the cockerells', will not tolerate more severe frost. The house can be insulated as a whole, which requires more draft power during summer, or insulated temporarily with for example straw bales as done at Ekhaga Försöksgård, research farm of The Swedish University of Agricultural Sciences (see Fig.2). In either case, an extra, covered run (see ig.3) might be attached during winter to meet the space requirements for example of the swedish standards of organic agriculture (KRAV 1999). Alternatively, the hen house might be "parked" in a greenhouse during winter.

Designs of different mobile houses can be found in Salatin (1991), Coleman (1995), Ciszuk & Sjelin (1996), Baßler (1997) and Sjelin & Ciszuk (1999).

Figure 2 Mobile houses, insulated with straw bales for the winter (Ekhaga Försöksgård, Uppsala, Sweden). Photo: L.-E. Liljedahl

Figure 3 Mobile house with appended, covered run for the winter (Kasby Gård, Knivsta, Sweden). Photo: L. Charpentier

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Study of the individual feed choice in a group of hens using an automatic registration system

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Abstract

A system for automatic registration of individual feeding activity was used in order to study the feed preference when given a choice of feedstuffs in a group of cross-bred hens in free ranching. A PIT (Passive Integrated Transponder)-tag system was used to separate and to register individuals when they were feeding. The feeders rested on a balance and the weight changes during a hen's feeding activity was transmitted to a computer. Five different feeders containing, respectively, whole wheat, whole oats, fish meal, meat-bone meal and oyster shell were installed into a hens housing system and continuous registrations were done during several months on 20 hens. During this period, the hens had free access to an outdoor range yard. Some examples of individual feed choice are given.

Introduction

The hens are in many cases able to adapt their feed intake to their requirements in a quantitative (amount of feed ingested) but also qualitative (level of proteins, energy, minerals…) way. Then, from a practical point of view, the benefit of giving to free running hens a free choice of feedstuff have been shown (Emmans, 1991, Ciszuk *et al.* 1998). As the requirements can be different between individuals and can change also over time according to the individual health, growth and egg laying status, the experimental measure of the feed preference of each animal in a group is of great importance to understand such feeding behaviour.

Individual feeding quantity and preference is often obtained from single animals in a cage (Sahin and Forbes, 1997), but this method disregards the social factors. To discriminate individual data in free running groups of hens, other types of registration procedures or systems are used, such as human observers (Murphy and Preston, 1988) or video observations (Sergeant *et al.*, 1997; Weeks *et al.*, 1997). However, both methods are labour intensive and thus expensive in the long run. Consequently, the experiments are generally time limited, both in terms of the number of registration days as well as in hours of observation per day. In this context, there was a need for a new tool allowing work under free-range conditions.

This paper describes a PIT (Passive Integrated Transponder)-tag system for automatic registration of individual feeding activity and as a preliminary account some examples of individual feed choice are given.

Material and methods

Description of the PIT (Passive Integrated Transponder)-tag system

In fish, an automatic device that registers and discriminates individual feeding activity in groups of fish, has been successfully tested and applied by using a PIT (Passive Integrated Transponders)-tag system in combination with self feeders (Brännäs *et al.*, 1994, Brännäs and Alanärä 1993, 1997). In these set-ups, all individuals are tagged with PIT tags that generate a unique code. The tag is activated and read when the fish approaches a reader device (antennae) close to a trigger the fish has to bite on in order to be rewarded by feed. By modification of this fish device, we have developed a PIT-tag system (Figure 1) where the feeding activity of individuals could be automatically recorded and discriminated from others in a group of hens. Here the picking activity of hens is recorded when they stick their head into a feeder. In this device, a method to record the amount of feed intake by each hen was included by placing a computer-connected balance under the feeder.

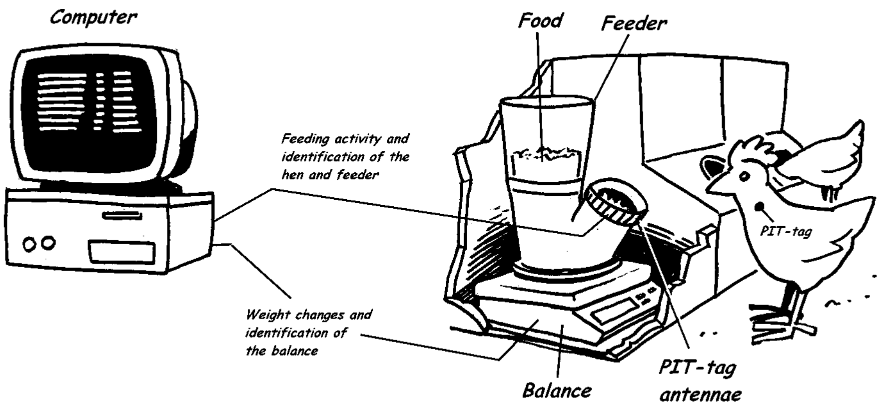

Figure 1 The automatic registration system for identifying individual hens when they are eating and measuring the amount of feed intake.

A Y-tube with an inner rubber collar at the opening contained the feed and a balance with a computer connection was placed under the feeder. A plywood box covered the feeder and balance. A PIT-tag system (Trovan LID 655 Decoder, Electronic Identification Systems) is used for the identification. A tag is then injected in the hens' neck that is activated when it comes close to the antenna (loop assembly), placed outside the covering box. Signals from both the feeder and balance are transferred to a 4-serial ports multiport board placed in a computer. (Drawing made by Åke Brännäs.).

Animals and experimental design

Twenty laying hens were introduced into a hens housing system (Figure 2) containing the feed registration device (5 feeders rested each on a balance) connected to two computers placed in the next room. There were 4 nests, perches, a water distributor and a free opening to an outdoor range yard at the disposal of the birds. The hens were 58 weeks old and cross-bred with Sk. Blommehoens (a Swedish land-race) as father and mothers of four different modern layers (LSL, Dekalb, Isa-brown and Hisex). There were 5 hens of each crossing. After a two week adaptation period (D0), individuals were tagged by subcutaneous injection of a transponder (PIT-tag) into the neck region, close to the head.

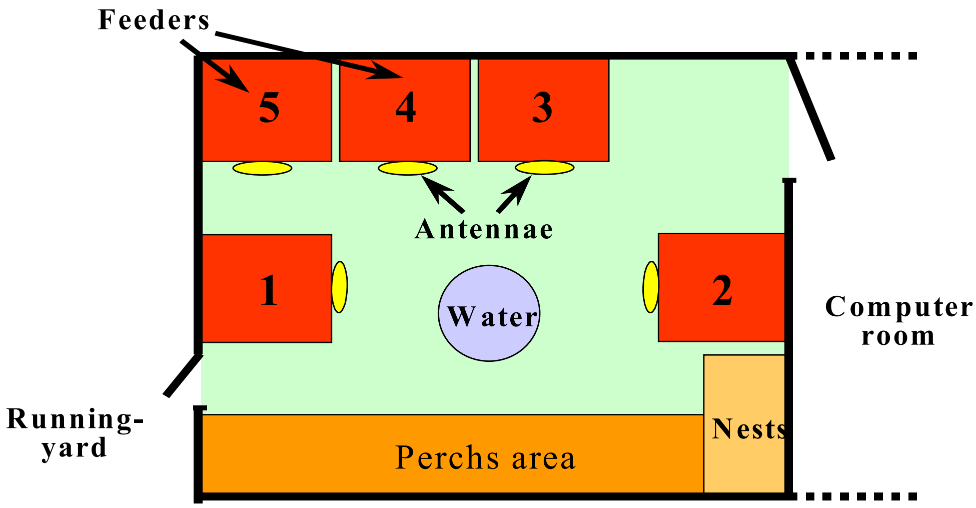

Figure 2 Hens-facilities

The 5 feeders contained whole wheat, whole oats, fish meal, meat-bone meal and oyster shell, respectively. Wheat and oats are vegetal sources of carbohydrate-energy and protein, although fish meal and meat-bone meal are mainly animal sources of protein (Table 1). Oyster shell provides mainly calcium carbonate ($CaCO_3$). Continuous registrations of the feed choice and intake of the 20 hens were done during 99 days, between April and July 1999. This registration time was separated into 3 periods of 71, 23 and 5 days, respectively, corresponding to a change of the location of the feedstuffs between the 5 feeders. These changes were made in order to see if the location of a feeder in the hens housing system could affect the feed choice of the animals.

Table 1 Chemical composition of the feedstuffs used

	Whole wheat	Whole oats	Fish meal	Meat-bone meal
Dry matter (%)	89.5	89.3	88.4	92.6
Crude protein (%DM)	11.8	12.5	74.2	50.2
Crude fat (%DM)	2.2	6.0	9.6	6.6
Ash (%DM)	1.7	3.7	14.3	40.5
Crude fibres (%DM)	2.5	9.8	-	-
Starch (%DM)*	81.8	68.0	-	-

* Rough estimation

Results and discussion

The data concerning 17 hens out of 20 have been used for this study. The average egg production during the experiment was fairly low with a rate of lay of about 45%. As the hens had free access to a pasture, they were able to find an additional feed-source by scratching and pecking outside. This additional feed intake could not be recorded during this study and we considered only the indoor feed intake. We will not discuss the effect of the cross-bred origin of the hens on their feeding behaviour in this paper.

According to our results, there were some strong differences between individuals in terms of amount of feed eaten and feed chosen (Table 2, Figure 3). The daily feed consumption varied from 44 to 166g according to individuals. The average intake given in the literature is about 130g a day of layer meal (Thear, 1997). On average, the preference of the hens for the different feedstuffs was in the following order: whole wheat>fish meal>whole oats>minerals>meat-bone meal. However, the preferences vary strongly between individuals, as shown by the high coefficients of variation (C.V.). The average intake of fish meal is quite high. A normal average for a group of modern layers should be 10-15% of the total feed intake (Ciszuk *et al.*, 1998). The choice of the source of protein differs a lot according to individuals, but it appears that there is a common disinterest for the meat-bone meal, despite its high content in crude protein, in comparison to fish meal. The biological value of the protein of meat-bone meal is inferior to that of the protein of fish meal (low content of methionin as main limit) and the actual meat-bone meal can not fully replace fish meal as a protein source in group-fed layers (Hult, 1998). In addition, the palatability of this feedstuff could be inferior.

Table 2 Mean daily feed intake (g) of 17 hens *.

Hens	Oyster shell	Whole wheat	Whole oats	Fish-meal	Meat-bone meal	Total
1	3.9 ±0.5	42.7 ±2.2	13.0 ±1.3	0.2 ±0.1	0	59.8 ±2.8
2	1.7 ±0.3	23.1 ±1.6	13.7 ±1.3	25.3 ±4.2	0.9 ±0.3	64.7 ±5.2
3	10.1 ±1.0	30.6 ±4.0	53.2 ±5.3	46.5 ±5.6	0.1 ±0.1	140.5 ±8.3
5	8.9 ±0.8	61.1 ±4.3	45.2 ±3.9	8.3 ±1.6	2.0 ±0.6	125.4 ±5.0
6	1.5 ±0.3	40.7 ±2.5	7.9 ±1.0	1.3 ±0.3	0.7 ±0.3	52.0 ±2.4
7	4.6 ±0.5	36.3 ±1.5	17.2 ±1.3	8.8 ±1.1	0.4 ±0.1	67.2 ±2.5
8	5.6 ±0.5	33.3 ±1.7	18.6 ±1.2	30.0 ±2.2	4.6 ±0.7	92.1 ±3.5
9	10.1 ±0.7	57.2 ±3.1	21.9 ±2.0	61.5 ±4.4	6.1 ±1.0	156.9 ±7.5
10	3.8 ±0.4	35.0 ±2.1	12.4 ±1.8	4.4 ±0.8	0.5 ±0.3	56.2 ±2.4
11	0.1 ±0.0	42.3 ±2.9	17.1 ±2.1	5.4 ±1.0	0.6 ±0.2	65.5 ±3.9
12	2.1 ±0.4	31.2 ±4.1	3.6 ±0.7	6.2 ±1.0	1.0 ±0.3	44.1 ±5.0
15	0.1 ±0.0	35.9 ±1.8	6.2 ±0.8	9.5 ±1.3	0.1 ±0.1	51.9 ±2.6
16	4.2 ±0.8	36.5 ±2.8	15.2 ±1.1	54.1 ±4.2	1.3 ±0.4	111.2 ±6.7
17	2.8 ±0.5	13.9 ±3.0	66.1 ±3.8	59.0 ±5.9	5.5 ±1.2	147.3 ±5.8
18	11.0 ±1.4	29.2 ±2.4	24.0 ±2.6	28.5 ±4.9	0.5 ±0.5	93.2 ±6.2
19	7.2 ±0.9	19.2 ±3.9	76.6 ±5.3	62.6 ±6.0	0.1 ±0.1	165.8 ±9.0
20	8.0 ±0.7	50.0 ±2.9	17.7 ±1.7	27.6 ±2.5	6.1 ±1.0	109.4 ±4.0
Average	*5.1 ±0.9*	*36.4 ±3.1*	*25.3 ±5.4*	*25.8 ±5.7*	*1.8 ±0.6*	*94.3 ±10.2*
C.V.	*8.5%*	*21.3%*	*17.7%*	*22.1%*	*31.0%*	*10.8%*

*Means and standard errors (n=84) have been calculated for the total experimental period, excepted the first days of each sub-periods and some days during which the feeding activity has not been recorded in a satisfying way (electricity cuts).

The "menu" of some hens (hens 1, 5, 6, 7, 10, 11, 12 and 15) contained a low proportion of proteins, because of a low intake of animal protein-source, in contrast with other individuals (especially hens 3, 9, 16, 17, 19 and 20) having a high intake of protein. Some individuals (hens 2, 6, 11, 12, 15 and 17) ate also a very low proportion of oyster shell, inducing a low intake of calcium. Only few birds (hens 3, 9, 19 and 20) had an optimal alimentation from a quantitative and qualitative point of view, according to the official recommendations (Bolton and Blair, 1978). This deviation from the feeding standards in a majority of the group might be related to the poor laying efficiency of the group. Consistent differences in the choice of feed between groups of hens laying heavily and groups laying poorly or not at all have already been shown during ancient studies (Jull, 1938).

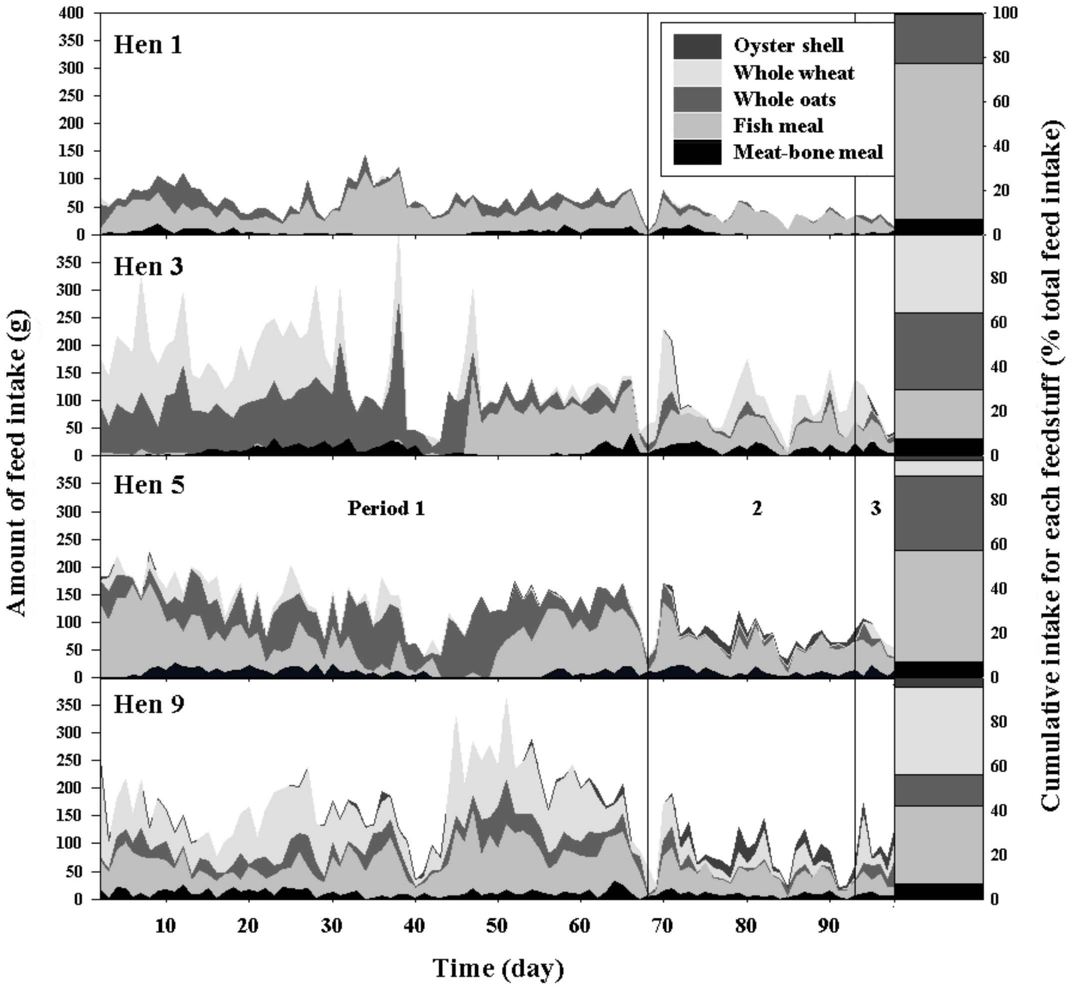

Figure 3 Variation in the amount of feed eaten and of the feed choice over 99 days for 4 individuals, and average feed choice of the hens expressed as percentage of the total intake. Some days (days 41, 68, 69, 84 and 85), electricity cuts happened, explaining the low daily feed intakes recorded.

The study of the variation of the feed intake over time (Figure 3) shows that while the feed choice varied strongly between individuals, it also varied over time. For instance, hen 5 ate preferably whole oats during for 45 days, then, suddenly whole wheat became her favourite feedstuff over the rest of the period 1 and over the periods 2 and 3. As the providing of these feeds remained unchanged, a variation of palatibility may be ruled out.

The location of the different feedstuffs in the room had an effect on the feed choice of individuals, mainly in the case of meat-bone meal. During the period 1, meat-bone meal was located in the feeder 5 (Figure 2), then it was in feeders 3 and 1 during the periods 2 and 3, respectively. Almost no meat-bone meal has been consumed over period 1, then hens started to eat it during period 2. The feeder 5 seemed to be less accessible than the others. Whole oats occupied this feeder during period 2, then it was replaced by whole wheat during period 3. The consumption of these feedstuffs did not dramatically decrease during these periods, which means than when the motivation of a hen is strong enough for a feed, she is able to make an effort to reach it. Hens have been described a long time ago as creatures of habit, consuming large quantities of a feed largely as a consequence of developing the habit of going to a particular container when all the containers are left in the same place in the room (Jull, 1938). Our results nevertheless point out that hens have feed preferences and are able to change their habit to satisfy themselves. A recent study (Dandury *et al.*, 1997) showed that chickens in pain can even choose to eat a feed containing analgesic drugs when offered a choice of drugged feed or normal feed.

Despite strong differences in the amount of feed eaten by individuals and the proportion of each feedstuff chosen respectively, the nycthemeral pattern of feeding activity (Figure 4) remained similar for all the 17 hens. It appears that hens ate oyster shell ($CaCO_3$) preferably at the end of the daylight (16:00-20:00). As the formation of the eggshell occurs most often during the night, it seems reasonable that the hens feel a need in minerals just before.

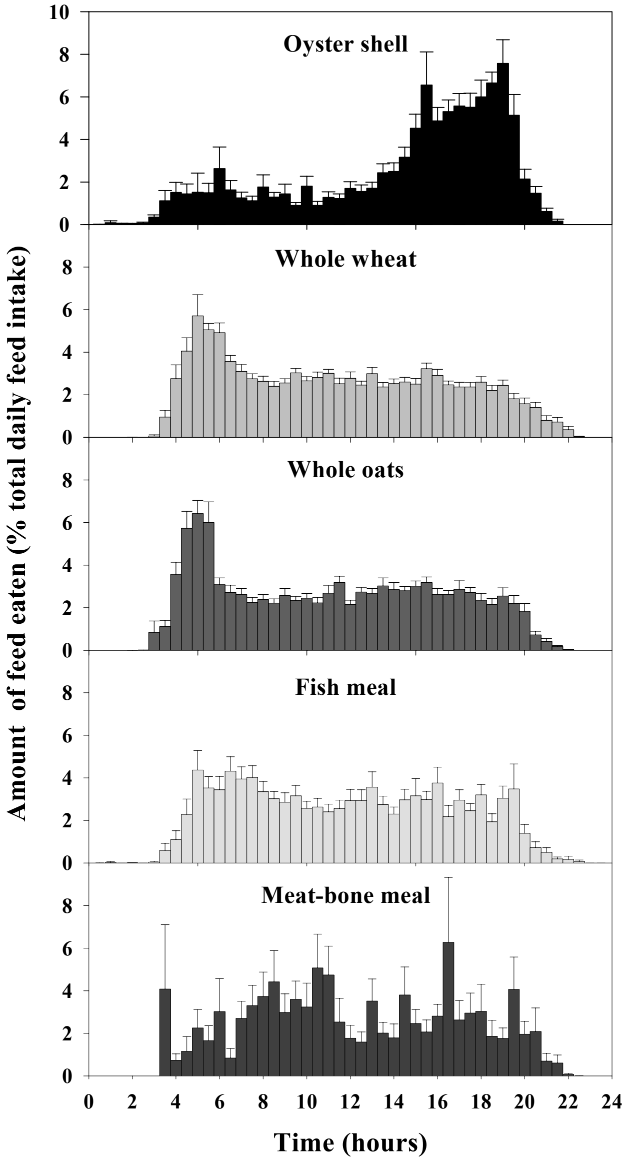

Figure 4 Nycthemeral pattern of feeding activity for each feedstuff. Graphs show cumulative data obtained over 99 days. Time-means and standard errors are calculated from 17 hens (n=17) and expressed as a percentage of the total amount of the respective feedstuff eaten per day.

In contrast, there was a peak of consumption of wheat and oats at the start of the daylight (04:00-06:00). Were the hens hungry when they woke up? Obviously, the hens felt a need of energy at the start of daylight.

Curiously, no peak was visible for fish meal. As this feedstuff is mainly a protein source (only 9.6% of fat), it seems that the hens distinguished very well the energy sources from the protein sources and that their needs in protein were constant over the daylight. These results suggest in one hand that the energy and nutrient requirements of layers can be time-related over the day, and on the other hand that the timing of these needs differs according to the nature of the feed component.

In the case of meat-bone meal, for which the intake was very low, no distinct pattern appeared within the group of hens, as shown by the high standard errors.

Conclusion

The data presented here are only few examples of the type of information available using the automatic system for registration of individual feeding activity of hens. In order to get accurate results, an equal access for the hens to the different feeders is required, and the location of the feed between the feeders should preferably be changed during the experiment.

The group of cross-bred hens used in this study showed a high variability in their feed choice and nutrient intake, and also a low laying percentage. In order to establish how far the variations in feed choice and intake can be related to the actual individual egg production status, we have developed a further automatic registration system allowing measuring the individual egg production. This device will be described soon in a next paper. The utilisation of these both systems together is of high interest for studies of nutrition and feeding behaviour of hens at free range, but also to distinguish the best producers in a free range group for the purpose of genetic selection of layers.

Acknowledgements

We thank Torsten Eriksson and Professor Kurt Brännäs for making the programs in Turbo Pascal and the macros in Excel allowing extracting the data from the raw files, and Jiri Brazda and Anna Larson for helping to care of the hens. The Swedish Forestry and Agricultural Research Council financed this work.

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Non-commercial hen breed tested in organic system

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Abstract

Two lines selected under floor conditions (New Hampshire and White Leghorn) and their crosses were compared with the most sold stock for commercial organic egg production in Denmark (ISA-Brown) under organic experimental conditions at Danish Institute of Agricultural Sciences. ISA –Brown had clearly the highest egg yield despite the fact the organic environment supplied sulphur amino acids below the requirements. However cannibalism was several fold higher in this breed compared to the other breeds and therefore the ISA- Brown seems unacceptable under organic condition unless methods are found to control their behaviour.

Background

The high yielding hen has, through many generations, been selected for high performance on the base of their production capacity measured in individual cages. Thus little attention has been paid to her genetically based ability to behave well in larger flock of hens. The result of such breeding policy is a high yielding hen, but it seems that she has lost some of her ability to have social relation with many hens in large flocks (Sørensen, 1996). In free-range systems with large flocks, including organic farming systems, too many cases have been observed in which hens have started to perform feather pecking that ended with an unacceptable high rate of cannibalism.

The market share of organic farmed eggs in Denmark has during the years 1996-1998 increased from nought to 12%. - In 1998 the market shell-egg from non-caged hens was 40% (Anonymous, 1999).

The breeds used in organic egg production systems in Denmark have, so far, been the ISA Brown, which are laying brown shell'd eggs, have a high laying capacity and are available on the market as day old as well as pullets ready to lay. The drawback in using this breed is the increasing evidence that it has many stories in which larger flock has started to perform feather pecking. Thus the question has been raised many times during the last few years: is breeding material available that is better suitable for production in organic systems?

A small scale Danish Hatchery "Hellevad" has bred a New Hampshire line ever since 1960 under floor condition and with a mild selection pressure on laying traits. Later (1981) they continued the female line (White Leghorn) of the former "Skalborg" hen, which were known to perform well in floor systems (Sørensen, 1997).

Ever since 1947 the Random Sample Test (RST) was the system after which the various breeding materials were compared (Dickerson, 1965). In Denmark, the RST-test was carried out in floor system until 1980. In most other countries the test was carried out using cages 10-20 years earlier. The values of the RST are that the egg producers got the comparison of many different breeds and can make his choice among these, but it also gives an excellent base for evaluating the changes that have taken place over time (Flock, 1995). Most RST-stations were supported by public funds, and managed by research institutes, but as the breeding became more and more commercialised, these arrangement were given up and the RST stations have been closed one by one, which means that only four are left in Europe at the moment and none of them are placed in the Nordic countries.

With an obvious interest to study the commercial available breed combination which has some lack in its behaviour in the organic environment with other non-commercial breeds or breed combinations its is necessary to built up an investigation similar to the RST system in an organic environment. Under the Danish research program for organic farming it was possible to establish such an opportunity, and the two lines from "Hellevad", their crosses and the most sold stock for brown-shelled eggs ISA Brown were compared.

Material and Methods

Hatching eggs from the New Hampshire (NH), the White Leghorn (WL) and their crosses (WLΓ × NHE) from "Hellevad", and ISA Brown were received and hatched, and the chickens reared in the conventional system at the Research Centre Foulum. The 1-d-old chickens were vaccinated against MD, but otherwise no prophylactic treatment was used, and they were not beaks trimmed.

At 16 weeks of age (ultimo July), the pullets were placed in the organic environments in 24 "Eco cottage" each on indoor area of 8 m² and with access to 200 m² grassy field. Such a unit will house up to 40 hens following the rules. The "Eco Cottage" had wall and floor of pinewood, and electric power was installed to give light and to ensure the supply of drinking water during periods with temperature below zero. The floor was littered with chopped wheat straw. The interior was equipped with 6 nests and with perches and the feed was supplied from a hopper feeder connected to a small silo with a capacity for two weeks of food supply.

As the WL pure line did not deliver enough hatching eggs, only 3 replicates were placed with 25 hens per replicate, while 6, 7 and 8 replicates were placed for respectively WL×NH, NH and ISA Brown, with 30 hens per replicate. During 6 months to the age of 43 weeks, the hens were tested for laying traits, mortality and some behaviour trait. All eggs were daily counted and weighed per replicate, thus the age at 50% rate of lay is given as the age when the replicate of 25-30 hens has had a daily yield above 12.5-15 eggs during at least 2 days. Rate of lay for the total period is calculated from that day on a hen day base. Egg weight is simple average of all eggs. Feed intake was calculated on the base of feed consumed from the age of 18 weeks and onwards. Return weighing of left food was performed at the end of the trial at 43 weeks of age. Body weight was carried out individually at 16 weeks of age and at 39 weeks of age. Rate of lay during the last 4 weeks is given in order to see their laying capacity during January where a cold period with minus degree down to –10C° was observed.

Indoors, there was 16 h light regime throughout the experiment. Ventilation and temperature were given by the climate. A pelleted complete feed ration with 80% of the ingredient, organic grown, were fed ad lib.

The composition and the chemical analyses are presented in Table 1.

Table 1 Composition and chemical analyses of the diet used throughout the laying period

Ingredient	%
Wheat	29.3
Barley	7.5
Pea meal	44.0
Oats	5
Grass, dried	2
Calcium carbonate	4
Oystershell grit	4
Rapeseed oil	2
Salt	0.3
Dicalcium phosphate	1.5
Vitamin premix	0.4

Component, analysed	Average	Range of 4 batches min – max	Recommended level, NRC, 1984
Metabolizable energy, per kg	10.94	10.82-11.04	11.6
Crude protein, g/10 ME	137	129-146	170
Fibre, %	5.53	5.21-5.98	
Moisture, %	12.6	11.9-13.2	
Calcium, %	2.73	2.61 -3.28	3.28
Phosphor, total, %	0.58	0.54 - 0.62	0.52
Methinine + Cysteine, g/kg	4.19	4.09-4.28	5.3
Threonine, g/kg	5.19	4.88 - 5.58	4.41
Lysine, g/kg	8.13	7.75 - 8.47	6.38

Data are given per replicate and statistically analysed by a model, which contained the genetic group. The means are presented as Least Square means due to the unbalanced nature of the data.

Results

The results regarding egg laying and mortality are presented in Table 2. In Table 3 the data regarding feed and body weight is given. The means given are per breed and estimated as Least square means and supplied with signs where statistical difference between the breeds are found.

Table 2 Results from laying traits and mortality for the various breeds.

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.

There is obviously a considerable difference in laying capacity among the four lines in which the ISA-Brown had the highest, while the Skalborg line and the cross between the Skalborg and the New Hampshire was the second and New Hampshire was the poorest. This is further clarified in Figure 1 which shows the laying curves for the four breeds. The last 4 weeks of the testing period were a typical winter month with night temperatures down to -10 °C, no insulation or extra heat was supplied, even then the hen yielded almost without any reaction to the low temperature. It is surprising that the ISA-Brown even under that condition was able to lay at a rate which is 6-8 percentage point below the level yielded at the Dutch Random Sample Test station at the same age interval.

Regarding mortality, the lines were ranked in almost the opposite way. In particular the cannibalism of the ISA-Brown was to such a level that it was above 10% in six of the eight replicates within a period of 6 months from 18 to 43 weeks of age. Hardly, any cannibalism was seen for the other breed. The higher mortality of New Hampshire was partly due to a mild outbreak of coccidiosis, which mainly hit the New Hampshire.

Table 3 Feed intake and body weight of the various breeds.

Traits	NH	WL	WL × NH	ISA-Brown	P< [1]
Feed conversion, kg feed/kg eggs 18-43 weeks	4.05[a]	2.91[bc]	3.41[b]	2.45[c]	0.0001
Food intake per day, g	116 [a]	100 [b]	116 [a]	115 [a]	0.0009
Body weight at 16 weeks, kg	1.73 [a]	1.20[d]	1.57[b]	1.43[c]	0.0001
Body weight at 39 weeks, kg	2.30 [a]	1.80[d]	2.14[b]	1.96[b]	0.0001

[a-d] 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.

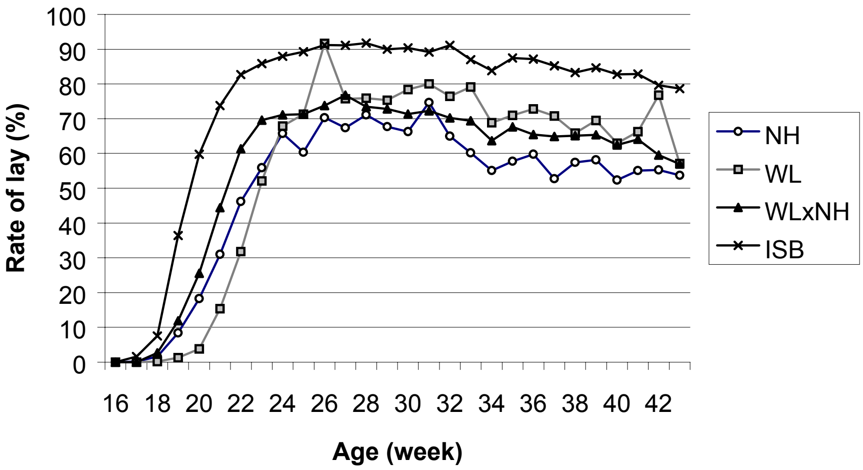

Figure 1 Laying curves for 4 breeds/crosses

Regarding feed consumption and feed conversion, the data shoved a modest value. The daily feed intake of 116 g for the three breeds/crosses should be compared with 131 g observed for the organic hens recorded in the efficiency control by the Danish Poultry Council (Anonymous, 1999). An explanation could be that the outdoor facilities of grassy fields supplied the hen with that much of grass and insects, earth-worme etc. that it corresponds to the difference of 16 to 18 g. Comparing the body weight of ISA-Brown in this test with the Dutch Random Sample test (Anonymous, 1997) shows that the body weight will be somewhat larger in an organic system compared to the cage environment, as our results of 1.95 kg at 38 weeks are already larger than the 1.90 at the 74 weeks obtained in the caged hens at the Dutch Random Sample test.

Conclusion

ISA-Brown was clearly the best layer also in an organic system, also in an organic system in which sulphur amino acids in the diet was below the requirement, but they performed an unacceptable behaviour regarding cannibalism that makes them unacceptable under the organic concept unless some other methods are found to control their behaviour.

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Concept for ecological pig production in one-unit pens in twelve-sided climate tents. Design and layout

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Abstracts

The idea of the concept "One-unit pens in twelve-sided climate tents" as the basis for an entire organic pig production system is elaborated. Areas highlighted are the construction of tents, the ability of the system to support animal natural behaviour and welfare, and the integration of the tent system in land use including landscape.

One-unit pen placed in the middle of outdoor area. Bygholm pilot test.

Introduction

"Sunshine and daylight are nearly as necessary for the complete development of pigs as for the flowering of plants. Piggeries should therefore be equipped with many windows...........many disease-carrying parasites and parasitic plants will have the best flourishment conditions in places with subdued light. Because the resistance towards diseases is

principally highest for pigs that are kept in light and airy pens, infirmity in pigs is mainly found in dim, humid and dirty pens………… The pigs should therefore have the best possible access to sunlight and fresh air." Brief Instructions for Pig Breeding and Keeping by V. Cramer, veterinarian, 1856.

Ecological pig production is based on the production of outdoor sows in places where the piglets have access to straw bedded areas during the fattening period. Up to now, climate tents have only been used for housing of pregnant sows and fattening pigs, but present investigations aim at completing the system by giving farrowing sows access to climate tents, too. At the same time it is attempted to optimise the production systems by using the one-unit pen principle where pigs are kept in the same pen and batch from birth to slaughtering. The idea and preliminary results of a large-scale implementation project are given in the following.

One-unit pens in twelve-sided climate tent

A twelve-sided climate tent is placed in the centre of a 15.2 × 15.2 m area covered by a membrane on top of which a layer of sea shells is spread. Each tent is divided into six farrowing pens. At the time of weaning, the sows will be removed from the pen, whereas the piglets from the six batches will remain in the pen until slaughtering in a batch of 60-70 heads, depending on the number of weaned piglets per batch. At the time of weaning the sows will be distributed over two similar tent systems with three boars in each system, and 2-3 sows will remain in each of the tent systems until 4-5 weeks before farrowing, after which they will be removed to a tent prepared for farrowings.

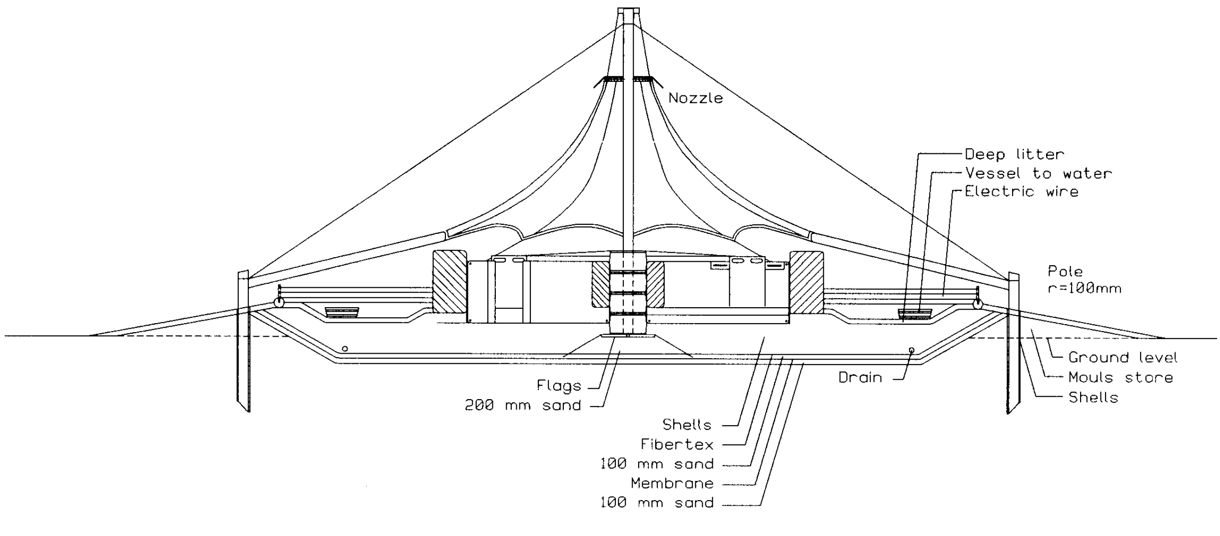

Figure 1 Climate tent with firm bottom, profile scale: 1:100.

The climate tents are equipped with firm bottoms, thereby making them stationary systems to be placed in areas with changing crop rotations (Figure 1).

The bottom of a climate tent consists of a basin with chamfered edges. The soil has been removed from the centre and deposited as an embankment forming the sides surrounding the basin. The solid bottom consists of a geomembrane placed on top of a 10 cm layer of sand. The geomembrane is laid out in one unbroken piece made of 1 mm polyethylene sections approved for storage purposes and pre-welded by the manufacturer. On top of the membrane there is a 10 cm layer of sand covered by a Fibertex canvas. On top of the Fibertex canvas there is a drainpipe connected to a suction well. At the same time the suction well may be used as a measure for control of the density of the membrane. The Fibertex canvas is covered with a 50-90 cm layer of whole common seashells, thus serving as drain layer for the deep bedding. The mast is made of undressed larch and placed in a well consisting of five well rings. In order to support the mast and for rainwater to be drained into the basin to obtain a dry lying area, the well is filled up with sea shells. The tent is stretched out between 4 undressed larch masts, which have been drilled into the ground outside the square membrane. The grating is surrounded by ∅15 cm rafts and filled with sea shells. In the initial production phase, straw is placed alongside the tent to absorb rainwater, thereby reducing the quantity of liquid in the basin. At the outer side, the bank slopes slightly to facilitate the access of vehicles and to permit the occurrence of low vegetation or permanent grass and the access of cultivation.

To ensure constant cooling of the tent, atomisers are located at the top on the ring that holds up the tent.

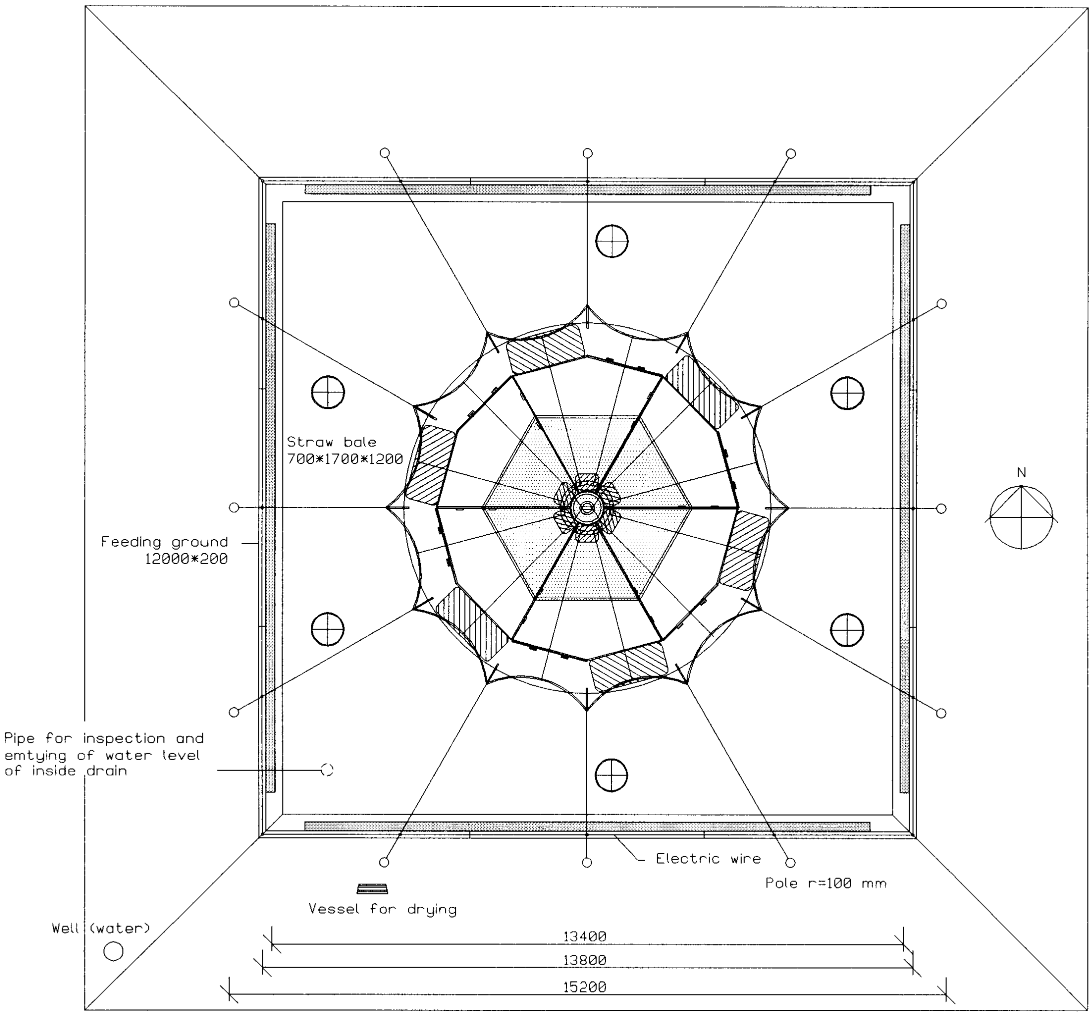

Figure 2 Plan of one-unit pen

Layout of hut for 6 farrowing sows

Each tent includes six farrowing pens with access to separate outdoor areas. The pens are subdivided by means of 1.2 m high plywood plates. During the farrowing period a small straw bale suspended from the middle of the wooden barrel under the covering will help to keep out the cold and protect the piglets. The outdoor areas are separated by single electric fences, thus allowing the piglets to become acquainted before weaning. The entrance provides good possibilities for inspection of the pen without disturbing the pigs unduly. The design of the tents permits easy inspection from the outside in general, as well as under the covering and in the piglets' corner. The height of the farrowing pen allows persons to stand upright while protecting themselves with a wooden plate. The climate in farrowing huts under climate tents is more dry and warm in winter and more cool and airy in summer than the climate in conventional outdoor farrowing huts. At the same time the seashells serve to keep the farrowing hut floors dry, contrary to the floors in conventional outdoor farrowing huts.

Layout of pen for 66 fattening pigs

At the time of weaning, the pigs will be stalled in the pen, and the sows will be removed. The straw bales used for insulation of the walls will gradually be used for bedding as the pigs grow. In the middle of the growth period the pigs may be grouped according to size.

Layout of pen for pregnant sows

Pregnant sows are kept in the same type of housing system as fattening pigs. The watering troughs can be moved about and placed on the grass areas during the summer. The sows will have access to grass areas 150 days a year. Thereby, lactating sows can be kept in the controlled outdoor areas throughout the year, at the same time complying with the ecology rules which prescribe that sows should be given access to grass areas at least 150 days a year. Each tent houses three boars, and once a week 2-3 dry sows will be placed in each of the tents. From previous surveys, good results were obtained with this type of dynamic mating.

Wooden hut under climate tent

The twelve-sided hut with 167 cm long sides is placed in the middle of the tent. Every second wall element is equipped with an entrance. Side-hung rubber strips serve as protection against wind and cold weather, at the same time serving as an easy passage to and from the hut. At the bottom of the frame there is a 30 cm high threshold to prevent floor draught. The walls of the hut are made from 18 mm plywood plates reinforced by 1 × 6" rough boards. In the centre the hut is covered by a six-sided inner tent made of the same material as the tent. The inner tent serves to keep the hut warm in winter at the same time allowing sunlight to enter the hut and dry out the straw. Straw bales placed along the outside of the wooden walls serve as insulation of the hut.

Water in open wooden vessels

The pigs are given both food and water in 30-70 l wooden vessels. 14-day old piglets are given water in separate vessels similar to the other ones, except that they are lower (20 cm).

The vessels can easily be tipped over and rolled to a new location by one person. When tipped, the vessels are easy to wash. Each tent is equipped with a frost-free water supply device to ensure fresh water throughout the year. A spray nozzle is used to ensure effective rinsing of the vessel. The water vessels may be second-hand cognac barrels, the middle pieces of which will be used for protection of the mast.

Feeding

The one-unit pens will provide plenty of room for each pig. On four sides a 12 m long eating area may be established along the electric fence in the outdoor area. The pigs will receive their feed on the deep bedding along the fence or in long troughs for wet feed. If the pigs are fed twice a day on concentrate feed pellets in the morning and roughage in the afternoon, they will develop a regular circadian rhythm, and the manager will get a good grasp of the situation, so that he may help in case of injuries or illness. The aim is to obtain a feed consumption of 2.8 FU/kg live weight gain by means of a simple feeding system, which will permit a variable choice of feed components.

Pig landscape and crop rotation

Environment and architecture

From a building engineering point of view the tent has a clear geometrical location in the centre of the square outdoor area. At the same time there will be no risk of percolation of manure under the tent. This construction along with the free access to roughage will allow pregnant sows to be kept on a bedded outdoor area in periods, when expedient, e.g. at times where the grass is especially exposed to wear and where it will be advantageous to collect the dung in the bedding. Thereby, the area can be kept green throughout the year, and at the same time the farrowing huts will be replaced by a far smaller number of farrowing tents for a given herd of sows.

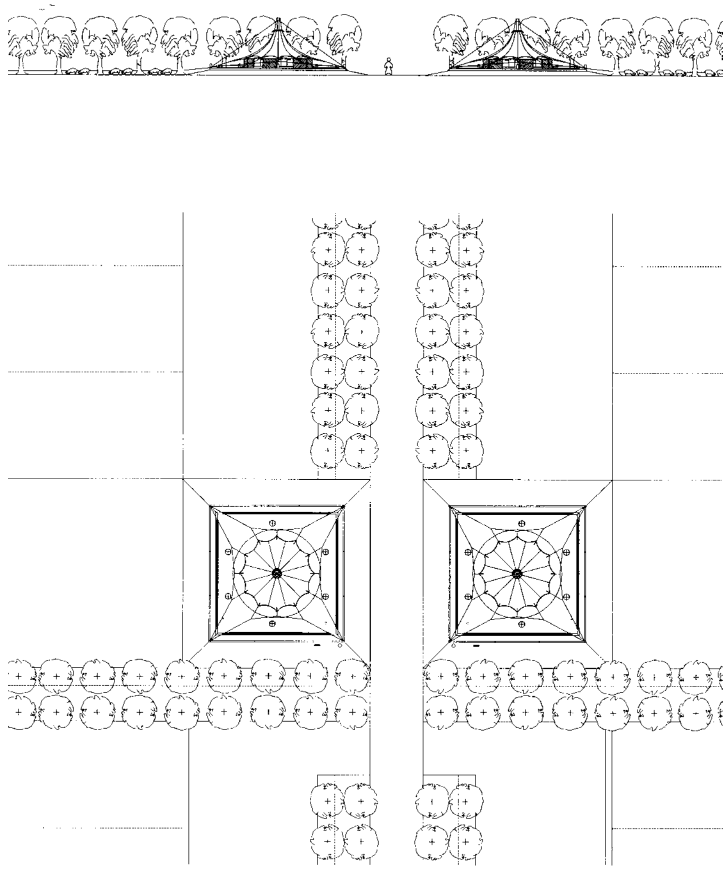

Figure 3 Tents placed alongside field lane. The tent systems may be placed in groups of two tents close to field lane and windbreak belt

The combination of tents, windbreaks and green borders makes up a "pig landscape" to which the animals will have constant or occasional access. At the shady side of the plantation, an area with a minimum width of 24 m will be sown with grass or a similar crop from which the pigs may eat part of the year. The sows will not have ringed snouts, so therefore they will be able to collect feed from the ground outside the grazing period, just as fattening pigs.

By placing the tent systems close to a lane and a windbreak belt, or at the edge of a wood, they will represent a new building style with tents fitted into the landscape. Thereby complying with the below statement of the jury in connection with the awarding of the ID 98 prize (Danish industrial design award).

"At the same time the tents rise in the landscape as impressive sculptural objects, thus making up a tolerable solution to be multiplied throughout Denmark"

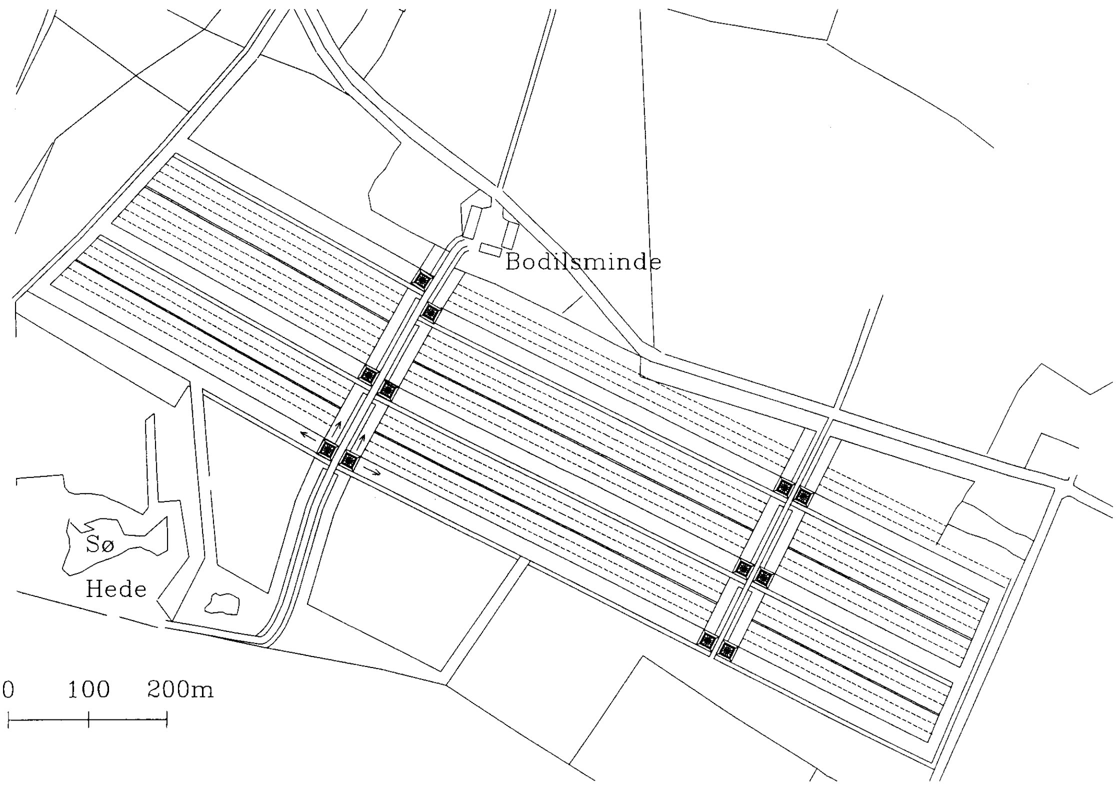

Figure 4 Example of a plan at an authentic farm

An area consisting of meadows and windbreaks for sows and fattening pigs as well as proper cultivated areas is a unique feature of this project

The pigs will be most comfortable in the shady areas and where the windbreaks will shelter them. Trees to protect sows and fattening pigs from the weather are very rarely seen in practise. 6 m wide windbreaks will be established from east to west at approximate intervals of 100 m and from north to south along either side of an existing road and a new short cut road. In the windbreak areas, puddles will be established for the pigs to wallow, and the vegetation (oak, beech, hazel, elder, etc.) will be selected with special reference to the demands of pigs. Some of the grass areas will be used for cultivation of grass for hay; other areas will be used for grazing purposes. The areas will form part of a five-year crop rotation where the pigs may eat from one crop in the summer or autumn and where hay from another crop may be ensiled to serve as fodder for the sows during winter.

Crop rotation in green borders

1. Barley undersown with clower seed
2. First year clover seed
3. Second year clover seed
4. Oat
5. Potatoes

The best cultivation results will be obtained in unshaded areas sheltered by windbreaks where animals will have no access, and therefore, they will not cause damage to the soil structure. One exception, however, will be if a certain job, e.g. removal of couch grass, is to be made. Semi-compost from the united pens will be used to fertilise the cultivated areas. With windshields placed from east to west at 100 m intervals and from south to north along the two access roads, the landscape will apparently be sufficiently rough to obtain a climatic effect which will raise the soil temperature by 1ºC (Reference). At the same time the occurrence of biotopes will be sufficiently high for a biological effect over the ground to occur.

Crop rotation in the production area

The most significant element within plant production will be the organisation of crop rotations. The crop rotation should be organised to satisfy the feeding demands of the pigs widely. The crop rotation will mainly consist of grain and leguminous plants. A certain part of the pig feed will consist of concentrates. As far as possible, second crops will be used in the autumn for collection of mineralised nitrogen. The following crops will be included in the crop rotation:

1. Barley undersown with clover seed
2. First year clover seed and set-aside
3. Oat
4. Triticale undersown with spring sown secondary crop
5. Leguminous plants (peas, lupin, horse beans) followed by secondary crop
6. Barley undersown with leguminous plant/grass as secondary crop.

Seasonal management

Both in conventional indoor systems and in outdoor farrowing huts, the production is normally based on special pens and farrowing pens as well as pens for weaners, fattening pigs and pregnant sows. For all pen types a continuous management will be needed to ensure that all pens will be constantly occupied.

In the one-unit pen system, pens will remain unchanged, irrespective of the type of pigs stalled, e.g. farrowing sows, piglets, fattening pigs or pregnant sows. It will therefore be possible to carry out seasonal management on the basis of knowledge of pigs' natural mating and farrowing periods, and thereby, to avoid having unoccupied pens.

In the world of nature, the months from November to January are the mating period for pigs. Farrowings will take place during the succeeding spring in the months of March, April or May, and under favourable conditions there will be another mating period after the spring farrowing period. Below is given an example of a seasonal management.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mating				xx	xxxx	xx				xx	xxxx	xx
Farrowing		xx	xxxx	xx				xx	xxxx	xx		
Weaning				xx	xxxx	xx				xx	xxxx	xx
Slaughtering		xx	xxxx	xx				xx	xxxx	xx		
Cleaning out		xx	xxxx	xx				xx	xxxx	xx		

The seasonal management includes nine sows and weekly farrowings over a period of eight weeks.

The following advantages will be obtained from seasonal management:

- There will be no farrowings during the warmest period from June to August and during the coldest period from December to February. Thereby, the mortality in piglets may be reduced. Experience from outdoor pig production shows that farrowing outside those periods will imply optimum well being and optimum growth conditions for the pigs. There is reason to discuss whether optimal animal welfare is compatible with farrowing during hot periods, where the risk of heat stress in the sows will be at its highest.

- Farrowings will take place in the most suitable periods. This will open up the possibilities for optimising the farrowing percentage and the number of liveborn pigs.

- Deep bedding may be removed from the pens and spread directly on the field without intermediate storage in the periods with highest biological activity, i.e. March ±2 weeks and September ±2 weeks. This will provide optimal chances to ensure organic binding and to minimise the risk of N-losses.

- In the periods where high attention should be given to pig production, the farrowing and mating periods will be different from the ones where special soil treatment will be needed. Moreover, there will be dull periods suitable for holidaymaking.

Elements of natural animal behaviour and health

Pigs kept in same pen and batch from birth to slaughtering

In that the pigs stay in the same environment from the time of weaning, they will be familiar with their pen-mates from birth to slaughtering. Moreover, the method wills neither involves transportation or mixture of pig batches, and small herd sizes can easily be established. With weaning 7 weeks after farrowing the weaning conditions are optimised and the risk of weaning-diarrhoea will be reduced.

No ringed snouts

The pilot tests showed that whether or not the sows have ringed snouts, they would not perform rooting behaviour during the nest-building period. And because the sows only graze during the summer half, it will not be necessary to ring their snouts in order to protect the soil.

Initial housing effect after each batch

The tents will be cleaned after each batch (1-2 times a year). The upper 5-10 cm layer of sea shells, which will be entangled with the deep bedding, will be removed with the bedding. Before a new batch of pigs is installed, a 10 cm layer of unused sea shells will be spread on top of the deep bedding. Prior to spreading, the seashells will be submerged into boiling water at 140^{o}C.

Individual temperature control

In tents with outdoor areas the pigs may choose to stay in a covered, warm couch or in the open in the winter. In the summer spreading a thin layer of lime on the tent canvas can reduce the influx of light into the tent. Together with an atomisation of water this will help to reduce the temperature inside the tent and in the outdoor area. When the tent is placed in the centre of the outdoor area, the pigs will always be able to find a sheltered or shady place. During warm periods, the sows and the fattening pigs will furthermore have access to mud pools. At the south side of the tent two canvas coverings will be placed to obtain variations in the climate.

Labour consumption

The sows will remain in the tents until they are in an advanced stage of pregnancy. This way, extra work in connection with removal of the sows after mating can be avoided.

Considerable reductions in labour consumption can be obtained if the dung cleaning in houses for farrowing sows, weaned piglets and fattening pigs is performed in one work operation, and therefore become less time-consuming.

One step of the handling process can be omitted by avoiding storage of the deep bedding and instead distributing it directly on the field. Heavy tasks, such as transport of straw, manure and roughage, can be minimised by placing the systems close to cultivated areas.

N-evaporation

The hypothesis is that the evaporation of nitrogen from store/pig house can be halved by only cleaning the deep bedded outdoor area once a year, after which the deep bedding will be distributed directly on the field. With this method, storage losses can furthermore be avoided.
The following things should be considered in connection with reduction of nitrogen evaporation in livestock buildings:

- A high C:N-relation (1.3 kg of straw/kg gained) and a low stocking rate (about 2.7 m^2/fattening pig) are essential factors for the reduction of nitrogen evaporation

- Due to the low temperatures, the nitrogen evaporation from bedded outdoor areas will be low in the winter

- The nitrogen evaporation is expected to be reduced in the summer by keeping the surface of the bedding mat moist. This can be done by collecting spare rainwater from the surface of the tent and distributing it evenly over the outdoor area, as well as by means of atomisation of water in dry, warm periods, thereby allowing the pigs to cool down, when needed.

- An even compost formation can be obtained by placing a sufficiently thick deep bedding mat in the outdoor area and by changing the location of the feeding and watering areas and the location of the entrances to the tent to ensure that the pigs distribute the manure homogeneously.

By keeping the lactating sows inside the bedded outdoor area and likewise the pregnant sows during the winter, a considerable reduction in the nitrogen evaporation from the sow area can be obtained. Because the deep bedding will appear as semi-compost, in which most of the nitrogen is organically bound, only a limited nitrogen evaporation will take place during application. The objective is to reduce the total nitrogen evaporation to 20%.

Ecological farm buildings and financial circumstances

The concept of ecology has been extended to include considerations of choice of materials and design, both as regards buildings and establishment. An optimum cycle should be aimed at, so that no problems will arise, e.g. in connection with removal of tents and equipment. Furthermore, a reduction of the energy consumption involved with the building activities and establishment of the system is a matter of great potential. If energy is involved with the production of materials, a reduction of the consumption of materials will be of utmost importace. Naturally, the use of environmentally harmful materials should be avoided. Finally, the K.I.S. (Keep It Simple) principle should be a primary objective within ecological architecture and planning.

- On establishment of the tents no earth will have to be removed. The topsoil should be scraped away and used to form an embankment around the pool. On removal of the tent, the soil may be put back.
- The production of the 1 mm thick low density polyethylene membrane will involve a minimum consumption of energy, and on removal, the membrane may either be reused or burned, by which CO_2 or H_2O will be generated.

- The seashells will form part of a cycle where calcium is transferred from the ocean to the acid fields. At the same time the waste problem within the clam industry will be solved.

- All masts will be made from undressed larch timber. A minimum preparation effort will be involved, and the fact that the masts are secured in holes drained with in seashells, will help to ensure the durability of the masts.

- The plywood sheets, which have been treated with non-toxic paint, may be replaced by undressed boards.

- Feed boxes and steel fences will not be used.

- The roads will be covered by crushed brick material.

- The water vessels may be second-hand cognac barrels, the middle pieces of which will be used for protection of the mast.

- The double-curved tent has a shape, which serves to limit the use of materials in order to establish a stable construction. The tent is made of very strong relatively thin armoured polyethylene foil.

- The influx of light will provide a warm and dry climate similar to that created by the sun in greenhouses.

- Straw bales are used for insulation, thereby serving as CO_2 stores until they are used for bedding and eventually brought back to the fields to be used as semi-compost.

Animal health and welfare aspects of organic pig production

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Abstract

In the spring of 1997 a research project was initiated in four private organic pig herds, based on clinical recordings, characterising infectious disease patterns and endoparasitic infections. In this presentation focus is mainly put on the results of clinical findings in the organic pig production herds during a period of 18 month. Where very few health problems related to the organic production method could be identified for the sow herds, relatively many but still herd specific disease problems were found in the slaughter pig population.

Introduction

Organic pig production is a relatively new production method in Denmark, despite the fact that it took its beginning during the 1970s in Denmark. Organic pig production has, however, gained interest during the past few years as consumers' demand for alternatively produced meat increase. From an animal health and welfare point of view, a number of interesting aspects exists both with regard to free range sows (piglets must not be weaned before 7 weeks of age) and slaughter pigs.

Danish legislation for the organic pig herd requires that animals must have

- access to grazing 150 days each summer, except for slaughter pigs, given that they have access to an outdoor area
- access to straw bedding (all animals must be able to lay down at the same time)
- access to roughage
- no prophylactic medication
- a withdrawal period after veterinary medical treatment three times longer than in conventional herds
- weaning at the minimum age of 7 weeks.

In the following the results of 1½ years case study in four organic pig herds will be briefly presented and discussed.

Material and methods

On farm study was performed in four herds of size from 60-250 sows per year. Blood and faecal samples from 10 sows per herd at project start and 4 x 15 pigs during the study were examined for antibodies (infectious diseases) and endoparasites, respectively. Clinical examinations of groups of animals were made every 6th week, together with recordings of indoor environment and bedding. Data was collected by the project veterinarian, local veterinarians and project technicians.

Results

Summary of recordings during 1½ year in sow-herds

Very few clinical diseases were recorded, and almost no treatments during the study period. Physical injuries causing lameness, skin traumas and sun burn were the most prominent clinical findings on the sows. In some herds it seemed difficult to ensure a stable body condition over different seasons (major differences between recordings), or in general (differences between sows at the same recording). Piglets were mostly recorded because of skin traumas, and relatively many piglets died with traumas. The hygiene in the sow huts was mostly recorded as dry and clean. If the feeding of both sows and piglets was appropriate, the weaning age of 7 weeks apparently did not cause any problems and the body condition of the sows was sufficient. Separate farrowing areas seemed to be a success. The most prominent problem in all herds with regard to the outdoor sow area seemed to be practical problems with much driving on the area, transporting food, water and sows. These problems had potential influence on animal health, e.g. deep tracks causing injuries when walking.

Summary of recordings during 1½ year in slaughter pigs

Very herd specific disease problems were described. The prevalence of e.g. pneumonia varied from 0 to 25% (found at one herd visit). Endoparasites were found a potential problem, also in deep litter systems. In general, a wide variation was seen between herds with regard to disease signs. Within the herd, changes over time was also described.

Discussion and future perspectives

When evaluating disease patterns and health in the organic pig herds, a differentiation between problems related to the production form and problems related to management and lack of experience of organic production methods should be made clear. The slaughter pig housing systems illustrate this. Many experiments were made, using existing buildings and trying to adjust them to the pig herd. Continuous adjustments of routines were likewise described, and in one herd in particular difficulties in structuring the slaughter pig flocks and a continuous moving around with groups of pigs were described. Difficulties like these do not necessarily belong the the organic production method, but rather to the single farm and farm management.

The difficulties in finding organic pig production herds for the study and the wide variation within and between herds indicate that organic pig production is under development, and many areas for future improvement do exist. Appropriate slaughter pig housing systems on deep litter or with straw and including outdoor areas must be regarded as relevant areas for development. In the sow herd, a more holistic approach ensuring an optimal interplay between land use and animal welfare must be found, e.g. avoiding too much traffic on the sow outdoor area. The relatively high piglet mortality must be regarded as a severe animal welfare problem that needs further investigations.

Production results and sensory meat quality of pigs fed different amounts of concentrate and ad lib. Clover grass or clover grass silage

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Abstract

The aim of this work was to evaluate the effect of different amounts of concentrate (100 vs. 70 percent according to a scale) and ad libitum roughage, given as fresh or ensiled clover grass, on production results, carcass and sensory meat quality of pigs.

The experiment comprised 4 replicates of 4 pens (2 treatments x 2 pens). Each pen contained 13 pigs, thus the total number of pigs was 208. The sensory quality of the meat was evaluated in two winter replicates and one summer replicate only. For this part of the study, only 5 pigs per pen were selected according to treatment, replicate, pen, litter, and sex, resulting in 60 pigs totally.

As roughage, fresh clover grass was used in the two summer replicates except in the final period of the second replicate, where grass silage was used. In the two winter replicates, the pigs were fed grass silage. The roughage was given ad libitum from a hedge placed on an outdoor area for both treatments. In all replicates the pigs were fed a concentrate mixture based mainly on cereal grains and soybean meal, minerals and vitamins in an indoor feeding trough twice a day. One of the treatments was fed “High” amount of concentrate (100 percent) and the other treatment “Low” amount of concentrate (70 percent). The relative levels of concentrate feeding refer to a scale based on time span from start of treatment at approximately 25 kg live weight. The pigs were slaughtered at approximately 100 kg live weight.

In general the performance of the pigs was good, as overall means of daily gain was 832 gramme and percentage of lean meat in carcass was 61.7. Roughage as either fresh grass or grass silage was on net energy basis consumed at amounts of 4 per cent of total energy intake, when concentrate was fed at “High” level (semi ad libitum). When concentrate was fed at “Low” level, the roughage consumption as either fresh grass or silage amounted to 5 to 6 per cent of the total NE intake. The “Low” concentrate feeding reduced daily gain of the pigs considerably (11 to 16%), while the feed conversion ratio showed a positive tendency (9 to 10%). The carcass quality expressed as percent of lean meat increased contemporarily by 0.8 to 1.1 units.

In spite of the relatively small number of observations per treatment (30) on sensory quality estimation, results showed increased tenderness and decreased hardness at 1st bite, when concentrate was fed to 100 percent of the scale compared with 70 percent. Concurrently the acidity of meat

seemed to be less. All other sensory attributes (eating quality attributes) showed no difference between treatments.

Background

In organic pig production, all animals must have access to roughages, primarily due to the welfare and health of the animals. A tightening of the rules for organic farming within the EU involves among other things that in 2005, the husbandry will be fed a 100% organic diet (Sørensen, 1999). Enforcing such a demand will result in a large degree of feed self-sufficiency, as purchased organic cereal grain is expensive (Tersbøl and Kristensen, 1997). To ensure the nitrogen supply and thus maintain the cereal grain yield, part of the fields in organic farming crop rotation must be used for nitrogen-fixating crops. Thereby it is possible to cut down on traditional concentrate feed. The potential to replace ordinary pig feed by roughage is considerable in pregnant sows, but production of finishing pigs also holds potentiality. Basic experiments on digestibility and utilisation of roughages for finishing pigs are given in Carlson et al. (1999). The aim of the present experiment was to study possible usage of roughages, here fresh or ensiled clover grass, for finishing pigs, when the allocation of concentrate feed is restrained and varied. Growth rate, feed intake and utilisation together with carcass and sensory meat quality of the pigs was studied.

Materials and method

The experiments were carried out in a stable with 4 pens with adjoining outdoor facilities. Each pen admits 13 pigs. Concentrate feed was fed in troughs in the pens, while roughage was fed ad libitum in hedges placed on the outdoor area. The allocated amounts of weighed clover grass and silage were adjusted to the pigs' feed intake, by which the feed waste was minimised. The design of facilities is described in detail in Møller & Olsen (1998). The experiment comprised 4 replicates (see Table 1).

Table 1 Experimental design

Replicate	Period	Roughage	Production	Meat/Sensory quality
1	August-Nov 97	Clover grass	52 pigs	-
2	Dec 97 - April 98	Clover grass silage	52 pigs	20 pigs
3	April - August 98	Clover grass silage	52 pigs	20 pigs
4	August - Nov 98	79% clover grass 21% clover grass silage	52 pigs	20 pigs

In all the replicates, the pigs were fed concentrate feed according to one of two treatments; one with semi ad lib. (High) and feeding twice a day (Madsen et al., 1990a; 1990b), while the other one constitutes 70% of treatment one (Low) (see Figure 1). Initially, the pigs were allocated according to litter, sex and initial weight with half the pens on each of the two treatments. The pigs were weighed at the start, after 4 and 8 weeks, and at selection for slaughter. Slaughter weights and meat percentages were recorded for all the pigs.

In replicate 2, 3 and 4, five pigs per pen were selected for sensory meat quality studies at the Danish Meat Research Institute in Roskilde. The pigs were selected according to age and weight, and samples of 25 cm from the M. Long. Dorsi were taken from each pig. A panel of 9 persons evaluated the prepared meat for the following traits: meat flavour, acidity, off-flavour, hardness at first bite, tenderness and juiciness according to a scale from 0 to 15 (low scores = low intensity).

Statistical analyses of data were carried out as analyses of variance by the SAS GLM procedure (Statistical Analysis Systems Institute, 1995). The dependent variables, feed intake and feed conversion ratio (FCR), were analysed with pen as observation, while the dependent variables concerning growth rate, carcass and meat quality were analysed on individual animal basis. Least squares means were calculated for all dependent variables. For feed intake and FCR, corrections were carried out for effects of replicate, initial and final bodyweight. Furthermore, the characteristics growth rate and meat percentages were corrected for effects of dam and sex. Sensory meat quality characteristics were corrected for effects of replicate, pen (replicate) and sex.

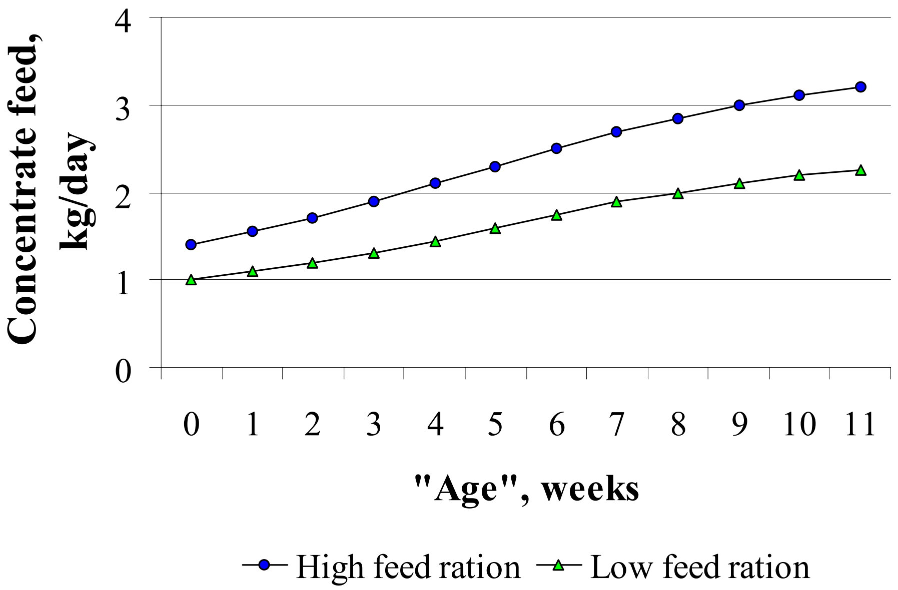

Figure 1 Feeding curves for high and low energy levels, respectively. At approx. 25 kg live weight, the pigs were fed an energy level equivalent to week 0. The energy level was adjusted once a week until week 11, after which it was stable until slaughter at approx. 100 kg.

Results

The concentrate diet consisted of barley, oats, wheat, peas, soy bean meal, rapeseed cake, lysine, animal fat, minerals and vitamins. The results of analyses of concentrate feed and roughage appear from Table 2.

Table 2 Analyses and estimated energy values of concentrate feed, clover grass and clover grass silage

	Concentrate 1997	Concentrate 1998	Grass replicates 1 + 4	Silage replicates 2 + 3
$EFOS_p$ [1)]	86.5	88.0	66.6	57.0
FU_p/kg [1)]	1.08	1.08	0.12	0.23
kg/FU_p	0.92	0.92	8.0	4.4
FU_p/kg dry matter	1.22	1.19	0.70	0.54
Chemical content				
Dry matter, %	89	91	17.8	42.6
Per cent of dry matter				
Crude ash	5.5	5.9	13.1	9.5
Crude protein	21.3	22.1	21.8	13.7
Crude fat	5.9	2.9	3.4	2.0
Crude fibre	6.1	5.4	19.6	29.0
Soluble fibre (SDF)			4.9 [2)]	2.5
Insoluble fibre (IDF)			38.4 [2)]	54.1

1) Boisen & Nielsen, 1994, 1 FU_p = 7.72 MJ NE
2) Result of replicate 4 only

It was impossible to avoid waste of roughage on the outdoor area, and due to pollution with faeces and urine it was impracticable to gather and weigh. Therefore the stated amounts of roughage are the amounts given. In replicate 4, two pigs from the group Low died before slaughter. The most important production results are given in Table 3.

Table 3 Production results for pigs fed clover grass or clover grass silage on High and Low concentrate level, respectively (LS means)

Replicate	1 + 4		2 + 3	
Roughage	Fresh clover grass		Clover grass silage	
Level of concentrate	High	Low	High	Low
Pens with 13 pigs	4	4	4	4
Initial mean weight, kg	26.5	26.8	24.6	24.5
Number of feeding days	87 ^{a}	98 ^{c}	84 ^{a}	99 ^{c}
Daily gain, g	849 ^{a}	754 ^{c}	936 ^{a}	790 ^{c}
Feed intake per pig, kg				
Concentrate	195.2 ^{a}	176.2 ^{c}	197.1	172.3
Roughage	72.3 ^{a}	85.8 ^{b}	41.2	55.3
Feed intake per pig, FU_p				
Concentrate	210.8 ^{a}	190.3 ^{c}	212.8	186.0
Roughage	8.7 ^{a}	10.3 ^{b}	9.5	12.7
FCR, FU_p/kg gain	3.03 ^{a}	2.75 ^{b}	2.86	2.56

a, b, c: By comparison of High and Low, results with different superscripts are significantly different (a-b: P<0.01 and a-c: P<0.001)

From Table 3 it appears that daily gain was reduced by 11 and 16 per cent, respectively, for pigs fed Low and that the intake of concentrate feed is cut by 10 and 13 per cent when supplemented by fresh clover grass or clover grass silage. However, the cut is only significant for pigs fed fresh clover grass. The roughage intake for pigs fed High and Low are 4 and 5 per cent of the feed units, respectively, for pigs fed fresh clover grass, and 4 and 6 per cent of the feed units, respectively, for pigs fed clover grass silage. The reduction in feed intake seems to result in a better feed utilisation of pigs, when the concentrate feed is supplemented with fresh clover grass or clover grass silage ad libitum. The difference is only significant for pigs fed fresh clover grass though.

Table 4 shows the results found at slaughter.

Table 4 Slaughter results for pigs fed clover grass or clover grass silage as supplement on High or Low concentrate level, respectively (LS Means)

Replicate	**1 + 4**		**2 + 3**	
Roughage	**Fresh clover grass**		**Clover grass silage**	
Level of concentrate	**High**	**Low**	**High**	**Low**
Pens with 13 pigs	4	4	4	4
Slaughter weight, kg	77.1	76.5	73.9	74.2
Loss at slaughter, %	22.9	23.6	27.6	27.5
Lean percentage	60.8 [a]	61.9 [b]	61.7 [a]	62.5 [b]

a, b, c: By comparison of High and Low, results with different superscripts are significantly different (a-b: P<0.05)

The lean percentage was significantly higher at Low concentrate level. The other comparisons show no significant differences (P>0.05).

At the evaluation of meat sensory qualities data of the selected pigs (see Table 1), almost identical differences were found between treatments for the three involved replicates. When this was considered together with the fact that silage feeding took place in the last period before slaughter in all three replicates, it was logical to summarise the sensory results for all three replicates. As expected, no interaction between the three replicates and the treatments was found. Figure 2 shows the results of the evaluation.

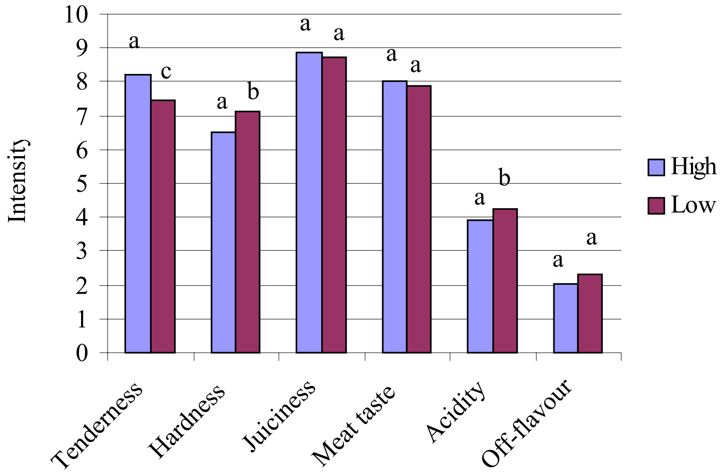

Figure 2 Analyses of meat sensory quality.
Results with different superscripts are significantly different (a-a: P>0.05, a-b: P<0.05, a-c: P<0.01)

The tenderness of the meat was best for pigs fed High (P<0.01). Furthermore, the hardness was significantly different between treatments (P<0.05). Pigs fed Low produced the hardest meat, which was in agreement with the lower tenderness of the meat. At the same time, the taste of the meat tended to be a little less sour in pigs fed High (P<0.05). The other sensory quality traits showed no significant differences between the two experimental treatments.

Discussion

In accordance with the results found in the present experiment, Nielsen (1999) also found a tendency to improved feed utilisation, when the concentrate level was reduced from High to Low, and a tendency to a further improvement of the feed utilisation by an extended reduction in concentrate level to 40 per cent of semi ad lib. This is surprising as pigs fed low concentrate levels have an extended growth period and thus require maintenance feeding for more days. This may be explained by a poorer utilisation of the nutrients in pigs fed high energy levels (Just et al., 1983a) or by the concept that an increased deposition of meat in relation to fat - demonstrated by the improved lean percentage - results in a lower use of energy of pigs fed Low, and Very low (Nielsen, 1999) concentrate levels in comparison to pigs fed the high energy level (Chwalibog, 1993; Thorbæk, 1975; Houseman & McDonald, 1973; Gädeken et al., 1974).

A contributing reason for the improved feed utilisation may be an underestimation of the energy value of the grass and the silage which - according to the $EFOS_p$ method - is estimated at 0.71 and 0.54 FU_p per kg dry matter for clover grass and clover grass silage, respectively. A comparison for evaluation of the energy value of the clover grass and clover grass silage can be made by means of an estimation of the energy content in the diets according to table values for digestibility of nutrients (Just et al., 1983b; Andersen & Just, 1990). By using the table values for digestibility, the energy value is 0.67 and 0.60 FU_p per kg dry matter for clover grass and clover grass silage, respectively. The energy value calculated according to this method is thus lower for grass, but a little higher for clover grass silage, when compared with the used values that are calculated by $EFOS_p$. Consequently, the comparison does not indicate a general underestimation by $EFOS_p$ of the energy value of clover grass or clover grass silage for finishing pigs. On the contrary, the result may reflect that the energy saved by a better utilisation of nutrients together with a lower fat ratio of the growth more than makes up for the extra energy requirement for maintenance in the group fed low concentrate levels.

The highest tenderness in meat of pigs fed mostly concentrate may be explained by the higher daily gain of 171 g by comparison of the two groups of sensory-evaluated pigs (see Table 5).

Table 5 Daily gain and lean percentage of the sensory-evaluated pigs

Concentrate level	High	Low
Number of pigs	30	30
Daily gain, g	967 ^{a}	796 ^{c}
Lean percentage	61.3 ^{a}	62.0 ^{b}

a, b, c: By comparison of High and Low, results with different superscripts are significantly different (a-b: P<0.05, a-c: P<0.01)

Corresponding results on meat tenderness have been found in experiments with cattle (Aberle et al., 1981), as the higher growth results in both a higher protein synthesis and a higher catabolism. This is also supported by the fact that the correlation between daily gain and tenderness is significant (r = 0.41;

P<0.001). Concurrently, the difference in daily gain has resulted in a small, but significant difference in lean percentage, which is advantageous to the slowly growing pigs (Table 5).

Conclusion

A reduced feeding intensity with concentrate (Low) supplemented with ad libitum intake of fresh clover grass led to a significantly increased clover grass intake, declined gain, improved feed utilisation and higher lean percentage in the carcass. Low concentrate levels and ad libitum intake of clover grass silage resulted in significantly reduced gain. However, no significant differences in roughage intake, feed utilisation and lean percentage were observed, but a tendency as seen with the pigs fed fresh clover grass was discovered. Low concentrate levels and ad libitum intake of roughage caused the meat to be less tender, to be harder and have a more sour taste, while there was no significant effect of the feed treatment on juiciness, meat flavour and off-flavour.

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Grass utilisation by outdoor sows in different seasons measured by the n-alkane technique

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Abstract

The intake and the digestibility of herbage, and the effect of level of supplementary concentrate feed, were measured in late Spring and late Summer in two studies each with eight multiparous, pregnant sows. Sows had access to a plentiful organic ryegrass/clover sward with a measured initial yield of 2.6 t OM/ha in Spring and 5.0 t in Summer, in a paddock of 1922m^2. After a week of adaptation to the herbage in the experimental paddock, sows were offered 1.5 or 3.0 kg/d of concentrate rolls for consecutive two week periods in a 'change over' experimental design with four sows on each treatment in each period. All sows were given an 80 g dose of 3 mm concentrate pellets with added C_{32} alkane marker, fed twice daily with the concentrate ration in individual closed feeding stalls with troughs. In the second week of each period, daily bulked faeces samples from each sow were collected. Samples of herbage were also taken to measure the sward density, chemical composition and n-alkane content. Herbage intake and digestibility estimates were calculated using faecal alkane recovery values determined in a concurrent validation experiment. Herbage intake was lower in the Spring study than in the Summer study (1.13 $\pm$ 0.13 v 2.00 $\pm$ 0.27 kg OM/day, $P<0.01$) and was unaffected by level of concentrate in either season. A high intake estimation for two sows in the Summer study appeared to reflect their frenzied feeding behaviour and possible loss of some marker pellets. Exclusion of these sows reduced Summer variance in intake (1.55 $\pm$ 0.14 kg OM/day). Herbage digestibility was lower in Summer (0.47 $\pm$ 0.05 v 0.79 $\pm$ 0.03, $P<0.001$) when fibre content was higher (52.5 $\pm$ 1.21 v 45.7 $\pm$ 2.42 g NDF/kg, $P<0.05$). Faeces of unrung sows indicated a high ingestion of soil or stones in some individuals. It was concluded that the n-alkanes technique can be used to estimate intake of herbage by grazing sows. However, the inclusion of the dosed alkane (C_{32}) in small pellets lead to some doubt about complete consumption of the marker dose by certain sows, with the possible associated overestimation of their herbage intake. The measured herbage intakes showed large individual variation and, therefore, the contribution of herbage to the diet and the degree to which it can substitute for concentrate will vary to the same extent.

Introduction

Organic pig production requires sows to be maintained on pasture. The extent to which this pasture can contribute to the nutritional needs of the animals will be dependent on their voluntary intake and ability to utilise the ingested herbage. Although organic pig farms are still relatively few in number, conventional outdoor sow herds have greatly increased in recent years (Close and Poornan, 1993; Edwards, 1994). Despite this, there is very little information on the nutritional value of grazed forage in different circumstances. Gannon (1996) reported that Crowther (1934) suggested a consumption of 6.3 kg of herbage daily by sows. Her own results, based on 6 sows over a 43 days experiment in Spring, suggested an intake of 11.5 kg of fresh herbage with an energy value of 18.3 MJ DE/day, accounting for approximately 56% of required energy during gestation.

The objective of this work was therefore to estimate the voluntary intake and digestibility of herbage eaten by grazing sows, and the way in which this is influenced by the herbage composition (stage of maturity) and level of supplementary concentrate consumed. Measurement of herbage intake by free-ranging animals is difficult to achieve, but a novel methodology has been developed in ruminants utilising the n-alkanes compounds found in the wax cuticle of plants as markers (Mayes *et al.,* 1986; Dove and Mayes, 1991). In the present study, this methodology was applied in two different seasons to pregnant sows grazing an organic pasture.

Materials and methods

The intake and the digestibility of herbage, and the effect of level of supplementary concentrate feed, were measured in late Spring and late Summer in two consecutive studies, each with eight multiparous, pregnant sows. Within each season, a 'change over' design was applied, with two periods and two levels of a standard diet. The sows were divided in two groups of four, with each group offered a different level of the concentrate diet (1.5 or 3.0 kg) during each of the periods.

The sows were of Camborough-12 genotype and had a mean liveweight of 291.4 ± 29.3 kg in the Spring study and 223.5 ± 12.2 kg in the Summer study. In Spring the animals were nose-rung, with a single bull-ring through the nasal septum, to inhibit rooting. One sow lost her ring during the trial and proved not to be pregnant, coming into heat during the second period of the trial. The data obtained from her during this period were treated as missing values. In the Summer study, insufficient rung sows were available and unrung animals were used.

The same experimental paddock was used in both studies. This paddock was 1922 m^2, and was an organic pasture, mainly composed of *Lolium perenne, L.* and *Tripholium repens, L.* It contained two corrugated metal sow huts, a row of lockable feeding stalls with troughs for individual feeding of the concentrate ration, and a water trough. To measure the availability and composition of the herbage for the sows, samples of herbage were collected at the beginning of the study and every two days during the faecal collection periods in each of the seasons, using 18 quadrats (0.6m x 0.15m) on each sampling occasion. The cut samples were individually bagged and frozen for subsequent chemical analyses. Quadrat samples were defrosted and bulked for each sampling period.

The sows were weighed at the beginning and at the end of each study. After a week of adaptation to the herbage in the experimental paddock, each group of four sows received their specified level of the diet (1.5 kg or 3.0 kg per day per sow) divided between two daily feeds given in the individual feeding stalls. After two weeks with this treatment, the level of concentrate was changed over for each of the groups. All sows were given an 80 g dose of concentrate pellets with C_{32} alkane marker (1200 mg/kg in Spring and 1822 mg/kg in Summer) at each meal. In the second week of each period, daily faeces samples from each sow were collected from all defecations and placed in labelled plastic bags; all the faeces were separately frozen each day. At the end of each period, the faeces were defrosted and mixed to produce a bulk sample for each period for each of the sows.

Faeces and herbage were dried at 70°C for 48 hours prior to chemical analyses. The samples were analysed for dry matter (DM) and ash content, and for neutral detergent fibre (NDF; Rowett Research Institute method adapted from Van Soest *et al.*, 1991) and alkanes content (Mayes *et al.*, 1986). Herbage intake and digestibility estimates were calculated using faecal alkane recovery values obtained from a concurrent total balance study in housed sows (Wilson *et al.,* 1999) using the pair of n-alkanes C_{31} and C_{32}. The calculations of herbage intake were made on the basis of organic matter (OM) in order to avoid any error arising from the possibility of the sows eating soil.

Data were analysed within season by analysis of variance, carried out using the GLM procedure of the statistical program Minitab 11.21 for Windows. Period and Treatment and sow were used as factors in the ANOVA. A regression analysis was performed to investigate any relationship between the proportion of herbage in the total diet intake and the overall digestibility of the diet. T-tests were used to study the differences between the composition of the Spring and Summer herbage, as well as the differences of intake between Spring and Summer, and in Summer with and without certain individual sows.

Results

Herbage yield averaged over the measurement period was lower in Spring than in Summer (2.8 $\pm$ 0.17 v 3.6 $\pm$ 0.32 tonnes OM/ha). Both DM content (229 $\pm$ 8.8 v 259 $\pm$ 11.6 g/kg) and NDF content (457 $\pm$ 34.2 v 525 $\pm$ 12.1 g/kg DM) were significantly lower in Spring ($P<0.05$) before the herbage grew and matured.

The level of concentrate consumed had no significant effect on herbage consumption in either season, and pooled data are therefore presented. Figure 1 shows the distribution of individual herbage intakes in the two studies.

In the Spring study, sow no 3 was not included, because she came into oestrus during the second measurement period and exhibited abnormal grazing behaviour and very low herbage intake.

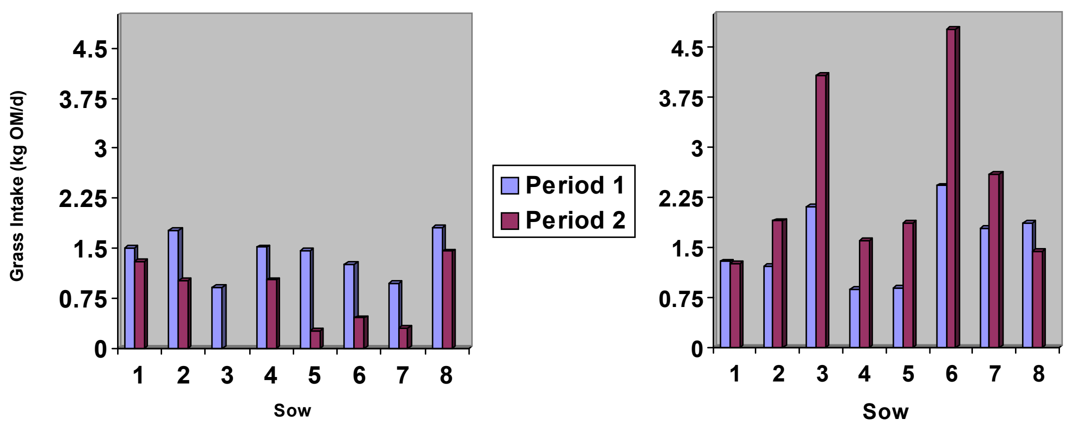

Figure 1 Comparison of OMI (kg/d) of herbage for each of the sows in each of the two periods of the trial using the pair of alkanes C_{31} /C_{32} during Spring (A) and Summer (B)

The herbage intake was greater in Summer than in Spring (P<0.01; Table 1) which also coincided with higher content of fibre of the herbage. Two sows in the Summer study (nos 3 and 6) showed very high apparent intakes of herbage. However, in observation of the animals during concentrate feeding it was noted that these sows had a frenzied feeding behaviour and appeared to be wasting some of the small concentrate pellets. Since this might have resulted in incomplete marker intake, and hence incorrect estimation of herbage intake, data were recalculated with missing values for these animals. The t-test revealed significant differences between the average values when these two sows were included or excluded from the data set (Table 1), but the mean value for the paddock was still higher than in Spring.

Table 1 The intake and digestibility of herbage by pregnant sows in two different periods in late Spring and late Summer.

	Mean	*sem*
SPRING STUDY		
Herbage intake (kg OM/day)	1.13	*0.13*
(kg fresh wt/day)	6.10	*0.78*
Herbage digestibility (OM)	0.79	*0.03*
SUMMER STUDY		
Herbage intake [1] (kg OM/day)	2.00	*0.27*
(kg fresh wt/day)	8.97	*1.18*
Herbage digestibility [1] (OM)	0.47	*0.05*
Herbage intake [2] (kg OM/day)	1.55	*0.14*
(kg fresh wt/day)	6.96	*0.62*
Herbage digestibility [2] (OM)	0.47	*0.06*

[1] With all sows. [2] Without sows showing frenzied feeding behaviour

The digestibility calculated for the overall diet (concentrate plus herbage) showed an influence of both the intake and fibre content of the herbage. Digestibility of the concentrate, estimated from the intercept of the regression line obtained by plotting diet digestibility against the proportion of herbage intake for each sow, indicated a value of 0.81 in Spring and 0.73 in Summer (Figure 2). The calculated digestibility of herbage in each study was significantly lower in Summer (P<0.001; Table 1). If the two suspect sows were omitted, the Summer value did not change.

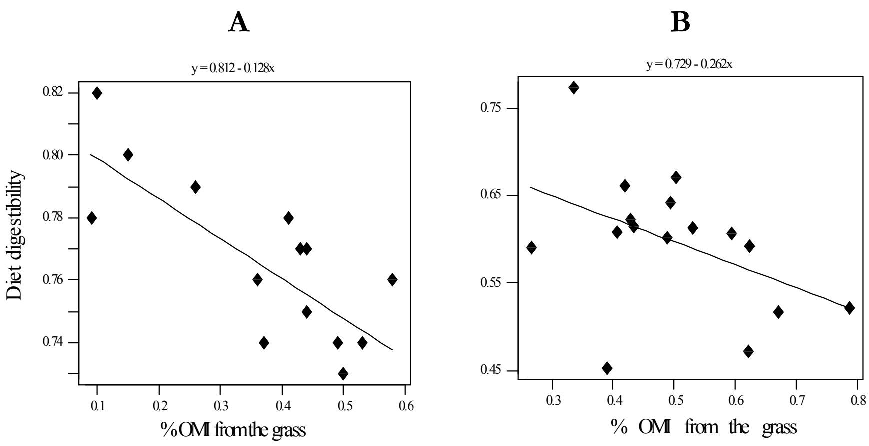

Figure 2 Comparison of regression lines of the overall digestibility of the diet against the proportion of herbage in the total diet intake (OM) in the Spring (A) and Summer (B).

If it is assumed that the gross energy of herbage is 19.0 MJ/kg OM (AFRC, 1993), the apparent digestible energy intake from herbage can be calculated from the intake and digestibility data for each sow. These estimated DE intakes were 16.1 $\pm$ 1.63 MJ/d in Spring and 21.9 $\pm$ 2.42 MJ/d in Summer, although this latter value was reduced to 17.81 $\pm$ 1.47 MJ/d if the suspect sows were omitted.

In the Summer study, when sows did not have nose rings, considerable rooting occurred within the paddock. Ingestion of soil by some sows appeared to be substantial, as indicated by faecal ash contents which were much higher in the Summer study than was recorded in the Spring study when no rooting occurred. In one extreme case (sow no 1) faeces were produced which had an ash content of 937 g/kg DM. Faeces composition of the unrung sows also indicated a high ingestion of stones in some individuals: one of the sows (no 4) produced a bulked faeces sample containing 450 g/kg fresh weight of stones.

Discussion

The n-alkane technique can be effectively used to estimate the herbage intake by grazing pigs, as reported in this trial and also by Gannon (1996). It does not compromise the behaviour or welfare of the sows, since no actions disruptive to the animal are needed. The inclusion of the dosed alkane (C_{32}) in small pellets as the elected form of administration of the marker was shown to be a good alternative for easy practical application in outdoor trials, rather than the treated shredded paper used by Gannon (1996). However it lead to some doubt about complete marker intake in a small number of sows which showed frenzied feeding behaviour with a tendency to scatter their pellets and possibly lose some. This might be overcome by improved feeding trough design.

Gannon (1996) suggested from comparison between different individuals in her trial that the level of concentrate did not affect the herbage intake of the sows. The results of the present study confirm this suggestion in a more controlled experiment permitting within-pig comparison. However, there was very large between-pig variation in intake, a result noted previously for other types of bulky feedstuffs (Livingstone and Fowler, 1984). On average, herbage intake was higher in Summer than in Spring, indicating that it might be influenced by the nutritive value of the herbage, with sows compensating by increasing intake as fibre content increased. The digestibility of overall diet (herbage plus concentrate) was inversely proportional to the intake of herbage. These results agree with those found previously in studies of fibrous feedstuffs (Livingstone, 1985; Livingstone and Fowler, 1987). In the Summer study, with the sows eating more of a herbage with a higher content of fibre, the negative effect of the herbage intake on digestibility was nearly twice that in the Spring study. The apparent lower digestibility of concentrate in the Summer study may have been a consequence of the suppressive effects of fibrous feedstuffs on the digestibility of other diet constituents (Low, 1993). The present study also revealed that unrung sows can ingest very high levels of soil and stones. Further information on this will be relevant to assessment of mineral balances in organic sows, but it also has animal welfare implications.

In conclusion, the n-alkanes technique can be used to effectively estimate intake of herbage by grazing sows. However, the method of administration of the dosed alkane (C_{32}) requires care to avoid potential overestimation of herbage intake. The measured herbage intakes in this experiment showed large individual variation and, therefore, the contribution of herbage to the diet and the degree to which it can substitute for concentrate will vary to the same extent.

Acknowledgements

MRF was in receipt of a study grant from the European Social Fund. SAC receives financial support from SOAEFD. We thank Stuart Lamb, Margaret Wallace and Mike Birnie for their assistance with laboratory analyses. The facilities of Department of Agriculture, University of Aberdeen, and the MLURI are gratefully acknowledged.

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Housing of finishing pigs within organic farming

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Abstract

In organic farming finishing pigs may be kept indoors, provided they have access to an outdoor area and are given some kind of roughage. In order to investigate the effect of different sizes of outdoor areas on the performance and the behaviour of pigs, a study was carried out with an outdoor area of 1.0 or 0.5 m² per pig in an uninsulated house with deep bedded pens and an insulated house with partly slatted floor pens. Besides the effect of the access openings on draught, gas and dust concentration was investigated.

The performance of the pigs was satisfactory compared to conventional herds, and it was not affected by the size of the outdoor area. Significantly more pigs were lying outdoors, and there was a tendency towards more active pigs when they were given 1 m² per pig instead of 0.5 m² per pig. The rate of aggression among the pigs was not influenced by the size of the outdoor area and the degree of soiling of the outdoor areas was equal for both area sizes. The risk of draught through the access openings into the pens can be minimised by using side mounted rubber plates.

Houses with access openings to outdoor areas and with natural ventilation will result in a high ventilation rate and consequently a low concentration of ammonia, carbon dioxide and dust.

Introduction

According to the Danish regulation for organic farming, pigs should have access to grassland half the year, but finishing pigs may be kept in houses all the year round, provided they have permanent access to outdoor areas and the possibility of eating some kind of roughage. When the project was started the regulation gave no indication as to the size of the outdoor areas or the design of the pens. To obtain more knowledge concerning an appropriate function of finishing houses for organic pigs, two existing houses at the organic research station "Rugballegaard" were established with outdoor areas and the following types of pens:

1. Deep bedded
2. Partly slatted floor

The aim was to study the effect of 1 or 0,5 m²/pig of outdoor areas on the performance and the behaviour of the pigs. Furthermore it was the aim to investigate gas and dust concentration and draught coming from the access opening in houses with deep bedding and partly slatted floor.

Materials and methods

Houses

The house with deep bedded pens was uninsulated with natural ventilation and 4 pens, each containing 27 finishing pigs and a pen area of 1 m^2/pig. The pigs were fed ad. lib. from two feeders and watered from two water bowls. Through an access opening in the wall, 0.8 m high and 0.5 m wide, the pigs entered the outdoor area, which was covered with concrete floor. Two of the outdoor areas was 1 m^2/pig, the other two was 0.5 m^2/pig. There was a slurry channel 50 cm wide in front of the house. In order to give the pigs the possibility of cooling during the summer a sprinkler system on the outdoor area sprayed water for periods of 15 sec. 3 times per hour, when the temperature exceeded 20-21 °C

The house with partly slatted floor was insulated with natural ventilation and 4 pens each containing 13 pigs and a pen area of 1 m^2/pig of which 28% was slatted floor. A part of the solid resting area was covered to provide protection for the pigs against draught and a limited amount of straw was used in the resting area. Two of the outdoor areas was 1 m^2/pig, the other two was 0.5 m^2/pig. The pigs were fed ad. lib. from feeding troughs and watered from water bowls. The access openings and the outdoor areas were arranged as described for the house with deep bedded pens.

Performance

The experiment included four batches of pigs in each house. The pigs were placed in the pens at a weight of about 25 kg and delivered to the slaughterhouse at a weight of about 100 kg. The pigs were weighed four times during the housing period. All feed added to the feeders was recorded to give the total feed consumption. From these data the daily weight gain, the feed intake per day and the feed conversion ratio were calculated. In the outdoor area the pigs were fed on roughage, consisting of clover grass as fresh material or as silage.

Behaviour

One day each week it was observed how many of the pigs in the two different sizes of outdoor areas were active, lying or behaving aggressively towards other pigs.

The observations took place in the periods from 10 to 12 in the morning and from 13 to 15 in the afternoon.

Cleanness of the outdoor area

Once a week the cleanness of the outdoor areas was assessed using a marking scale from 0 to 2, where 0 means clean and 2 means soiled.

Indoor climate

The access openings and the natural ventilation provided sufficient ventilation rate to simulate an open house with an indoor temperature close to the outdoor temperature. The resulting gas and dust concentrations in the house was measured. The access openings may cause draught in the pens. Therefore, different designs of coverings were investigated with respect for their effect on draught.

Results and discussion

Performance

Table 1 shows the daily weight gain, the feed conversion ratio, the feed intake per day per pig, the meat content and the mortality.

Table 1. Effect of outdoor area and type of house on pig performance

	Deep bedding		Partly slatted floor	
Size of outdoor area, m^2/pig	0.5	1.0	0.5	1.0
Daily weight gain, g	900	910	916	927
Feed conversion ratio, FU_p/kg weight gain	2.64	2.67	2.67	2.64
Feed intake per day per pig, FU_p	2.36	2.40	2.51	2.42
Meat content, %	59.6	59.7	60.9	61.1
Mortality, %	0.9		0.5	

No effect of the size of the outdoor area or type of house was seen on the performance ($P > 0.05$) The consumed roughage is not included in the feed conversion ratio or the daily feed intake, but it amounts to 4-5% of the total energy intake (Danielsen et al, 2000). The performance of the pigs was satisfactory and better than that seen at the best 25% of the Danish farms (Landbrugets Rådgivningscenter, 1999). The meat content was not affected by the different sizes of the outdoor area ($P > 0.05$), but it was significantly lower in the house with deep bedding than in the barn with partly slatted floor ($P < 0,05$).

The mortality in the deep bedding house was 0.9 % compared to 0.5 % in the partly slatted floor house. In both cases it is less than that found in conventional herds (Landbrugets Rådgivningscenter, 1999).

Behaviour

Table 2 shows the percentage of active pigs on outdoor areas at different age and in houses containing pens with deep bedding or partly slatted floors.

Table 2 Effect of age, house and outdoor area size on the percentage of activity

% active pigs on outdoor areas				
Days after start	Deep bedding		Partly slatted floor	
	1.0 m² per pig	0.5 m² per pig	1.0 m² per pig	0.5 m² per pig
10	13.2	11.5	20.1	17.8
40	10.7	9.4	16.7	14.7
80	8.1	7.1	12.8	11.2

There was a tendency towards more active pigs in the outdoor areas with 1.0 m²/pig than with 0.5 m²/pig ($P = 0.055$). There was a significant difference between the two type of houses ($P < 0.0001$), as the pigs in pens with partly slatted floors were more interested in using the outdoor areas than the pigs in pens with deep bedding. As the pigs grew older their use of the outdoor areas decreased ($P <0.0001$).

Table 3 shows the percentage of laying pigs on outdoor areas at different temperatures and in houses containing pens with deep bedding or partly slatted floors.

Table 3. Effect of temperature, house and outdoor area size on the percentage of laying pigs

% laying pigs on outdoor areas				
Temperature °C	Deep bedding		Partly slatted floor	
	1.0 m² per pig	0.5 m² per pig	1.0 m² per pig	0.5 m² per pig
10	1.5	1.1	0.8	0.6
15	8.1	5.9	4.6	9.3
20	33.9	26.6	21.8	16.5

The number of laying pigs increased strongly from temperatures about 15 °C and was higher on outdoor areas connected to deep-bedded pens. There was significantly more laying pigs on areas of 1 m²/pig compared to 0.5 m²/pig for the simple reason that there was not room enough on the smaller area.

Aggressions among the pigs were at the same level in outdoor areas of 1.0 or 0.5 m² per pig ($P > 0.05$).

Cleanness of the outdoor areas

The pigs soiled the outdoor areas depositing 80-90 % of their faeces and urine. There was no difference in degree of soiling between the two areas.

Indoor climate

The relation between outdoor and indoor temperatures in the two houses are shown in Figure 1.

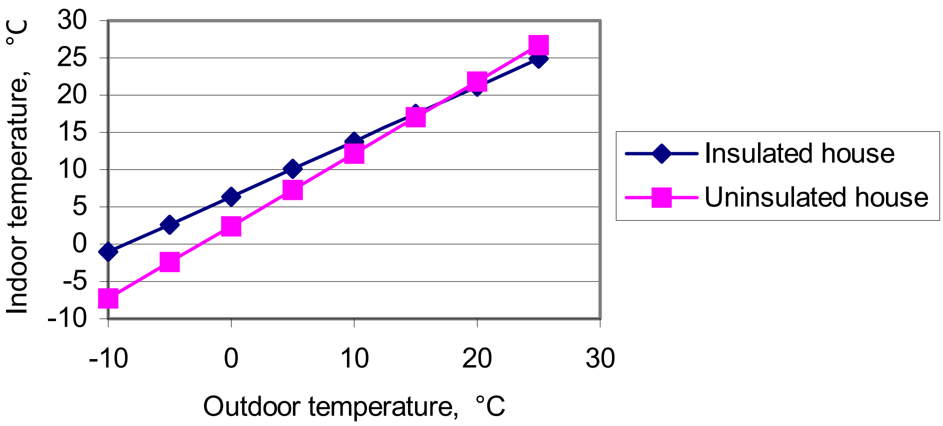

Figure 1 Relation between outdoor and indoor temperature.

It is seen that in the uninsulated house the indoor temperature under cold conditions is only a few degrees higher than the outdoor temperature, while in the insulated house the temperature will remain at about 7°C above the outdoor temperature. However, it will still be quite different from the temperatures in ordinary houses, due to the higher ventilation rate, which will also give low ammonia, carbon dioxide and dust concentrations, as shown in Table 4. The table compares the results of the present study with the results from an EU research project (Pedersen,1996) carried out in ordinary houses with fully slatted floors.

Table 4. Concentration of ammonia, carbon dioxide and dust.

	NH3 ppm	CO2 ppm	Total dust mg/m^3	Respirable dust mg/m^3
House with deep bedding	4.6	410	0.72	0.10
House with partly slatted floor	3.6	650	0.37	0.07
House with fully slatted floor Pedersen et al, 1996	13.7	1300	2.44	0.21

Both the gas and the dust concentrations were much lower in the investigated houses compared to that found in the EU research. This implies better air quality for the pigs as well as a better working environment for the stockmen.

To avoid draught through the access openings, different designs of coverings were tested under reproducable conditions in an air physics laboratory. The test showed that openings with top mounted plastic or rubber strips will cause draught in the pen, because the strips will flicker in the wind. The risk of draught can be reduced considerably by using two side mounted rubber plates overlapping one another by 5 cm. Thereby, the wind will be prevented from blowing directly into the pen, and the overlapping will prevent the wind pressure from opening the cover (Møller, 1999).

Conclusions

The size of outdoor area did not influence the performance of the pigs.Significantly more pigs were lying outdoor with outdoor areas of 1 m^2/pig than with 0.5 m^2/pig. There was a tendency towards more active pigs in the larger area, but there was no difference in the rate of aggressions among the pigs.

Regarding cleanness of the outdoor areas there was no difference using 1 or 0.5 m^2/pig.
The high ventilation rate in houses with access openings to outdoor areas and with natural ventilation will result in low concentrations of gas and dust.

In order to avoid draught from access openings, it is recommendable to use side mounted rubber plates that overlap one another by 5 cm.

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Sows on pasture

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Abstract

For organic animal production, it is important to use organic feed and to obtain high levels of self-supply. For sow herds, one way to fulfil the aims is to have the sows on pasture and include roughage in the diet. Sows on pasture raise questions as: How is the grass cover maintained? What is the feeding value of grass? How high an intake of grass can sows obtain? A number of organic and conventional farms with outdoor sow herds participate in projects at The Danish Institute of Agricultural Sciences (DIAS). Management, grass cover and grass height are registered regularly. There is a seasonal variation in the level of grass cover. During winter, the level of grass cover is very low, especially for conventional herds and in gestation paddocks. The grass cover increases in the spring and decreases in autumn because of wear and climatic conditions. The level of the grass cover is similar for lactation and gestation paddocks, however, the grass is lower in gestation paddocks, because pregnant sows are restrictively fed, so they are hungry and therefore motivated to graze.

Introduction

Three important factors, which are different compared to conventional pig production, and which influence organic pig production are 1) use of organic feed, 2) to obtain a high level of self-supply and 3) to use roughage in the diet. In addition to this, the three factors interact and support or reinforce each other. If farmers want to feed organic feed, which at the same time is only available in limited amounts and at very high prices on the market, it is an advantage to grow the feed on the farm. At the same time, this is in accordance with the organic idea of self-supply locally. In an organic crop-rotation system, clover-grass paddocks are advantageous to fixate nitrogen for next year's crop and to improve soil-organic matter. Clover-grass can be used as roughage for the pigs, either for sows on pasture or as silage in the winter period. In the following, the three factors: organic feed, self-supply and roughage in the diet will be elaborated.

As the legislation is today, pig farmers can use a maximum of 20% conventional feed for a transitional period. The transition period expires five years after the rules have entered into force (European Union, 1999), so if the legislation does not change in the meantime, organic pigs must be fed 100% organic feed in five years time. One way for the farmers to accomplish this is to grow the feed they need for their livestock on their own farm. This is in accordance with one of the ideas of organic production the idea of self-supply.

Moreover, the European proposal for a regulation of organic production describes how organic livestock production must provide for a close relationship between such a production and the land available. This includes suitable multi-annual rotation systems and the feeding of livestock with organic crop products produced on the holding itself (European Union, 1999). This dependence on internal resources makes the relations between cropping system and herd very important. The average crop production is higher if a high proportion of the crop rotation consists of fields with grass/clover, which supports the soil fertility (Kristensen & Kristensen, 1997). However, intensive pig production is based on cereals, and it is uncertain if a production based on home-grown products meets the needs for intensive pig production. Level and composition of energy-, protein- and amino acids are expected to differ between cereal-based rations and rations of cereals and roughage.

The Danish legislation of today requires that in organic production all animals must be fed roughage all year round and have access to grass areas for at least 150 days per year. Growing-finishing pigs of more than eight weeks can be kept indoors, provided that they have access to an outdoor exercise area and are fed roughage ad libitum (Plantedirektoratet, 1999). Because of the positive experience with conventional outdoor sow herds on pasture all year, the organic sows will often be outdoors all year round, too, so it is relevant to investigate the potential of sows on pasture.

In Denmark, 30,000-40,00 conventional sows are outdoors all year round. Age at weaning is the main difference between conventional and organic outdoor systems. So far, age at weaning has been at least 49 days for organic and at least 21 days for conventional sow herds. However, paddock layouts, feeding practices, management of herd etc. do not differ significantly between the two systems, so it is possible to use the experience from conventional outdoor herds in the development of organic outdoor herds.

Experiences indicate that the results obtained in conventional outdoor herds can be at the same level as in those kept indoors, except for feed intake, which is higher outdoors due to exercise, temperature and a higher milk production. To limit the import of feed to the organic herd, it is relevant to investigate how much of the feed consumption can be grass. The opportunity for the sows to graze depends on grass cover and grass production.

Materials and methods

Table 1 shows characteristics of eight private farms, four conventional ones and four organic, with outdoor sow herds. Either the farmer or staff from the Danish Institute of Agricultural Sciences/the Danish Bacon and Meat Council (DBMC) makes registrations on the farms.

The farmers register the position of the animals in the system. Since this summer, managers of conventional herds also register use of medicine, use of straw, reasons for culling and reasons for removing a sow from her group. In addition, they register time spent handling straw and manure. A technician from DIAS/DBMC visits the farms every fortnight. At each visit are recorded the level of grass cover in each paddock and the average body conditions of the sows in each paddock.

The average herd size is higher for conventional than for organic herds. However, the conventional herds were established prior to the organic herds. The average number of piglets produced per sow is higher for conventional than for organic herds, because of a lower age at weaning in the conventional herds. However, herd No 8 is at same level as the conventional herds. Herd No 7 has a very low level of piglets produced per sow, because of a high total mortality rate and a low farrowing rate.

Feed consumption differs between conventional and organic herds as well as within the two types of systems. Herd No 3 has a higher feed consumption than the other herds, because feed for sows were used for young female pigs and gilts. Feed consumption was higher in organic than in conventional herds because of a higher age at weaning and use of silage.

The stocking rate was lower on organic farms, as required by legislation. In spring, sows are shifted to new paddocks later on the organic than on the conventional herds. This may be beneficial for the maintaining of the grass cover. On all the farms, arable land is sandy soil, except on farm No 5, which have loamy sand.

Table 1 Production results of four conventional and four organic outdoor sow herds, 1998

Production results							Stocking rate		
Herd	Herd size No. of sows	Produced piglets/ sow	Total piglet mortality (%)	Feed consumption (SFU/sow) Conc	Silage	Total	Area with grass (ha)	Sows per hectare	First insertion
Conventional									
1	125	21.4	22.4	1,542	0	1,542	7.7	16.2	Early April
2	249	21.9	22.3	1,590	33	1,623	14.7	16.9	Late Feb.
3	313	20.2	22.1	1,721	0	1,721	16.7	18.7 1)	Early April
4	121	20.0	29.4	1,637	0	1,637	5.4	22.4 1)	Early May
Organic									
5	74	18.9	25.1	1,693	236	1,929	9.7	7.6	Mid April
6	236	17.0	21.8	2,148	95	2,338	15.1	15.6	Mid April
7	50	13.0	34.0	1,383	181	1,563	4.0	12.5	Late April
8	205	20.2	16.9	1,694	164	1,859	13.2	15.5 1)	Early May

1) Mating unit is indoors, so the actual stocking rate is lower

Results

Figure 1 illustrates the level of grass cover as mean of conventional and organic farms for each of the years. For both types of farms and for all three years, the level of grass cover is very low in the beginning of the year. Reasons for this are that it is the end of the period for use of an area and climatic conditions. The grass cover reaches a higher level during April and May because shifts to new paddocks and climatic conditions favour the growth of grass. In autumn, the grass cover decreases because of wear and climatic conditions.

The development of grass cover is similar for organic and conventional herds. However, the grass cover on conventional farms reaches a lower level during winter compared to the grass cover on organic farms. Possible explanations are a higher stocking rate and an earlier time for the first insertion on the conventional farms (Table 1). Organic farmers may be more motivated to limit the loss of nutrients, because they need nutrients for next year's crop, since they cannot use fertiliser, so they lower the stocking rate.

Besides the differences in the level of grass cover caused by stocking rate and time of first insertion, it is likely that the function of a paddock influences the level of grass cover. Legislation requires a lower stocking rate (in animals per hectare) in lactation paddocks than in gestation paddocks, because of a higher level of feed supplied to lactating sows, which causes an increase in the nutrient input. The lower stocking rate is expected to cause a higher level of grass cover during winter (as seen in Figure 1). Edwards & Watson (1997) showed higher levels of grass cover in lactation paddocks than in gestation paddocks.

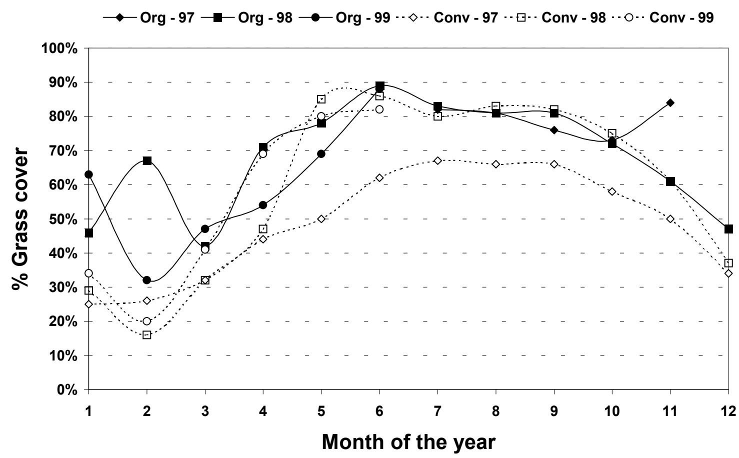

Figure 1 Grass cover on organic and conventional farms, 1997-1999

Figure 2 illustrates the level of grass cover in organic and conventional lactation paddocks, and organic and conventional gestation paddocks. Differences in the level of grass cover between lactation and gestation paddocks are not as obvious as expected. One reason for this is that the actual stocking rate does not differ in practice between lactation and gestation paddocks.

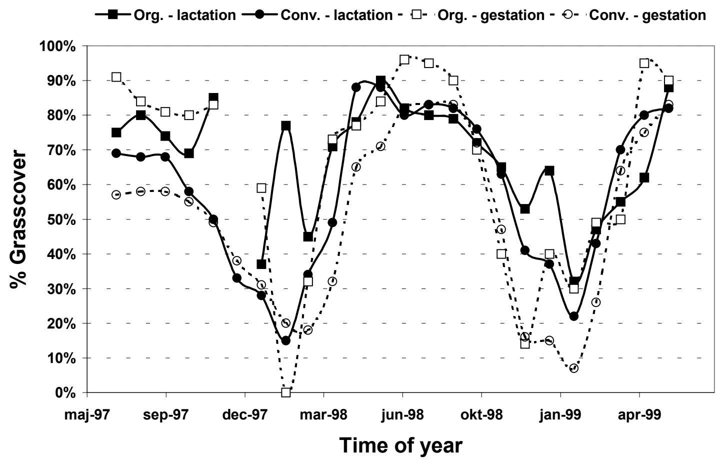

Figure 2 Grass cover in lactation and gestation paddocks

Lactating sows are fed ad libitum, so they feel no hunger and have low motivation to graze. Pregnant sows are fed a restricted ration, which is often inadequate to make the sows obtain satiety for a longer period of time. The lack of satiety motivates pregnant sows to graze. Figure 3 illustrates the difference between the function of two types of paddocks. During spring, summer and autumn, vegetation grows because of climatic conditions favouring growth. The pregnant sows keep up with the growth of grass, whereas the height of grass increases in the lactation paddocks.

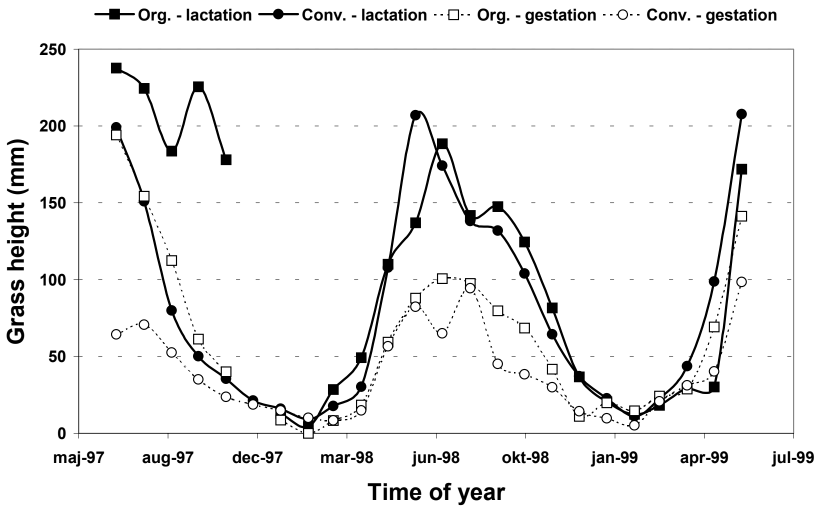

Figure 3 Grass height in lactation and gestation paddocks

Discussion

As appears from Table 1, a big amount of supplementary feed is given to outdoor sows. Compared to total intake, feed intake averages 1,250 SFU for indoor herds. Furthermore, outdoor herds have access to grass. It is obvious that the managers do not acknowledge grass as a source of energy. The reason is their uncertainty about the capacity of sows for grass intake as well as about the feed value of grass during the growth season and in relation to the variety of grass.

(Sehested et al. 1999) showed that grass made up a substantial part of the daily energy intake for pregnant sows (30-45%). Therefore, grass is a very relevant source of feed in outdoor herds in general, and in organic herds in particular. A high intake of grass increases the possible level of organic feed as well as the level of self-supply. In addition to this, grass as feed fulfils the requirement of roughage provided to the sows. Other advantages of grass is that it contributes to satiate the sows and, consequently, to a less aggressive behaviour (Berger, 1998) and perhaps also to a lower piglet mortality rate. Moreover, grass cover serves as a carpet, so that straw in farrowing huts are less exposed to dirt and humidity. The higher level of hygiene causes a lower level of piglet mortality (Berger et al., 1997; Kongsted & Larsen, 1999). Another advantage is that grass reduces the risk of nitrogen pollution (Watson & Edwards, 1997).

However, experiences indicate that, for the time being, grass is not considered a substantial part of the ration for private outdoor sow herds. Possible explanations are that there has to be a high level of grass cover, which offers grass of substantial quantity and quality.

A French investigation (Ogel, 1997) concluded that three factors are essential to maintain the grass cover. It is:

- Area available
- Ringing of the sows
- Supplementary paddocks

French recommendations are between 650 m^2 and 850 m^2 per pregnant sow (Ogel, 1997). In comparison, Danish legislation requires 550 m^2 per pregnant sow. A lower stocking rate influences the level of grass cover. Analyses of the stocking rate on farms with outdoor sow herds, which participate in projects at DIAS, support the French findings (Figure 1).

A sow without a ring in the snout quickly turns the soil upside down. In accordance with this, Watson & Edwards (1997) experienced that unrung sows reduced vegetation cover to 10% within a month.

If the grass has been degraded, the sows have to be removed from the paddock for some time for the grass to recover. For this purpose supplementary paddocks may be used (Ogel, 1997). However, in Denmark it is not common practice to have vacant paddocks, so if the grass cover decreases, it continues to decrease until the sows are shifted to new paddocks in spring (Figures 1 and 2).

Future aspects

The Danish investigations include grass as feed for pregnant sows (Sehested et al., 1999) and level of grass cover and grass-height on private farms with outdoor sow herds. However, the grazing behaviour of the sows has not been studied in Denmark. French scientists studied the grazing behaviour of pregnant sows (Guilloux et al., 1998). Sows spent more than 60% of their time resting. The remainder of the time was devoted to grazing (16%) and foraging (12%). Grazing contributed to satiety for a longer period of time, and, consequently, caused a lower level of aggressive behaviour when the sows were fed next morning (Berger, 1998). Grazing behaviour differed between days and between sows (Guilloux et al., 1998). The sows in the French experiment (Guilloux et al., 1998) were fed supplementary feed at a higher level than the sows in the Danish experiment (Sehested et al., 1999). Therefore, it is relevant to study the grazing behaviour of sows fed at a low level.

In addition to grazing-behaviour, relevant subjects for further investigations are sows' capacity for grass intake, nutritive value of grass at different times of the year, and of different varieties.

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A health monitoring study in organic pig herds

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Abstract

A health monitoring study is being carried out in four organic pig herds. Only preliminary results are available. Initially, blood samples from sows are examined to detect pathogens in the herd. Cohorts of growing/finishing pigs are followed by repeated blood sampling, and the patterns of seroconversion compared. Causes of death in piglets are examined by submission of dead piglets to the laboratory during a period. Diagnostic submissions are carried out in case of clinical problems.

Except for some problems in herd No. 1, a good state of lung health was found in the finishing pigs. Few lesions were found in the lungs at slaughter. Antibody titres and findings at slaughter probably reflect different housing conditions during the growing/finishing period. Post weaning diarrhoea due to enteropathogenic *Escherichia coli* has sometimes caused problems. Few other infections have been found.

Causes of death in suckling piglets were dominated by traumas (crushing) and starvation /weakness.
No problems related to the outdoor conditions have been recorded.

Introduction

Organic pig keeping has been increasing much in prevalence in Denmark in recent years, but organic pig production still accounts for only 0.1% of the total pig production in Denmark (Lauritsen and Larsen, 1998). Organic pig herds have mostly been very small and a part time activity for the owner, but some larger herds have now been established.

Compared to indoor housing outdoor housing allows more space for exercise, and because the stocking density is low, this will probably favour a good state of health. Housing conditions differ very much. Less control of the environment is possible, and the close contact to the wild fauna may be a risk factor (Feenstra and Andreasen, 1995). Organic pig herds have more restrictions on the use of drugs than conventional outdoor herds. Thus, much attention must be given to management routines, e.g. rotation of paddocks, to prevent disease problems. A previous study in outdoor conventional sow herds has shown that a good state of health was maintained in most herds, but in case of deficient management a very high piglet mortality was seen as well as other problems (Feenstra and Andreasen, in press).

According to the rules for organic farming finishing pigs must have outside access, but indoor pens with outdoor runs instead of paddocks with grass are accepted. Moving pigs to partly inside housing may result in more crowded conditions, and proper knowledge of optimal housing of finishing pigs is lacking (Møller and Olsen, 1998).

In order to identify possible health problems and create a better basis for advisory services, a health monitoring study involving four organic pig herds is being carried out. The study consists primarily of serological (blood) screening and monitoring programmes with the focus on growing/finishing pigs. As pigs will develop antibodies (seroconvert) when they are exposed to infectious agents, examination of blood samples can give information about pathogens present in the herd. Other elements of the study are post mortem examinations of piglets and diagnostic submissions in case of clinical problems.

The study is designed in close cooperation with the Danish Institute of Agricultural Sciences, the Royal Veterinary and Agricultural University and the Federation of Danish Pig Producers and Slaughterhouses, where other aspects of organic pig keeping are studied in the same herds. The study will be finished by the end of 1999. For this reason, data processing has not been finished and results are preliminary.

Methods

Serological screening and monitoring

At the beginning and end of the study blood samples are screened for antibodies to common porcine pathogens and to some agents, which may be transmitted under outdoor conditions. Of the latter, only results for *Salmonella* are reported here.

Every three months, groups of piglets are ear tagged, and blood samples are collected from the same animals after weaning, 6 weeks later and before slaughter. Development of antibodies to common pathogens in the individual herds as well as to *Salmonella* in all herds is followed in the period from weaning to slaughter. The lungs of these pigs are examined for lesions. As a supplement to the serological examinations for *Salmonella* pools of faecal samples (about 10 per herd) from growing/finishing pigs are examined bacteriologically for *Salmonella* at the end of the study.

Causes of death in piglets

In each herd, a plan was made to collect all stillborn piglets, dead suckling and weaned piglets up to 4 weeks after weaning during a three months period. The piglets were frozen and submitted to the Danish Veterinary Laboratory with intervals of about two weeks.

Diagnostic submissions

In addition to the scheduled submissions of blood samples and dead piglets the owners and practising veterinarians were asked to submit diagnostic material, e.g. dead pigs, organs or faecal samples, in case of clinical problems.

Results

Initial serological screening

Blood samples from 10 sows per herd were examined. In all four herds serum antibodies to *Mycoplasma hyopneumoniae* were detected. Antibodies to *Actinobacillus pleuropneumoniae*, serotype 6 were found in two herds and to serotype 12 in three herds. Antibodies to PRRS virus were present in three herds (Table 1). Antibodies to *Actinobacillus pleuropneumoniae,* serotype 2, 5 and 7 were not detected. *Salmonella* antibodies were present in all four herds.

Table 1 Initial serological screening for respiratory pathogens. Number of seroreactors (sows with antibodies) out of 10 sows tested per herd

Herd No.	Ap 2	Ap 6	Ap 12	M..hyo.	PRRS
1	0	5	4	5	9
2	0	9	0	9	9
3	0	0	9	5	0
4	0	0	10	6	8

Ap. Actinobacillus pleuropneumoniae, serotype 2, 6 or 12
M. hyo. Mycoplasma hyopneumoniae
PRRS. Porcine reproductive and respiratory syndrome virus

Serological study during the growing/finishing period

Results from the first two groups of pigs in herd No. 1 and 3 and three groups in herd No. 2 are available. Herd No. 4 did not participate in this part of the study.

Generally, the weaned piglets were without antibodies to common pathogens in the herd, but seroconversion took place during the finishing period. In herd No. 1 seroconversion took place earlier and with higher antibody titres than in herds No. 2 and 3. Two typical examples from herds No. 1 and 2, which had comparable results at the initial sow screening are shown in the graphs below (Figure 1 and 2). The patterns of seroconversion are clearly different. The results indicate a higher infection pressure during the growing/finishing period in herd No. 1.

When lungs were examined after slaughter, a high proportion had (mostly small) lesions typical of *Mycoplasma* pneumonia in herds No. 1 and 3. The lungs from herd No. 2 was without lesions. Six of 86 lungs had chronic pleuritis (from 5 to 50% of the lung surface).

Further, antibodies to *Salmonella* were detected in finishing pigs in all herds (mostly low titres). *Salmonella* was not isolated from any of the faecal samples.

Post mortem findings in piglets

Only from herd No. 2 the submissions of piglets for post mortem examinations were carried out according to the plan. In total 108 piglets were submitted from this herd, of which 10 were stillborn. In the liveborn suckling piglets crushing was the most important finding (65%), followed by weakness/starvation (25%) Thus, almost all deaths in this age group were associated with trauma or weakness, and few infections have been seen. (Table 2).

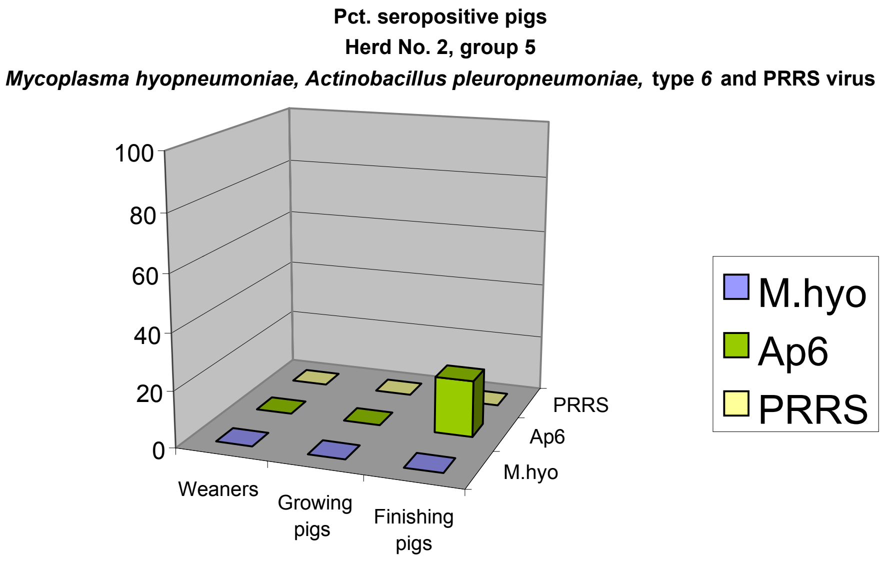

Figure 1 Pattern of seropositive pigs, example from herd 1

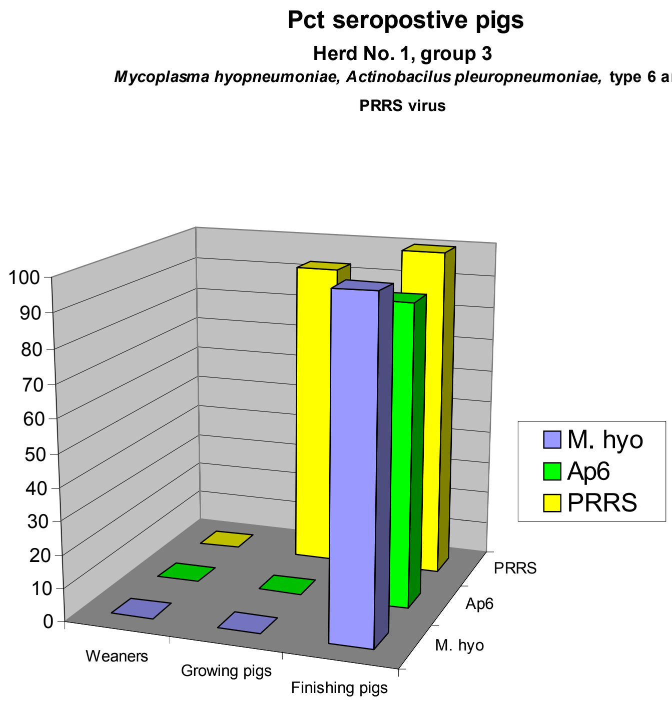

Figure 2 Pattern of seropositive pigs, example from herd 2.

Table 2 Results of post mortem examination of 98 liveborn piglets from herd No. 2, submitted during a three month period.

Cause of mortality	Trauma (crushing)	Weakness/ starvation/ cold	Enteritis (diarrhoea)	Other	In total
Age 0-3 days	51	17	1	1	70
> 3 days	10	6	3	4	24
Suckling piglets in total (< 7 weeks)	61 (65%)	23 (25%)	4 (4%)	5 (5%)	94 (100%)
Weaners (> 7 weeks)	1	0	3	0	4

Diagnostic submissions

In herd No. 1 respiratory disease among growing/finishing pigs caused considerable clinical problems at times, but little material has been submitted. Acute pleuropneumonia caused by *A. pleuropneumoniae*, serotype 6 and *Pasteurella multocida* has been diagnosed. Both herds No. 1 and 2 have experienced problems with diarrhoea after weaning. In herd No. 2, enteropathogenic *Escherichia coli* was isolated from severe cases of diarrhoea during several months. The problems started outdoors in a very rainy autumn period and continued when weaned piglets were moved to indoor pens with deep bedding. Endocarditis due to *Erysipelothrix rhusiopathiae* (erysipelas) was found once in herd No. 2.

Discussion

Except for herd No. 1 the lung health in the finishing pigs was found to be good. In herd No. 1 *A.pleuropneumoniae*, serotype 6 and Pasteurella multocida has been diagnosed in cases of acute pleumonpneumonia, but the serological results suggest that the problems were multifactorial. Both growing and finishing pigs had rather crowded lying areas and thus very close contact, which will increase the infection pressure, when pathogens are present.

The recorded pneumonic lesions were mostly small and typical of uncomplicated *Mycoplasma* pneumonia. Pleuritis from 5 to 50% of the lung surface was found in 6 out of 86 lungs, which is a low prevalence compared to the records from the Danish slaughterhouses (Christensen, 1995). However, the prevalences cannot be directly compared. In a Swedish study (Hanson et al., 1999) pleuritis recorded at slaughter was found to be significantly less prevalent in organic pigs housed outside than in conventional indoor finishing pigs, but no difference was found in the prevalence of pneumonia, which was low in both groups.

Diarrhoea in weaners and growing pigs has caused problems, especially in herd No. 2. The problem increased when the paddocks were wet and continued when the pigs were moved inside on deep bedding. In case of infectious diarrhoea complete removal of the bedding and change of paddocks may be necessary to prevent spread of the infection to the following groups of pigs, as neither deep bedding nor paddocks can be cleaned and disinfected.

Contrary to the situation in the weaned piglets post mortem examinations indicated that severe neonatal diarrhoea was uncommon. This is in accordance with earlier findings in Danish outdoor herds (Feenstra and Andreasen, in press), in which it was also found that vaccination against Clostridium perfringens type C enteritis was essential to prevent losses. Vaccination was carried out in all herds in the present study.

Until now, disease problems related to the outdoor conditions have not been seen. One case of erysipelas in herd No. 2 underlines the need for strict compliance with vaccination programmes, as an increased risk of this disease in outdoor herds has been reported (Hanson et al., 1999, Feenstra and Andreasen, in press).

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Organic Pig Production in Denmark

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Abstract

Results from a survey of five organic pig farms are presented. In Denmark, organic pig production is limited and the pilot farm investigation contributes to approximately 15% of the total production of finishers. On the organic pilot farms 17.0 piglets were weaned per sow, which are considerably lower than in conventional pig production. The reason is partly the increased weaning age (7 weeks), partly management related conception problems. The daily gain of the slaughter pigs was similar to results from conventional production, whereas feed conversion rate and lean meat percentage were poorer. Based on these results, it is estimated that the organic system "needs" an extra price of DKK 5.00 per kg.

An attempt to get a better use of roughage for finishers by feeding a total mixed diet did not succeed because the feed conversion rate became markedly poorer.

Background and objective

In the early 1990's, organic pig production was stabilized at a low level of 3-4,000 finishers produced per year, which resulted in a situation of demand exceeding supply despite the favourable prices on organic pig meat. A situation like that could not go on where customers ask for pig meat and the slaughterhouses and producers are unable to supply the article.

In order to increase the supplies of organic pig meat and at the same time to determine a realistic meat price, The Federation of Danish Pig Producers and Slaughterhouses started a four-year-project concerning organic pig production. The project was started in the autumn 1996 on 4 farms, which were converted into organic production or were under conversion. The project takes place in co-operation with Freeland Food, FDB (coops), the Danish Institute of Agricultural Sciences and the Organic Service Centre and will be completed in July 2000.

The project is carried out with a total amount of about 500 sows including finishing pigs, distributed between the farms. Our aim is to optimize the production on these farms and to evaluate the possibilities of the economic survival of future organic pig production, and also to estimate a steady pork price at farm level. In addition, several trials will be carried out to solve specific problems.

The pig producers, who collaborate in the project, will be part of an economic safety net. This does not mean higher pork prices, as sales must take place on market terms.

Materials and methods

The investigations consist of a systematic data acquisition from the four farms, including production results, farm management effects and nutrient balances so that each farm can be examined as a whole. Additionally, development projects are carried out on the farms with the object of rationalizing organic pig production so that production is effected with maximum consideration for pig welfare, working environment and surrounding environment. The development projects comprise a.o.:

- Development of systems for handling roughage.

- Development of ecological feed mixes, including alternative protein sources.

- Development of functional pen layouts complying with the ecological rules and the rules concerning welfare, environment and working conditions, and at the same time respecting the pigs' climatic conditions and behavioural needs.

Results

Development of organic pig production

The development of organic pig production in Denmark is given in Figure 1. From the early 1990's, organic pig production was stabilized at a level of 3-4,000 finishers produced per year.

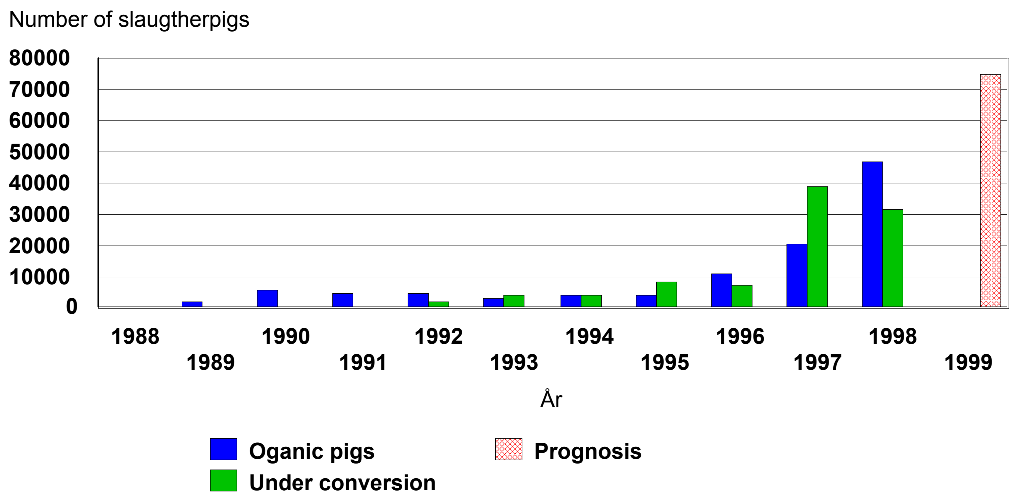

Figure 1 Development of organic pig production in Denmark

In 1996, the number of finishers produced exceeded 10,000 and in 1997 the number doubled to approx. 20,000. From 1997 to 1998 the number of organic finishers more than doubled to approx. 46,000. This corresponds to approx. 0.2% of the total Danish pig production. At the end of 1999, the number of organic finishers produced is expected to amount to approx. 75,000. It is questionable, whether this increase is exclusively a result of this project, however, as production still maintains a low level and as the project itself contributes with approx. 10,000 finishers per year, part of this development can be attributed to this project.

Farm No. 1 (retired from the project January 1st, 1999)

Production volume: 240 sows, 3,000 finishers produced, 1,000 weaners sold at 30 kg.

History: Land was converted to organic farming in 1987. The pig production was operated conventionally until 1993, when the sows were let outdoors. In 1997 the pig production was converted to organic production.

Land: 67 ha, sandy soil. Crops 1997: Spring barley (whole crop), industrial grass (ordinary rye grass and grass clover), potatoes, carrots, barley and peas (whole crop), spring wheat, grass (grazing).

Paddocks/houses: Common farrowing paddocks, outdoor runs/gestation paddocks. At the beginning of 1998 indoor service unit. Weaners housed in kennels with outdoor area. Finishers indoors in strawflow pens with access to outdoor run.

Batch operation: 1-week operation.

Farm No. 2

Production volume: 70 sows, 1,300 finishers produced.

History: Land was converted to organic farming in 1998, whereas the pig production was converted in 1997.

Land: 65.1 ha, of which 13.8 permanent pasture Sandy soil. Crops 1997: Winter rye (whole crop), spring barley (ripeness), barley and peas (whole crop and ripeness), grass clover (grazing).

Paddocks/houses: Single farrowing paddocks, outdoor service/gestation paddocks. Weaners entered directly in finishers house approx. 1 week after weaning. Finishers on deep litter with access to outdoor area.

Batch operation: 3-week operation.

Farm No. 3

Production volume: 60 sows and finisher production.

History: Land was converted in 1998. Pig production was converted to organic production in September 1998.

Land: 47,4 ha, sandy soil. Crops 1997: Spring barley (ripeness), grass clover, barley and peas (whole crop), spring wheat, field peas, oats.

Paddocks/houses: Single farrowing paddocks, outdoor service/gestation paddocks. In the middle of 1998 indoor service unit. Planning to enter weaners directly in finisher pens. Finishers on deep litter.

Batch operation: 3-week operation.

Farm No. 4

Production volume: 280 sows, 3,000 finishers produced and sales of weaners at 30 kg.

History: Land was converted to organic farming in 1998, whereas the pig production was converted in 1997.

Land: 184 ha, of which 94 permanent pasture Sandy soil. Crops 1997: Spring barley (whole crop and ripeness), barley and peas (whole crop), green barley, field peas, potatoes.

Paddocks/houses: Single farrowing paddocks, indoor service unit (AI). Outdoor gestation paddocks. Weaners entered directly in finishers house on deep litter with access to outdoor area.

Batch operation: 3-week operation.

Farm No. 5 (Project member as of January 1st, 1999)

Production volume: 60 sows, 1,000 finishers produced and sales of weaners at 30 kg. 6,000 laying hens.

History: Land was converted to organic farming in 1997, whereas the pig production was converted in 1998.

Scheme 1 Description of the five farms included in the project.

The characteristics of the farms included are given in scheme 1.

Production results of project farms

The average production results from the 4(5) farms appear from Table 1. These results should be regarded as the long-term production level of a large-scale organic pig production.

Table 1 Results for sow production

	Average 4 organic herds, 1998	Average in DK (traditional herds, 1998)
No. liveborn per litter	11.0	11.5
No. weaned per litter	9.4	10.2
1st parity litters, %	34	21
Deaths until weaning, %	14.7	12.0
Weight at weaning, kg	14.0	7.2
Feed consumption/sow/year, SFUs	1905	1350
Feed consumption/piglet, SFUs	24	45
No.non-productive days/litter	30.9	16.9
Farrowing rate, %	74	85
No. litters/sow/year	1.91	2.26
Weaned pigs/sow/year	17.0	23.0

To a large extent these results are influenced by the fact that organic weaners are weaned when they are at least 7 weeks old. This substantially influences the production volume per sow, weight at weaning and feed consumption per year sow. Weaning age of 7 weeks means a longer cycle for each sow, which results in a reduction of litters per year sow compared with traditional production. At the same time, weaning weight is increased from 7-8 kg to 14-18 kg. This means that the sow converts a larger amount of feed compared with traditional systems. In indoor systems the average feed consumption is approx. 1,350 SFUs per year sow. In traditional outdoor production with a weaning age of 4 weeks the average feed comsumption is approx. 1,600 SFUs per year sow. Naturally, the weaning age of 7 weeks causes a small reduction in feed consumption in weaner units. As it appears from Table 1, organic piglets' feed consumption is approx. 24 SFUs per pig compared with approx. 45 FUs per pig in traditional systems.

In Table 2 is given the results of slaughterpigs.

Table 2 Results for slaughter pig production

	Average of 4 organic herds 1998	Average in DK (traditional herds, 1998)
Initial liveweight, kg	29.8	31.7
Aver.slaughter weight, kg	82.2	77.1
No.feeding days per pig produced	97	89
Daily gain, g	813	786
Feed/kg gain, SFUs	3.24	2.91
Feed/pig prod., SFUs	241	191
Of this roughage, SFUs	8	-
Aver.lean percentage, %	58.2	59.9

Considering the results from the finisher units primarily slaughter weight, feed conversion and slaughter quality differ from traditional production. Slaughter weight is approx. 82 kg, which is approx. 5 kg higher compared with traditional production. Naturally, this affects feed conversion as well as slaughter quality. The average feed conversion is approx. 3.2 FUs per kg of gain compared with the average feed conversion in traditional production of approx. 2.9 FUs per kg of gain. At the same time, slaughter quality has dropped by approx. 2%, as the average lean meat content of traditional pigs amounts to 59.9%.

As it appears, the finishers' intake of roughage is very low. Roughage amounts to approx. 3% of the total feed consumption.

Economy

A comparison of production costs (Sept, 1999) in traditional and in organic production has been carried out. The results appear from Table 3.

Table 3 Production economy of pig production. Costs per slaughterpig produced, (DKK, SEPT 1999)

	Traditional	Organic
Feed costs	367	732
Veterinary costs	20	15
Energy and straw	20	67
Sundries/Breeding costs	36	25
Ground rent	-	9
Work	98	185
Maintenance etc.	26	28
Interest	76	77
Depreciations	102	76
Total costs per pig	745	1214
Costs per kg pork	**9.80**	**14.80**

As it appears from Table 3, organic pig production requires an excess price of DKK 5.00 compared with conventional production in order to pay all production costs.

Roughage for Finishers

Barley/peas whole-crop silage for finishers has been tested in one herd. Whole-crop silage is allotted as complete feed (Total Mixed Ration), and production results, health and economy recorded. From Table 4 it appears that the analysis of TMR feed differ in dry matter, crude protein and crude fibre.

Table 4 Feed analysis of TMR feed and control feed

	Control	TMR
Dry matter, pct.	87.7	63.1
Crude protein, pct.	17.4	13.8
Crude fat, pct.	4.6	3.4
Crude fiber, pct.	4.9	7.1
FUs (EFOS) pr. 100 kg	103	77*)

*) Estimated from EFOS

Production results appear from Table 5.

Table 5 Results from TMR-feeding of finishers, (30 percent wholecrop silage, and barley/peas)

	Control	TMR feeding
Number of pigs	1151	1063
Initial weight, kg	36.4	38.7
Average slaughterweight, kg	82.9	80.8
No.feeding days per pig produced	83	86
Daily gain, g	877	784
Feed/kg gain, FUs	2.95 a)	3.66 b)
Average meat percentage, %	58.2	58.6
Mortality	2.4	1.9

a) and b) differ signifikantly ($P < 0,05$)

As it appears, the use of TMR feeding reduced the daily gain by approx. 90 g, and feed conversion was increased by 0.71 FUs per kg of gain. The drastically increased feed conversion is primarily attributed to a large amount of feed waste, from the feed cart as well as the feed troughs. Additionally, it cannot be excluded that the pigs have separated the feed leaving parts of the whole-crop in the deep litter.

Discussion

The preliminary results from the project indicate that large-scale organic pig production is practicable, however, production involves a considerable economic risk as there are many unknown factors, and the market is still quite small. Moreover, it is not yet possible to describe the long-term consequences of this production method.

The prohibition against fertilizers and pesticides means that the crop rotation must hold nitrogen-fixing crops and preferably perennial crops in order to minimize the weed risk. The consequence is that part of the crop rotation (min. approx. 40%) consists of roughage. As all animals must be fed roughage, it is a benefit to the production. As roughage has not been given in the traditional pig production, it is still an open question whether the pigs can eat large quantities of roughage and maintain good feed conversion.

From this project and from the last few years of experiments with whole-crop silage for conventional gestant sows we know that sows can maintain good body conditions, even if 70-80% of the daily energy uptake is from whole-crop silage. The results of these experiments indicate that the quality of whole-crop silage fluctuates very much from one year to another so that a supplement to roughage is required. In order to compensate for this variation it is recommended to allocate the roughage as a Total Mixed Ration by means of a feed mixer. In this way it is possible to make allowance for the variations in the roughage and to optimize the daily feed ration from one day to the next.

The protein-containing crops produced in Denmark that are grown traditionally in conventional pig production are very difficult to grow under organic conditions. Pure cultivation of organic rapeseed or peas makes heavy demands on weed control, and especially rapeseed is sentitive to insect attacks. As long as it is allowed to buy up to 25% (20% as of January 1st, 2000) of the daily feed requirements as conventional feed, the problem is of little importance, however, in five years with the EC regulations laying down 100% organic feeding, the problem will be significant.

Weaning age in organic pig production

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Abstract

The aim of this study was to investigate aspects of the welfare of organic sows and piglets in relation to age at weaning by means of weight and behaviour recordings. The study included 60 sows, housed in groups of three sows, and was performed as a randomised block design with weaning respectively five or seven weeks after farrowing. We did not find any differences in weight loss, restlessness or aggression towards the piglets between sows weaned at five and seven weeks after farrowing. Also there were no long lasting differences in weight gain or behaviour parameters of the piglets. On a short term basis piglets weaned at the age of five weeks had a small depression in growth rate following weaning and appeared more fearful towards humans compared to piglets weaned at seven weeks of age. Overall there were no indication that sows suffered more by seven weeks of lactation than by five weeks of lactation but the piglets seemed to profit by a suckling period of seven weeks compared to weaning after five weeks.

Introduction

In Denmark organic produced piglets must be at least seven weeks of age before weaning. The seven week lactation period has been mentioned as a potential threat to sow welfare because of weight loss and a growing conflict between the willingness of the sow to suckle and the piglets demand for food. On the other hand weaning at an early age might threaten the welfare of the piglets.

The aim of this study was to investigate aspects of the welfare of sows and piglets in relation to age at weaning by means of weight loss and behaviour recordings of the sows during the lactation period and weight gain and behaviour recordings of piglets weaned at five or seven weeks of age.

Materials and methods

The study was performed as a randomised block design with two treatments and ten replicates distributed over the period of a year. A replicate consisted of two groups of sows and piglets selected randomly for weaning at five or seven weeks of age. The sows were of traditional outdoor genotype (Camborough 12, Pig Improvement Company Ltd.). A group consisted of three sows and their piglets (approx. 30 piglets per group) and was housed in a fenced pasture divided into three separate enclosures each containing a farrowing hut. This prevented physical contact between sows but allowed the piglets to mix. From the end of their fourth week piglets were offered piglet feed in a separate feed dispenser. After weaning the piglets were housed in an outdoor strawbased tentsystem as described by Andersen et al.(1998).

The sows were weighed and their body condition was determined when they were placed in the farrowing paddock and when they were weaned. Records of sows that were weaned seven weeks after farrowing were also made when the piglets were five weeks old. All piglets were weighed at 5, 7 and 10 weeks of age.

The behaviour of the sows were recorded immediately before weaning at five or seven weeks, respectively, after farrowing. In the case of weaning after seven weeks, the sows were also observed at five weeks after farrowing. The behavioural data included all occurrence sampling of the number of postural changes of the sows (restlessness) and of their aggression towards the piglets.

Piglet behaviour was observed once a week from the age of five to ten weeks by means of continuous focal observation. Additional observations were made at the day of weaning and the two following days. Each litter was represented by 4 piglets (2 male and 2 female) which made a total of 12 focal piglets per group.

To test the fearfulness of the piglets a "human approach" test was performed at day 1, 7 and 14 after weaning and for piglets weaned at five weeks of age also at day 28.

Performance data were subjected to analysis of variance (ANOVA), whereas the remaining data were analysed by the non-parametric test, Wilcoxon matched-pairs signed-rank test or Kolmogorov-Smirnov´s two-sample test (SAS, 1988).

Results and discussion

Weight loss of the sows is shown in Table 1. There was no significant differences in the total loss of weight in the lactation period between sows weaned five weeks after farrowing.

Table 1 Total weight loss and weight loss per week of sows in lactation period

Weaning age	5 week ls-mean ± std.err.	7 week ls-mean ± st.err.	Level of significance
Total weight loss in the lactation period:	-3.95 ± 2.13	-3.22 ± 2.24	n.s
Weight loss per week	-0.79 ± 0.43	-0.56 ± 0.45	n.s.

Also in the loss of condition of the sows there were no significant effect of piglet age at weaning. The ratio of replicates with an overall loss of condition in relation to the total number of replicates within the treatment with complete data on this variable was 3/10 for sows with 5 week of lactation and 3/9 for sows with seven weeks of lactation. None of the sows were skinny at weaning. This indicates that the weight loss of the sows caused by lactation was independent of the weaning age and harmless in respect to sow welfare.

Behaviour of the sows

The behaviour of the sows showed large individual variations and no overall differences between treatments (Table 3). Thus, there were no differences in the level of restlessness of the sows or aggression towards the piglets that could indicate that the higher weaning age was making the sows more uncomfortable or aggravated by their piglets.

De Passillé and Robert (1989) found that sows in farrowing crates becomes increasingly disturbed by the attention of the piglets to the udder as the piglets get older, and will use postural adjustments (piglet-avoidance behaviour) to limit the access to the udder. The increased activity of the piglets at the udder and their increased use of the sow as a substrate for exploration often leads to an increase in the level of aggression from the sow towards the piglets (Watson & Bertram 1983; Ladewig et al. 1984). The lack of effect of weaning age on restlessness and piglet-directed aggression in the present study may be due to the outside housing in a paddock which allowed the sows to avoid the piglets by merely walking away. Also the piglets had access to more natural substrates for exploration which might be an explanation for the stable level of restlessness and aggression towards the piglets between sows in the two treatments.

Table 3 Behaviour of the sows

	Restlessness [1]			Aggression towards piglets [2]		
	Sows weaned at 5 week	Sows weaned at 7 week		Sows weaned at 5 weeks	Sows weaned at 7 week	
		At 5 weeks	at weaning		At 5 weeks	at weaning
25 % fraction	3.0	4.3	3.3	1.7	2.7	2.0
Median 50%	5.5	5.0	5.0	2.4	6.4	4.7
75 % fraction	10.7	5.7	6.7	8.0	8.0	10.3

1) Average number of postural changes per sow in a two hour period

2) Average number of times the sow snapped at the piglets in a two hour period.

Weight gain of the piglets

There were no significant differences in weight gain between piglets weaned at five or seven weeks of age except in the period of 5-7 weeks of age (see table 4). In this period the piglets weaned at the age of five week had significantly lower weight gain than piglets still suckling their mother indicating that the piglets had difficulties coping with the weaning and the changed feed conditions. By the age of ten weeks these piglets had been able to compensate for the lower growth rate and no significant difference in total weight at ten weeks was found between piglets weaned at five and seven weeks of age.

Table 4 Weight gain of the piglets, kg

	Piglets weaned at the age of 5 week ls-mean ± std.err.	Piglets weaned at the age of 7 week ls-mean ± std.err.	Level of significance
Weight gain 0-5 week	9.84 ± 0.42	9.31 ± 0.42	*n.s.*
Weight gain 5-7 week	3.80 ± 0.42	7.43 ± 0.42	***
Weight gain 7-10 week	12.19 ± 0.42	12.36 ± 0.42	*n.s.*
Total weight 10 weeks of age	28.38 ± 0.57	29.10 ± 0.57	*n.s.*

Behaviour of the piglets

Weaning had a clear impact on the behaviour of the piglets regardless of age at weaning. The occurrence of aggression and manipulation of objects and pen-mates increased after weaning in both treatments whereas the occurrence of exploration and foraging decreased ($P<0.01$).

Belly-nosing was observed for the first time two weeks after weaning. There was an increasing level of piglets belly-nosing the following three weeks with no significant difference between treatments. Not all piglets developed belly-nosing and there was large variations within and between groups. The movements of belly-nosing resembles the movements of udder massage and the occurrence of belly-nosing is of most authors described as a sign of an unsatisfied need to suckle (van Putten & Dammers, 1976; Fraser 1978). The occurrence of belly-nosing in both treatments could indicate that piglets at both ages were still dependent of their mother.

The most prominent difference in behaviour was found in the human approach test. In the week following weaning the piglets weaned at five weeks of age appeared more reluctant to approach a standing person than those weaned at seven weeks ($P<0.001$). For both groups the latency decreased with increasing age.

An increase in aggression or manipulation of pen and pen-mates is often related to weaning (Fraser 1978) but is also under influence of factors such as changes in the environment, mixing with unknown pigs and transport to mention a few (Petherick & Blackshaw, 1987; Algers et al,. 1990, Puppe et al,. 1997). This is also the case for belly-nosing which have been found to increase in bare or restrictive environments (van Putten, 1980; Petersen et al,. 1995) and under social 'stress' (Dybkjær, 1992). The transition to a new and more restrictive environment is often the conditions for newly weaned piglets and therefore a part of weaning.

Conclusion

- There were no indications of sows suffering loss of weight or condition as a consequence of a seven week lactation period.

- Also there were no differences in restlessness or aggression towards the piglets between sows weaned at five or seven weeks of age.

- The lower growth rate in piglets weaned at five weeks compared to piglets still suckling their mother could indicate that the piglets at that age had difficulties coping with the loss of their mother and the change of diet.

- There was no long term difference in behaviour of piglets weaned at five and seven weeks of age. On a short term basis piglets weaned at five weeks of age appeared more fearful towards humans during the two weeks following weaning as compared to piglets weaned at seven weeks.

- The increased frequency of aggression and the occurrence of belly-nosing after weaning at five as well as seven weeks of age indicates that the weaning itself and/or the post weaning environment was stressful to the piglets and that at both ages the piglets were left with an unsatisfied need to suckle.

- Overall there were no indications of sows suffering a reduction in welfare following a seven week suckling period but some indications of piglets being advantaged by a suckling period of seven weeks compared to weaning after five weeks.

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Silage for outdoor lactating sows

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Abstract

A high level of self-supply is important in organic pig production. The aim of this study was to investigate if outdoor lactating sows were able to compensate for a low supply of concentrate by consumption of silage. Eighteen sows were divided in three groups receiving one of three diets. The three groups differed in maximum level of concentrate (group 1: 100 %, group 2: 85 % and group 3: 70 %). Silage was furnished ad libitum. There were no significant differences between group 1 and group 2 for the response-variables: litter gain, number of piglets weaned, energy-intake and protein-intake. Group 3 had significantly lower litter gain, energy-intake and protein-intake compared to group 1 but not compared to group 2. There were no significant differences in silage intake or weight loss in lactation between the groups. The results indicated that the sows only partly were able to compensate for a low supply of concentrate by consumption of silage. However, sows differed substantially in their daily intake of silage.

Introduction

From August 2000, EU-legislation changes and requires use of at least 80% organic feed in organic pig production. However, EU proposed to change the requirement to 100% after five years, which increases interest in self-supply because organic feed is very expensive to buy.

Therefore, it is advantageous if the free-ranging sows utilise the available grass as a feed source. A Danish experiment indicated that, if high quality is available, pregnant sows are able to consume one SFU grass per day which corresponds to 45 % of the energy intake (Sehested *et al.*, 1999). The question is if it is possible to utilise grass as feed for lactating sows too. In Denmark, where the lactating sows are fed ad libitum and the legislation for outdoor pig production requires approximately 1,000 square metre per lactating sow there is often grass of significant height in the farrowing paddock at summertime. This increases the risk for sows farrowing outside their huts, so use of grass for feed would not only reduce the cost of feed it would also reduce the risk of piglet mortality.

However, grass is only a relevant source of feed in summertime. To maintain nutrients in an organic rotation of crops it is important to grow crops, which fixate nitrogen. Some examples are clover, peas or other leguminous, which are valuable for silage too, and silage is an alternative to fresh grass in wintertime.

The aim of this study was to investigate if lactating sows were able to compensate for a low supply of concentrate by consumption of silage.

Materials and method

An experiment was made on a farm with outdoor pig production. Eighteen sows were randomly attributed to individual farrowing paddocks. The eighteen sows were divided in two batches with one-week interval. Within a batch, each sow received one of three diets. Between day 0 and day 4 after farrowing, feed ration increased progressively from 1.5 kg to 4 kg for all three groups. Afterwards, one kilo was added per day until feed ration reached 10, 8.5 and 7 kg per day per sow for group 1, 2 and 3, respectively. The silage was a whole-crop mixture of 1/3 of wheat, 1/3 of barley and 1/3 of peas. The composition of the silage is shown in Table 1. Feed was offered as dry pellets in one morning meal. Fresh silage was provided every day. The sows did not have access to roughage prior to the experiment. In addition, because it was winter, level of grass-cover was very low. No creep feed was given to the piglets.

Table 1 Silage composition

Dry matter (%)	28,8
Crude protein (%)	3,68
ME (MJ/kg)	3,00

Body weight of each sow was measured the day the sows were introduced into the farrowing paddocks (approximately one-week before their expected farrowing date) and at weaning. The litter weight was measured three times during the lactation period: within 24 hours of birth, at weaning and another intermediate date. The number of piglets after fostering and at weaning was registered for each sow. The amount of silage consumed per day was registered for each sow during the whole lactation period.

Results

The performances and the energy, protein and silage consumption of the three groups are presented in Figure 1. The three groups differed significantly in litter gain (P=0.047) but not in number of piglets at weaning (P=0.369). During lactation, the sows weight loss tended (P=0.066) to differ between the three groups. The three groups differed significantly in energy (P=0.009) and protein (P=0.013) consumption but not in silage consumption (P=0.226).

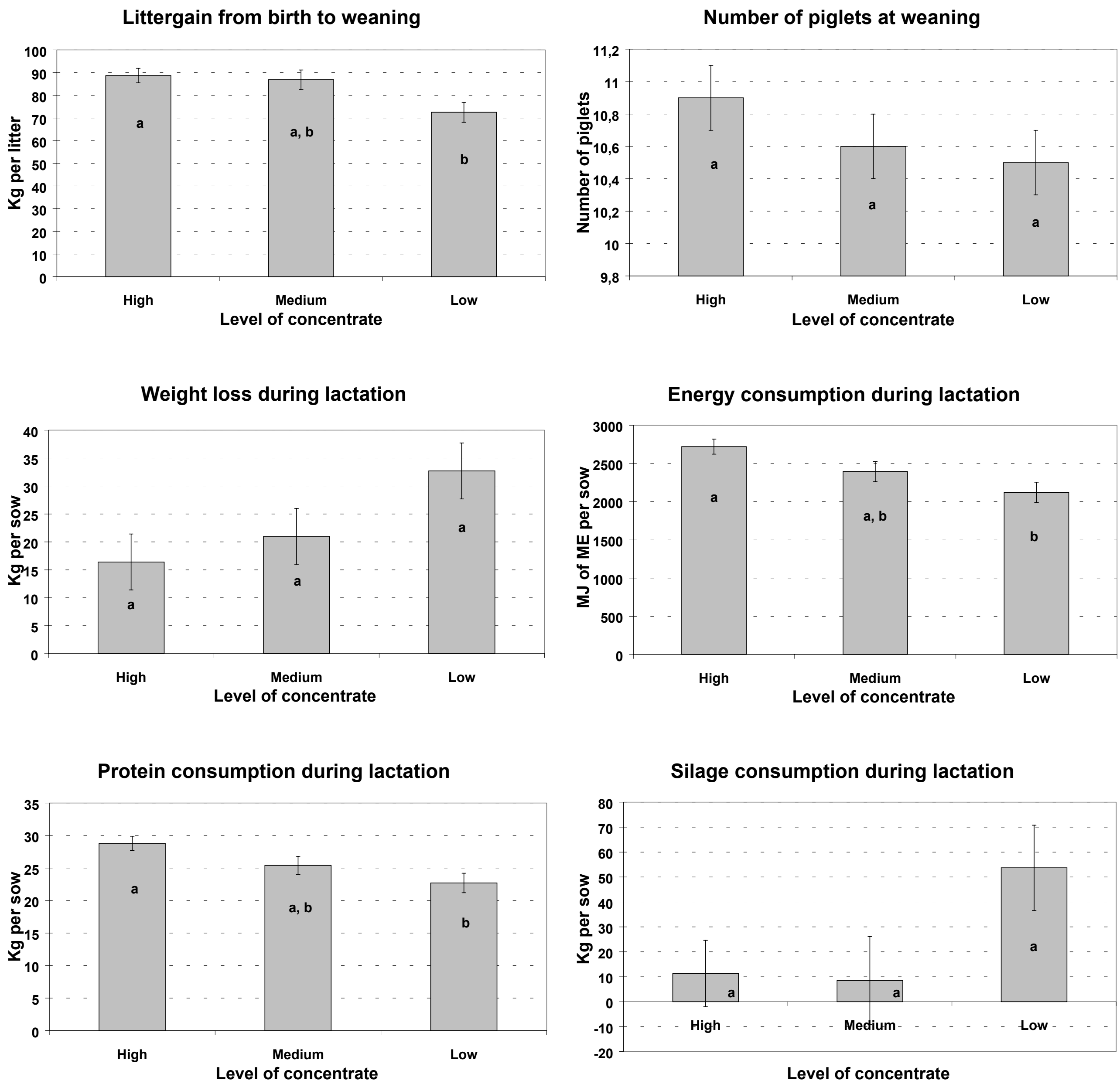

Figure 1 LS-means for the performances and the energy, protein and silage consumption of the three groups given high (10 kg per day), medium (8.5 kg per day) or low (7 kg per day) maximum level of concentrate. A, b, c: LS-means differed significantly ($P<0,05$).

Although not significant, silage consumption differed substantially between the groups. There was a very large individual variation between the sows (Figure 2).

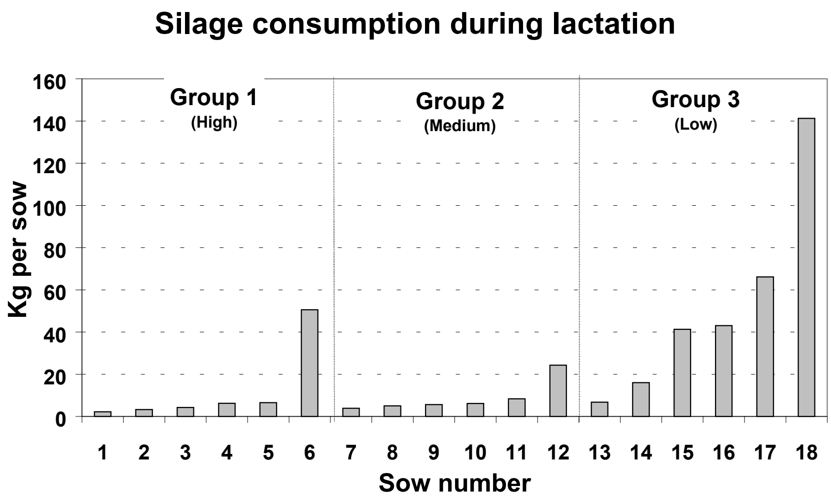

Figure 2 Silage consumption per sow of the three groups given high (10 kg per day), medium (8.5 kg per day) or low (7 kg per day) maximum level of concentrate

Figure 3 shows the reduction in concentrate intake between the three groups compared to the reduction in energy and protein intake between the same groups. The level of concentrate intake was 27.1 % lower in group 3 compared to group 1. However, by eating more silage, group 3 was able to limit the difference in energy and protein intake to 22 % and 21.1% respectively compared to group 1.

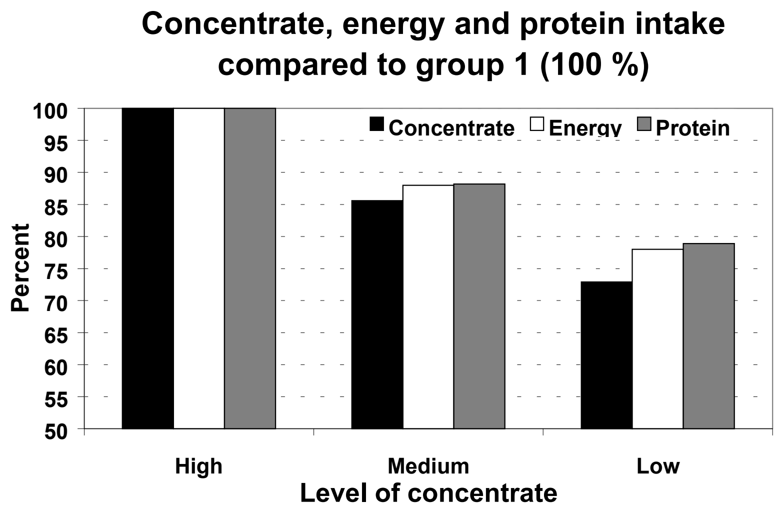

Figure 3 Reduction in concentrate intake between the three groups given high (10 kg per day), medium (8.5 kg per day) or low (7 kg per day) maximum level of concentrate compared to the reduction in energy and protein intake between the same groups

Conclusion

- *The results indicate that lactating sows only partly are able to compensate for a low supply of concentrate by consumption of silage*

For group 2 (85%) and group 3 (70%), intake of silage did not counterbalance the lower level of energy and protein supplied in concentrate. However, the reduction in energy and protein intake (as a percentage) between e.g. group 1 and 3 was lower than the percentage reduction in concentrate intake between the two groups. The lower level of energy and protein influenced production of the sows, so group 2 and group 3 had lower litter gain and increased weight loss compared to group 1.

- *The results indicate large individual differences between sows in level of silage intake*

Sows differed substantial in silage consumption within a group. During lactation the silage intake differed from 6,8 kg to 141,2 kg per sow in the group, which were fed the lowest level of concentrate.

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Feeding of ecological fattening pigs with pellets and roughage as complete feed

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Abstract

At the Danish Institute of Agricultural Science, Research Centre Bygholm, an ecological pig production system is under development. One of the developing topics is the feeding system. Two trials whith roughage and pellets given as a complete feed to fattening pigs in wooden vessels were carried out. The aim was to find a method of feeding a group of pigs with 10-20% of roughage by giving them free access to food and ensuring that all pigs would eat both pellets and roughage. Another aspect was to develop an environmentally desirable and simple type of feeding trough. The pigs were fed on the complete feed from an average live weight of 40 kg and until slaughtering. The feed consumption, the weight gain and the meat content were measured, and the overall consumption of roughage was calculated. The intake of roughage was 7 - 19% of the total energy intake when the pigs were fed restricted with complete ration pellets. The daily gain decreased with mixed feed compared to pellets and roughage offered separately. The pine vessels were not sufficient to ensure all pigs a feeding place. Feed restrictions from 20-40 kg with a complete feed did not result in a better roughage consumption or a better utilisation later in life, and in this trial it was not overtaken by a compensatory growth later on.

Introduction

At the Danish Institute of Agricultural Science, Research Centre Bygholm, an ecological pig production system is under development. One of the developing topics is the feeding system. Two trials with roughage and pellets given as feed mix to fattening pigs in wooden vessels were carried out. The aim was to find a method of feeding a group of pigs with 10 - 20% of roughage by giving them free access to food and ensuring that all pigs would eat both pellets and roughage. Another aspect was to develop an environmentally desirable and simple type of feeding trough. The pigs were fed on the complete feed from an average live weight of 40 kg and until slaughtering. The feed consumption, the weight gain and the meat content were measured, and the overall consumption of roughage was calculated.

Previous studies of feeding roughage to fattening pigs have shown that when offered a reduced level of the pellets (80% of normal) in an ad-lib feeder and the roughage in a hopper, the pigs were able to eat 8-12% of the roughage (barley-pea silage) without any reduction in their feed intake or daily gain. The feed conversion ratio was acceptable, but the variation in growth was high.

The target of this study was to limit the variation in growth, although the group of fattening pigs were slaughtered over a period of three weeks with a variation in live weight of maximum 15 kg.

To ensure the success of the target, the pigs were divided into two groups, one for small animals and one for large animals. The pigs were fed on a complete feed of pellets and roughage to give them equal access to the feed pellets.

Materials

The fattening pigs were all bought from one farm as weaned pigs and fed on a weaner diet equal to the feed in the sow herd until they reached a live weight of 35 kg. The feed consisted of 85% ecological complete ration pellets from a Danish commercial feedstuff factory and roughage given ad lib. During the winter ecological barley-pea wholecrop silage and during the summer freshly harvested organic clover grass from the fields of the research station was fed. Dry matter content of barley-pea silage was 24.5% and energy content was 0.17 FU/ kg fresh weight, dry matter and energy content in the fresh clovergrass were 12.8% and 0.09 FU/ kg fresh weight as an average of the harvest period. To ensure that the pellets and the roughage were mixed properly, the pellets were rolled before mixing. The round pine wood feeding vessels were 80 cm in diameter and 40 cm high. There were four vessels in a paddock with 30 animals.

Methods

The research included two trials each with four groups of fattening pigs. In the first trial two groups were fed with unmixed feed, i.e. pellets in ad-lib feeders and silage in hoppers, two groups were fed on a mixture of pellets and silage in vessels from 40 kg of live weight (Table 1). In the next trial all four groups were fed on a mixed ration, but with two different levels of roughage, namely a high (25%) one and a low (15%) one (Table 2).

Table 1 Feeding strategy in feeding fattening pigs with roughage and pellets separated or as mixed feed. Trial 1

Feeding strategy	**Separate feeding**		**Mixed feeding**	
Animal weight	**Group 1**	**Group 2**	**Group 3**	**Group 4**
20-40 kg				
Pellets	80%*	80%	80%	80%
Barley-pea silage	Ad-lib	Ad-lib	Ad-lib	Ad-lib
40-60 kg				
Pellets	80%	80%	80%	80%
Barley-pea silage	Ad-lib	Ad-lib	20%	20%
60-100 kg				
Pellets	80%	80%	80%	80%
Barley-pea silage	Ad-lib	Ad-lib	20%	20%

*Percentage of the recommendated feed level for 800 g daily gain

Table 2 Feeding strategy for feeding fattening pigs with roughage and pellets as mixed feed with high and low level of roughage. Trial 2

Feeding strategy	**High level of roughage**		**Low level of roughage**	
Animal weight	**Group 5**	**Group 6**	**Group 7**	**Group 8**
20-40 kg				
Pellets	100%	100%	95%	95%
Barley-pea silage	Ad-lib	Ad-lib	Ad-lib	Ad-lib
40-60 kg				
Pellets	100-75%	100-75%	95-85%	95-85%
Fresh clover grass	0-25%	0-25%	5-15%	5-15%
60-100 kg				
Pellets	75%	75%	85%	85%
Fresh clover grass	25%	25%	15%	15%

Statistical analyses (regression analyses) were made on daily gain adjusted to 100 kg live weight and meat content adjusted to 75 kg slaughtering weight for Trials 1 and 2, separately and combined.

Results

In the two paddocks with separated feed, the strongest pigs ate the pellets first while the others either ate the silage from the hopper or rested until the first ones had finished their meal. In the paddocks with complete feed the strongest pigs were likewise the first ones to eat. The ∅ 80 cm wooden vessels were expected to be large enough for at least six pigs to eat at same time, but two or three of the strongest pigs were blocking the vessels while eating and keeping the other animals away from the feed. Some of the crossed pellets blew away or were lying on the back of the strongest pig while it was rooting in the vessel, and some of the other pigs grabbed a small portion of feed and ran away. Instead of sufficient eating spaces for about 24 - 32 animals there was only room for 8 - 10 animals at same time, and consequently, the pigs were aggressive and very noisy

In the next trial with mixed feeding, only, the space around the vessels was enlarged, but still, the aggressions, the waste of crossed pellets and the noise seemed to increase. When the pigs reached a live weight of about 60 kg, the feeding in vessels, only, was given up. Groups 5 and 6 were fed on mixed diet from hoppers, only. Groups 7 and 8 were both fed from 2 vessels, and from a hopper with space for 8-10 animals.

Feed intake and production results are given in Table 3. In first trial the slaughtering period lasted over five weeks, and in the second trial it was extended to last over 10 weeks in order to get an acceptable weight at slaughtering. Due to an overestimation of content of digestible energy in the roughage at the planning of the experiment the mixed diet had a lower energy conccentration than planned. Therefore the pigs fed the mixed diet were offered less energy per day than expected.

After the slaughtering weight had been adjusted to 75 kg there were no statistically significant differences in meat percentage between Groups 1, 2 and 3, but a statistically better meat content was found in Group 4 than in Group 1 ($P<0.05$). In Trial 2 no statistical difference in meat content was seen, but all groups in Trial 2 had a significantly higher meat content than Groups 1, 2, and 3 in Trial 1 (P>0.01).

Daily gain was remarkably less in all the groups fed on mixed diet than in the two groups fed on separate diets. In Trial 1, The daily gain at 100 kg liveweight in Group 3 were 120g (P<0.01) and in Group 4, 170 g (P<0.01) lower than that seen for Group 1. In Trial 2, Groups 7 and 8, which were fed restricted in the whole period from 20 kg, had about 50 g lower daily gain but this difference was not significant. Alle the groups in Trial 2 had lower average daily gains than the groups in Trial 1. Group 4 had a slightly higher meat content than group 1. Probably because of less daily intake of energy an a higher intake of rouaghage with fibre, which depress feed utilization, they were not sufficiently supplied with energy and deposed less fat than group 1.

Table 3 Productivity results from two trials with roughage given separately from feed pellets or as a mixed diet.

Feeding strategy	Group number				Group number			
	1	2	3	4	5	6	7	8
Aver. initial weight, kg	23.0	23.0	20.6	19.5	18.5	13.4	14.4	19.2
Aver. slaughtering weight, kg	75.3	75.6	68.2	66.9	78.0	78.3	74.7	76.9
Feed intake								
Roughage, kg DM per produced pig	30	19	44	43	43	33	29	32
Roughage, % af FU intake	10	7	14	15	19	15	9	10
Feed intake FU/pig/day	2.4	2.3	2.4	2.2	2.2	2.1	2.2	2.3
Productivity results								
Aver. daily gain, g	814	823	691	645	611	647	565	561
Daily gain adjusted to 100 kg live weight	861[a]	864[a]	710[b]	746[b]	622[c]	621[c]	575[d]	564[d]
Meat content, %	57.6	57.5	59,8	59,6	60.1	60.2	59.9	60.7
Meat content adjusted to 75 kg sl. weight	57.4[a]	57.5[a]	58.3[a]	59.2[ab]	59.9[c]	60.9[c]	59.1[bc]	61.0[c]
Feed conversion ratio, FU/ kg gain	2.8	2.8	2.7	3.4	3.9	3.5	3.2	3.9

Values in the same row with different letters differ significantly

Discussion and conclusion

In half of the groups the consumption of roughage was about or 9-12% of the total energy consumed. There were no connection between intake of roughage and growth rate or intake of roughage and meat content. The total amount of energy consumed per pig per day as an average from the beginning to slaughtering only showed a variation of 0.5 FU, while the daily gain differed significantly. The greatest variation of 262 g was found between Group 2 and Group 8. On the other hand, the meat content was remarkably higher in Trial 2 than in Groups 1 and 2 in Trial 1, which implies that the pigs in Trial 2 did not have surplus energy for fat deposition (nor had group 7 and 8 for compensatory growth). Dietary fibres will reduce the energy utilisation of the total diet. An increase by 1% in dietary fibres from cereals will reduce the efficiency of the utilisation of metabolizable energy by 0.7% (Just 1982). In Trial 1, Group 1 consumed 7.5% of roughage with 23% of dietary fibres, and the feed conversion ratio was 2.8 FU/kg gain, while Group 3 and 4 consumed 15% of roughage and had a feed conversion ratio of 3.6 FU/kg gain. The amount of dietary fibres in the diet of Group 3 and 4 would cause a reduction in the utilisation of energy of about 0.05 FU/kg gain only.

Danielsen et al.(1999) fed two groups of fattening pigs either a semi ad lib. (high) ration or 70% of semi ad lib. (low) ration of concentrate pellets and fresh clover grass ad lib. The group fed the high ration consumed 2.5 FU per pig per day while the group fed the low ration consumed 2.0 FU per pig per day with a feed conversion ratio of 2.91 FU/kg gain and 2.70 FU/ kg gain respectively. The feeding results from group 1 and 2 in our trial were intermediary to those results of Danielsen et al. (1999), although the feed consumption of the 6 complete feed groups were at same level as in the research of Danielsen et al (1999) the growth rate and the feed conversion ratio were much less profitable.

The higher content of dietary fibre in the mixed diet can not explain the poor utilisation of the feed in these groups. The health conditions were at the same level. It was not possible to measure the feed waste, but it might have been very high at the time when the pellets were rolled and mixed with the roughage before it was unloaded in the pig units.

In conclusion

* To mix the feed in this particular way will not be the proper way to minimise the period of slaughterings. Variation in live weight gain in group fed pigs.

* With a pellet ration of 80% of that recommended, and with roughage ad-lib, it will be possible to achieve a feed conversion ratio of 2.9 FU/kg gain and a roughage consumption of about 5-10% of the total energy supply.

* Feed restrictions from 20-40 kg with a complete feed did not result in a better roughage consumption or a better utilisation later in life, and in this trial it was not overtaken by a compensatory growth later on.

Waste of crushed pellets from the complete feed could somewhat explain the very low feed conversion ratio in the six groups.

To reach a more equal growth in a group the next strategies will be to have one eating space per animal, to offer feed pellets in the morning and roughage in the late afternoon, and to divide the group of pigs into two when the group reach 50 kg liveweight in average, so the small pigs are fed in one group and the large in an other.

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Internal parasites in organic sheep farming

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Abstract

Organic sheep farming is increasing in Sweden. The majority of health problems in these flocks are caused by internal parasites, due to management without use of anthelmintics and/or adjusted grazing plans on the farms. A project is started to study parasites in organic sheep farming. Parasitism is multifactorial and consequently a large number of flocks are studied in different parts of the country and for three successive years (1997-99). Faeces samples from ewes and lambs at lambing-time and during the grazing-period are analysed from 100 KRAV-certified flocks and different models for preventing parasitism will be compared. The effect of lambing-date, geographic region etc will be statistically interpreted. The results will be used in farm-adjusted schemes and in order to minimize the use of anthelmintics.

The prevalence of *Trichostrongylidae* (except *Nematodirus* species) were 93% (1997) and 95% (1998). There were no differences between geographic regions. *Haemonchus contortus* was found in ewes after lambing in 24% (1997) and 16% (1998) of the flocks. Lambs on permanent pastures showed higher EPG - (egg per gram) values than lambs which have been grazing non-infected pastures. *Nematodirus battus* was found for the first time in Sweden. The project will continue during 1999 and results will be published in March 2000.

Introduction

Organic sheep-farming is increasing in Sweden. One of the most important challenges in this production is to handle the parasite-situation:

- What will happen when farmers stop using anthelmintics?
- Will their sheep and lambs be heavily infected with internal parasites?
- Which species of parasites will we found among sheep-flocks, from north to south, when we no longer "hide" parasite-infections through routine-drenching?
- How can we avoid parasite-problems? Which recommendations can we give the farmers?

The aim of this study is to collect knowledge and experiences, to build up competence among veterinarians, farmers and a laboratory capacity, in order to give adequate advice and service to organic sheep farmers.

Methods

The project is running for three years, 1997 to 1999. A three years period was important to avoid the influence of weather.

About 180 KRAV-certified farmers with herds of at least 20 ewes were invited to join the project. KRAV is the control organisation for organic production in Sweden. In 1997 72 farmers participated, in 1998 101 and in 1999 93 farmers.

The study includes analyses of faecal samples, telephone contact with farmers, regular summaries and processing of statistical material. At the end of each year participants have answered a questionnaire concerning pasture-area, size of the flock, parasite-free or infected lamb-pastures, health problems that may be due to parasites etc.

Each participating flock was sampled three times:

1. From 8 individual ewes after lambing, and mostly before turn out on pasture in spring

2. From 8 individual lambs 4 weeks after turn out on pasture
   The results will indicate survival of parasites from the previous grazing-season and the over-wintering infection in the ewes and on pastures.

3. From 8 ewes and 8 lambs in September-October.
   The results will indicate how much the parasites-infection is increasing during the same season.

On occasions with clinical indications of parasite-infection (diarrhoea) at other times in a flock, faecal sampling was made from 8 individuals.

Samples have been cultured and analysed by professor Olle Nilsson and Britt-Louise Ljungström at the Swedish Animal Health Service's laboratory of parasitology at Svelab, Kristianstad and SVA,Uppsala. The analyses have been conducted by and statistically interpreted by professor Olle Nilsson.

Results

This year's samplings have not yet been finished. To this date 5 500 samples have been analysed.

Ewes after lambing: 95% of the flocks sampled were infected with *Trichostrongylidae* - that means these species, *Nematodirus* excluded (Table 1). The most serious result, clinically and epidemic, is that the big stomach-worm *Haemonchus contortus*, also called barber's pole worm, was found in many flocks - almost 20% per year. In reality this figure is actually higher which I will return to. In several of these flocks *Haemonchus* was more or less resistant towards the most commonly used drugs, bensimidazols. *Trichostrongylus* species were found in more flocks than expected.

EPG-values were higher in 1997 than other years due to high prevalence of *Haemonchus* in 1997. EPG-values were higher in *Haemonchus*-positive flocks than in *Haemonchus*-negative flocks (Table 2, Figure 1).The spring-rise effect was more correlated with the time of year than with the lambing-time per se (Table 3). This is a very important finding since according to other studies the increase in EPG-values is more correlated to lambing (post-parturient rise) than season of the year.

Lambs after four weeks on pasture: *Trichostrongylidae* were found in 85% of the flocks (Table 4) and in 54% of the lambs. The EPG-values were on a low level (Table 5, Figure 2). The primary infection was lower on new pastures than on permanent pastures (Table 6, Figure 3) and not depending on if ewes were drenched or not.

Ewes in September-October: The EPG-values were low, which is to be expected - normally the egg-production falls down to zero after weaning (Table 7, 8).

Lambs in September-October: Prevalence on flock-basis was high concerning *Trichostrongylus spp* (Table 9). Prevalence of *Nematodirus spathiger* was low, and *Trichostrongylus filicollis* was found in more flocks compared to four weeks after turn-out, but EPG-values were low, as for *Chabertia*.

Nematodirus battus was found for the first time in Sweden in two of the participating flocks. This year a prevalence-study is conducted to determine to what extent *N. battus* is present in the Swedish sheep population.

Grazing sheep together with cattle or horses didn't as far as we could see change the prevalence and EPG among ewes and lambs (Table 10).

There were no differences between the northern part and the southwest and south-east parts of Sweden.

In some herds clinical problems have appeared in August-September with diarrhoea, wasting and sudden death among lambs due to *Trichostrongylidae*. These flocks were drenched with suitable anthelmintics.

Last autumn, we also sampled 17 flocks with "winter-lambs" - that is lambs which were not finished for slaughter in ordinary time (summer or autumn); instead they are fed indoors over winter and slaughtered in January-May, about one year old. 91% of the winterlambs had *Trichostrongylidae* eggs, compared to 79% of the lambs in September-October. EPG-values were also significantly higher among the winterlambs.

Discussion

So far, we can conclude that it is important to give lambs a parasite free pasture during the first three-four weeks after turn-out. This will reduce the parasite-burden of the lambs, the egg-production and thereby reduce the infection on pasture.

Tr. colubriformis may be a problem in the future, since this parasite build up an infection in the sheep over some years. For this and other reasons it is also important to let newly weaned lambs graze parasite free pastures, for example after making silage or hay.

Haemonchus contortus was found in 51 of the 150 flocks participating during 1997-99. Provided that the lambs are grazing areas with low parasite-infection, the most important way to avoid disasters is to check that the ewes don't infect pastures with *Haemonchus contortus.* The worm is very fertile, but to our knowledge *Haemonchus* do not overwinter on pasture. Thus pastures can be infected only via eggs from the sheep. If ewes are infected with *Haemonchus* the infection will increase on pasture from about midsummer and onwards. If the lambs graze together with infected ewes, the risk is very high that the lambs will get infected with *Haemonchus*. The clinical symptoms of haemonchosis are rapid weight loss, growth retardation, anaemia, oedema (swelling between the mandibulas) and sudden death. This can happen to both adult sheep and lambs. Therefor, this parasite causes suffering in sheep, and this is not in accordance with good animal welfare. Even more, when these lambs are slaughtered, carcass quality will not be as good as expected and desired, and these lambs are paid less than others. Since *Haemonchus contortus* was found in every third of the flocks our recommendation is to sample six ewes after lambing but two weeks before turn out on pasture. If analyses show more than 5-600 EPG *Haemonchus* should be suspected. If *Haemonchus* is demonstrated, the ewes should be drenched with avermectin before turn out.

We also recommend sheep-owners to sample their winterlambs in October in order to discover parasite-infections that may cause growth retardation and/or health problems. Of course, it is also advisable to analyse faeces-samples for parasites if the sheep show symptoms like diarrhoea, coughing or ill thrift. Bought- or hired-in sheep should be sampled or at least drenched with avermectin before turn out on pasture.

Table 1 Egg output from ewes after lambing in April-May (including a few ewes with lambing in March and June).

Species	**Herd prevalence (%)**		
	1997 n=72	**1998 n=101**	**1999 n=93**
Trichostrongylidae (excl. Nematodirus)	93.1	95.0	97.8
Ostertagia spp	93.1	97.7	87.1
Trichostrongylus spp	73.6	94.3	84.7
Haemonchus contortus	23.6	15.9	18.8
Cooperia spp	02.2	00.0	04.7
Nematodirus filicollis	51.4	43.0	38.7
Nematodirus spathiger	05.6	05.0	00.0
Bunostomum trigonocephalum	11.1	00.0	00.0
Strongyloides papillosus	44.4	47.0	52.7
Capillaria spp	12.5	07.0	15.1
Trichuris ovis	04.2	02.0	04.3
Chabertia ovina	81.9	72.0	78.5
Moniezia expansa	19.4	19.0	17.2

Table 2 Egg output from ewes after lambing, 1997-1999 in herds with and without *Haemonchus*

	Herds		
	Haemonchus +	**Haemonchus-**	**Significance of difference**
Number of individuals	352	1755	
EPG (Egg Per Gram), Geometric mean	0298	046	P<0.001

Table 3 Egg output from ewes after lambing in March ("post-parturient rise") or in April ("spring-rise"). The same ewes were sampled at both occasions. (N=83)

	March	April	Significance of difference
Prevalence-%	56.6	91.6	
EPG, Geometric Mean	13	123	P< 0.001

Table 4 Egg output from lambs in June-July, herd prevalence (%)

Species	1997 n=66	1998 n=81	1999 n=74
Trichostrongylidae (excl. Nematodirus)	87.9	88.9	79.7
Ostertagia spp	87.7	78.3	70.5
Trichostrongylus spp	55.4	78.3	52.2
H. contortus	00.0	05.8	06.8
C. curticei	03.1	04.3	00.0
N. filicollis	39.4	42.1	31.1
N. spathiger	10.6	11.1	02.7
B. trigonocephalum	00.0	00.0	00.0
S. papillosus	72.7	59.4	70.2
Capillaria spp	00.0	00.0	00.0
T. ovis	06.1	04.9	05.4
C. ovina	15.2	25.9	22.9
M. expansa	37.9	39.5	27.0

Table 5 Prevalence of Trichostrongylidae in lambs in June - July 1997-1999

Number of lambs	1737
Prevalence, %	53.8
EPG, Geometric Mean	018

Table 6 Egg output of Trichostrongylidae, comparing grazing in parasite free and permanent pastures spring 1997 and 1998. Haemonchus positive flocks are excluded.

	n	EPG Arithm	EPG Geom	Positive no	Positive %	P-value Re (95% C.I.)
1997						
Parasite free pasture	149	47	3	44	29.5	<0.0005
Permanent pasture	143	276	57	107	74.8	2.5 (1.9-3.3)
1998						
Parasite free pasture	152	38	3	49	32.2	<0.0005
Permanent pasture	141	263	46	100	70.9	2.2 (1.7-2.9)

Table 7 Egg output from ewes in September-October

Species	Herd prevalence (%) 1997	1998
	n=60	n=74
Trichostrongylidae (excl. Nematodirus)	40.0	78.4
Ostertagia spp	26.7	40.7
Trichostrongylus spp	21.7	48.1
H. contortus	05.1	05.6
C. curticei	01.7	00.0
N. filicollis	03.3	10.8
N. spathiger	01.7	04.1
B. trigonocephalum	00.0	00.0
S. papillosus	38.3	41.9
Capillaria spp	01.7	05.4
T. ovis	01.7	04.1
C. ovina	48.3	48.6
M. expansa	06.7	05.4

Table 8 Egg output of Trichostrongylidae from ewes and lambs in September-October, herd level

	Mean of herd mean ± sd Arithmetic	Geometric	P-value
Ewes			
1997 (60)	032 ± 075	003 ± 008	
1998 (74)	053 ± 079	008 ± 018	97/98 < 0.05
Lambs			
1997 (60)	269 ± 378	119 ± 177	
1998 (73)	384 ± 632	194 ± 134	97/98 > 0.05

Table 9 Egg output from lambs in September-October

Species	Herd prevalence (%) lambs 1997	1998
	n=60	n=73
Trichostrongylidae (excl. Nematodirus)	70.0	93.2
Ostertagia spp	67.7	65.7
Trichostrongylus spp	53.3	80.0
H. contortus	06.7	11.4
C. curticei	00.0	00.0*
N. filicollis	65.0	50.7
N. spathiger	15.0	13.7
B. trigonocephalum	00.7	00.0
S. papillosus	76.7	89.0
Capillaria spp	00.0	02.7
T. ovis	13.3	27.4
C. ovina	83.3	91.8
M. expansa	47.7	43.8

*) *Cooperia oncophora* and *Cooperia* sp: 05.7%

Table 10 Egg output of Trichostrongylidae comparing grazing with horses and/or cattle 1997 and 1998. Haemonchus+ flocks are excluded

	n	EPG		Positive		P-value
		Aritm	Geom	No	%	
Permanent spring-pasture and parasite-free or permanent autumn pasture						
1997						
Without horses/cattle	45	233	61	36	80.0	>0.4
With horses/cattle	78	193	61	65	83.3	
1998						
Without horses/cattle	56	171	45	43	76.8	>0.05
With horses/cattle	45	281	88	38	84.4	
Parasite-free spring-pasture and parasite-free or permanent autumn-pasture						
1997						
Without horses/cattle	31	302	52	22	71.0	>0.1
With horses/cattle	80	195	32	56	70.0	
1998						
Without horses/cattle	46	87	11	24	52.2	<0.0005
With horses/cattle	64	202	61	51	79.7	

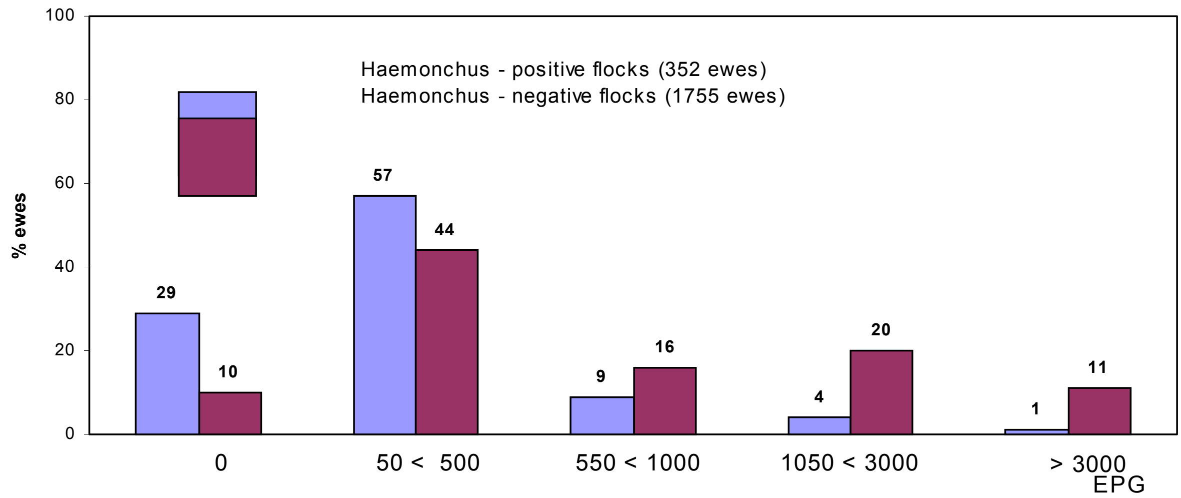

Figure 1 % ewes at different EPG-levels in Haemonchus positive and negative flocks.

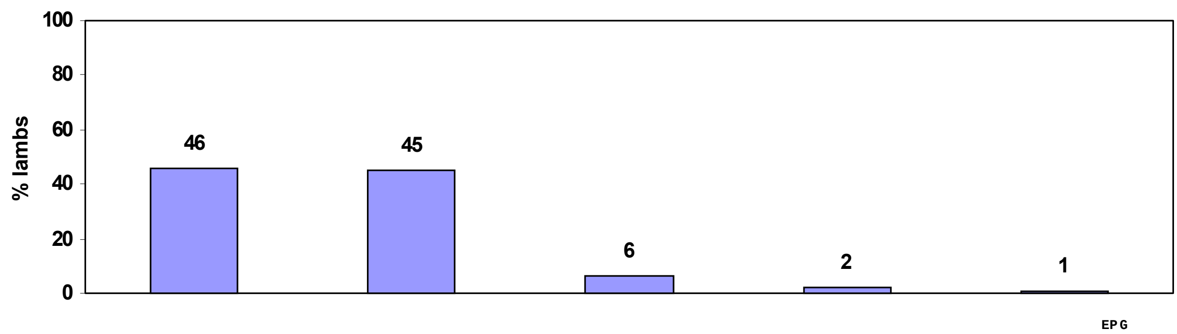

Figure 2 Distribution of EPG levels in lambs June/July 1997-99 (n=1737).

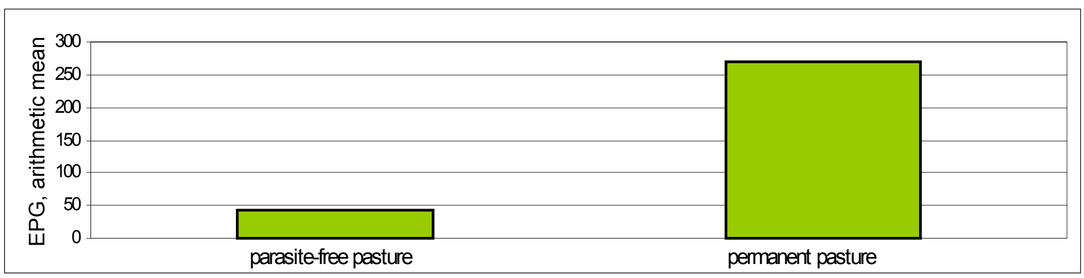

Figure 3 Egg output from lambs after 4 weeks on parasite-free and permanent pasture

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The potential of organic beef production using dairy breed bull calves

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Abstract

The organic farmer's background for selling young bull calves instead of finishing them for slaughter as well as the potential of beef production on dairy farms were investigated. Ten organic dairy farmers were visited and interviewed.

It was concluded that the uncertainty about the need for resources and the production economy made many farmers reluctant to start a steer production. There is a need for reliable investigation to facilitate calculations on the potential of organic beef production.

Introduction

In Denmark, the traditional way of using dairy bred bull calves is the production of young bulls slaughtered at about one year of age (Andersen, 1975). The production is based on large quantities of cereals and indoor systems with fully slatted floors. The Danish standards for organic farming, say that bull calves up to nine month old have to be on pasture in summertime and fully slatted floor is not allowed (Anonym, 1999). The new EU-rules applicable from year 2000 require 60% roughage in the daily feed ration. This means that a traditional bull production is not possible for the organic farmers and most organic dairy farms sell bull calves to conventional farms for beef production. The supply of organic high quality beef is thus restricted despite a steadily growing number of organic dairy farms. Selling bull calves may also be considered an ethical problem for organic farming, which is supposed to represent a wholesome approach to agricultural production.

The aims of the study were to[1)] describe the farmers' background for selling young bull calves,[2)] to analyse the potential of beef production on dairy farms and[3)] to describe options for steer production on the farms.

Method

Ten organic dairy farms that had participated in a herd-monitoring programme for two to ten years were used in a qualitative study of the potential of beef production. The farmers were interviewed (subject-interview) about management procedures, including selling or slaughtering of young bull calves, their attitude to beef production focusing on perceived limiting factors, ethics and future possibilities were assessed. On farms with steer production, the farmers were interviewed about housing facilities, feeding strategies etc. The interviews were taped and afterwards written down in a short version. A summary was sent back to the farmers proving the validity of the interview (Launsø & Rieper, 1995).

Results

At the time of the interview (February 1999) seven farms were selling or killing (one farm) all bull calves within two month after birth. Three farms had between 10 and 60 steers at present, and one farm had tried and later stopped steer production.

Perceived limiting factors of beef production

Listing main problems mentioned by the farmers in order of falling importance are: lack of stall capacity, shortage of own feedstuffs and expected poor production economy. Some other farmers mentioned working stress, lacking interest and that they always had sold the bull calves.

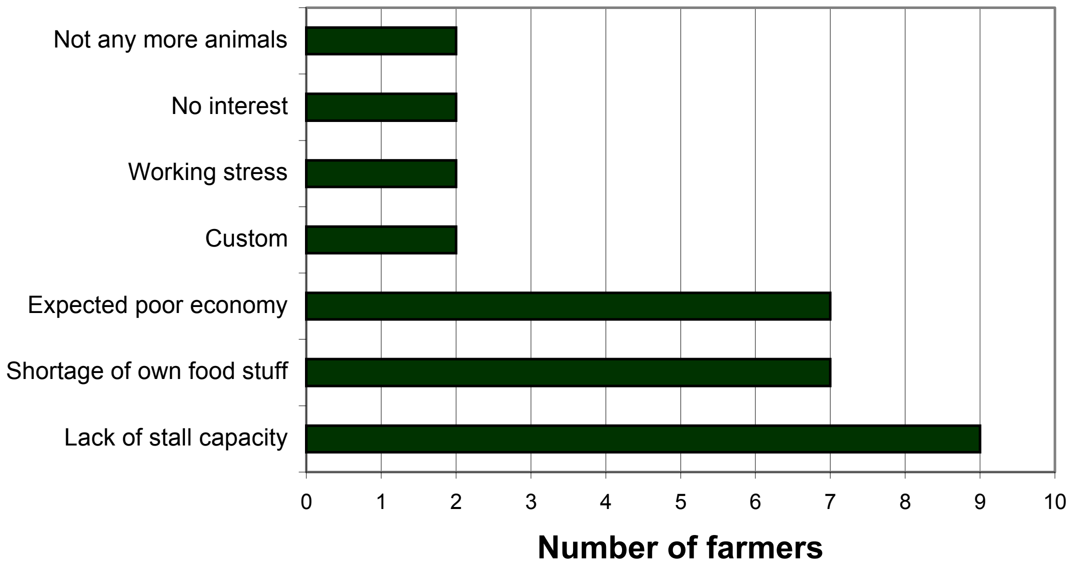

Figure 1 Limiting factors for specialised beef production mentioned by the farmers

The majority of the farmers did not consider it ethically wrong to sell the bull calves to conventional farms, if the welfare of the calves is acceptable. Only two to three farmers felt that they should have the calves on their own farm, according to the basic concepts of organic farming. Five farmers would prefer a production of the bull calves on organic farms in stead of conventional farms and two other farmers mentioned it as a problem, if the supply of organic beef is scarce.

Seven to eight farmers stressed that the production does not have to take place on their own farms. Seven farmers knew other local organic farms, which theoretically could take over the bull calves. Eight farms were reluctant to reduce the number of cows and all farms were ruled out the option of reducing milk yield to get additional place and/or feed for steers or bulls. Cross-breeding of some cows with a beef breed was considered to be an option for five farmers and one farmer is already practising this. Eight farmers preferred production of steers to bulls and nine farmers were reluctant to have bulls on pasture. Bulls were not considered acceptable in beef production due to their temperament and need of great amount of cereals, which was characterised as non-organic.

The steers produced on four farms were housed in existing stalls and in one case in an old stall, which was bought. Two farms borrowed fields for summer grazing and had bought fields too. The other two farms made no changes to accommodate the steers. The steers are part of the existing production and it is important to the farmers, that the steers do not demand much work or costs. The present steer production is on an experimental basis investigating economy and meat quality. However, experience was limited because three of the farmers had not slaughtered any steers yet, but all were satisfied with the production so far.

On one farm it was difficult to attain a carcass weight of 200 kg for the Jersey steers. Despite a very good eating quality, experienced by the farmers themselves, the prize paid from the slaughterhouse had been low. Other problems mentioned was a low daily gain for the young calves on pasture, for adult steers on marginal grazing areas and parasitic infections.

Of the six farms without steer production additional feed can be found on five farms by means of reduced selling of feed, by borrowing fields and by using own areas differently. Four farms out of six may find additional place in existing stalls.

Discussion

The farmers mentioned perceived lack of resources as the main reason for selling the bull calves. Figure 2 shows the farms self-sufficiency, defined as the netto yield on the fields divided by feed consumption of the herd (Mogensen et al., 1999). There is no relationship between a high degree of self-sufficiency and farms with a steer production.

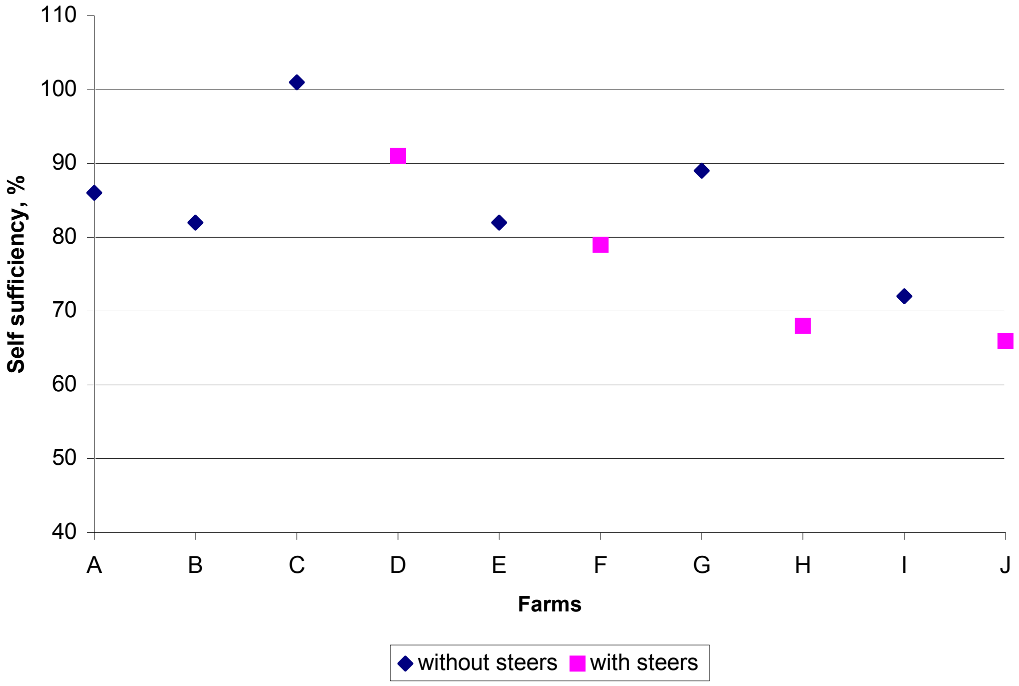

Figure 2 Self-sufficiency of the farms

The farmers are reluctant to produce steers on the expense of milk production. Calculations with production data from the interviewed farms show a reduction of net return pr. cow of 22 to 62% (Figure 3). This is calculated by using the feedstuff from one cow for a equivalent number of steers.

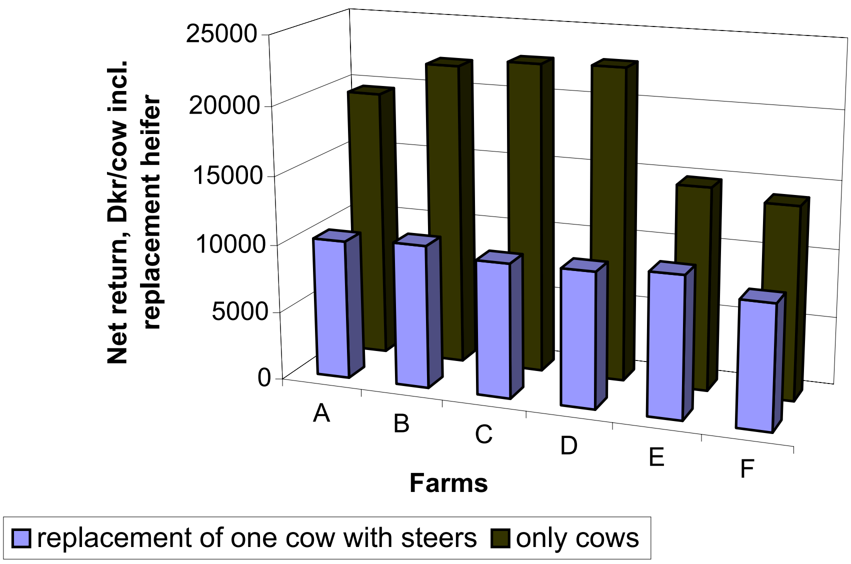

Figure 3 Net return pr. cow incl. replacement heifer calculated for milk production only and for replacing one cow with an equivalent number of steers

Other features of steer production discussed with the farmers were intensive versus extensive production systems and crossbreeding. Net returns were calculated based on the following assumptions using data from the farms:

- Extensive production: 600 g daily gain in summer and 500 g in winter, slaughtered at 26 month and 500 kg.

- Intensive production: 900 g daily gain in summer and 700 g in winter, slaughtered at 22 month and 580 kg.

- Crossbreeding: 10% less feed consumption, a better classification of 1 point and 2% higher dressing out percentage (Steen & Kilpatrick, 1995; Keane et al., 1989).

With the new EU-bounty for beef in force from year 2002 (Anonym, 1999b) the intensive production will obtain a 6-15% higher net return than the extensive production (Figure 4). Crossbreeding with beef breeds raised net return by 22 to 25% (Figure 4).

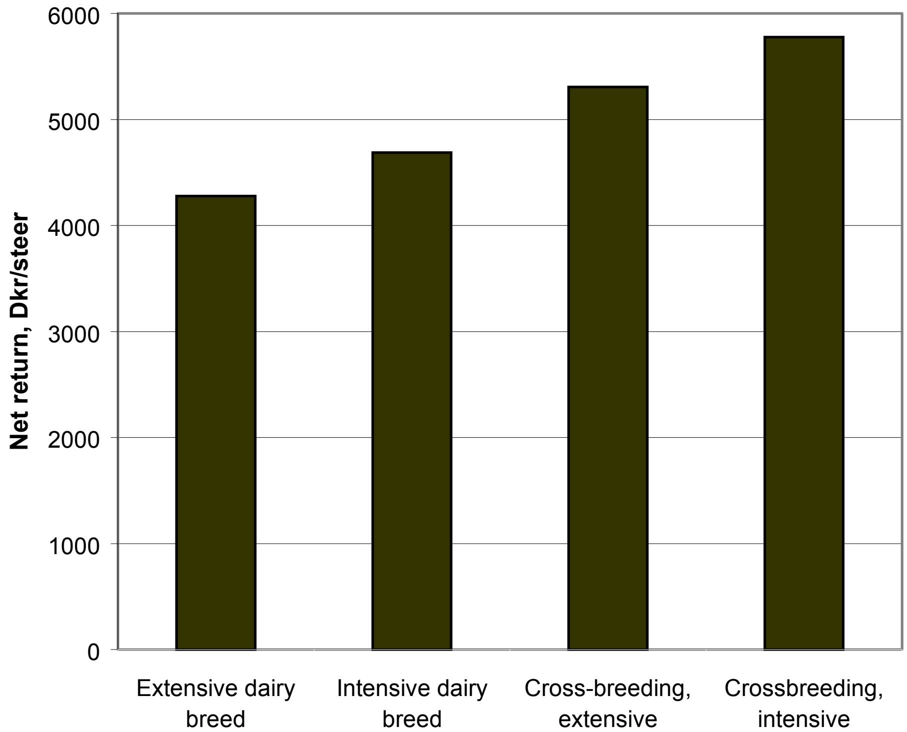

Figure 4 Net return of steer production (mean of 6 farms)

Conclusion

It can be concluded that perceived lack of resources and/or expected poor economy are the main reasons for not initiating a steer production. The uncertainty about the need for resources and production economy makes many farmers reluctant to start a steer production. Also the farmers` opinion on steer production including personal interests in beef production and general aims of a wholesome organic production are important factors influencing the farmers choice. It is evident that resources for steer production should not be found at the expense of milk production. The production of steers seems to be better accepted by organic farmers than rearing bull calves. Possible new ways of production may include crossbreeding with beef breed or collaboration with plant breeders. Based on modelling, intensive steer production seems to achieve a higher net return than extensive production. Practical results investigating extensive versus intensive production as well as crossbreeding are limited and further investigations are necessary for more accurate calculations.

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Homeopathic treatment of infectious diseases in animals, evaluated by scientific criterions

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Abstract

A study is planned at the Norwegian School of Veterinary Science to evaluate the effect of homeopathic treatment of infectious diseases. The main research is to be done on mastitis in dairy cattle. A brief introduction to the project and the principles of homeopathy is given.

Introduction

In ecological husbandry the use of synthetic drugs is restricted. There is also a generally increasing worry about the side effects of these drugs, e.g. bacterial resistance to antibiotics. As a result of this, interest in alternative ways of treatment is increasing.

This project is a part of NORSØK's (Norwegian Centre for Ecological Agriculture) institute program «Alternative veterinary medicine and biological protection of plants». It is planned as a four years Ph.D. study at the Norwegian School of Veterinary Science.The intention is to do a scientifically acceptable evaluation of homeopathic treatment of infectious diseases in animals. The main research will be done on mastitis in cattle.

What is homeopathy?

The main principles of homeopathy are the principles of similarity and potenciation. Explained in a simplified way similarity means that the patient is cured by giving a homeopathic remedy producing the same symptoms if given undiluted to a healthy individual. The remedies are potenciated by a special form of dilution and shaking and are claimed to be effective even diluted beyond Avogadros number.

The classical homeopathic treatment is supposed to be individual. The homeopathic remedy is chosen according to the totality of symptoms and not the diagnosis. The treatment is meant to stimulate the patient to re-establish his balance and not primarily to get rid of the disease. The patient's environment should formed be in a way that allows the patient to establish this balance.

Homeopathy is not a scientifically accepted treatment. The principles of similarity and potenciation mentioned above are difficult to explain by traditional scientific thinking, and there is still a lack of documented effect. Despite of this there seem to be an increasing interest in and use of homeopathic treatment and also other forms of "alternative medicine".

Some trials on homeopathic treatment of animals have been done, but there is mostly a lack of scientific quality in the design of these studies (small number of animals, suboptimal statistics, no blinding etc.). There is a need for studies of good quality, designed in a way that can be accepted both by homeopaths and traditional veterinary medicine.

In countries like Germany, Austria and France homeopathy is, to a certain degree, implemented in veterinary practice. The extent of homeopathy used in Norwegian farming is unknown. Very few Norwegian veterinarians use homeopathy, but some homeopaths trained to treat humans also treat animals and some farmers treat their own animals (after various amounts of homeopathic and medical education).

Challenges in planning a clinical trial including homeopathy

Planning a clinical trial including homeopathy raises several concerns:

- Designing the study in a way that is acceptable to both homeopathy and traditional veterinary medicine.

- Recruiting patients to an experiment including a treatment that is not scientifically accepted.

- Ethical doubts in treating diseases by placebo and a form for treatment of which the effect often is referred to as a placebo effect.

- According to the principles of classical homeopathy, the treatment should be individual. The homeopathic treatment can not be standardised by diagnosis.

Why homeopathy and mastitis ?

In ecological agriculture it is not acceptable to use synthetic drugs as a routine. Homeopathy is a «legal» alternative.

Mastitis is a disease that is economically important in Norwegian husbandry. Medical treatment of mastitis is an important contributor to the total amount of antibiotics used in Norwegian farms, but does not always have the expected effect. There is an increasing attention towards use of antibiotics and resistance problems. Use of homeopathy might be a way to reduce the use of antibiotics.

A dairy cow gets a lot of attention compared to most other farm animals, and there will be a lot of information about the animal available. This information is useful for the homeopath when selecting the homeopathic remedy for treatment.

The study

A pilotstudy will be performed in the winter 1999 – 2000. The main study is planned to start in the autumn of 2000. The study will be performed as a field experiment.

Cows with spontaneously occurring clinical mastitis are included. All animals are examined by a vet and a homeopath. Randomly selected animals are given a homeopathic remedy or a placebo preparation. The homeopathic remedy is chosen according to classical homeopathic principles (individually).

The experiment is planned as a double blind study. Neither the attending homeopath, the veterinarian nor the patient/owner will know if the cow gets homeopathic treatment or placebo. The cows are clinically examined and the milk tested for bacteria, cell count etc. All infected quarters are emptied at frequent intervals. If the cows show sign of severe illness they are given traditional medical treatment.

The study is expected to answer the main question

- Is there any significant difference in the healing from mastitis between cows given homeopathic treatment and cows given placebo?

- Is there any difference in frequency of new mastitis cases between the group given homeopathic treatment and the group given placebo?

In addition the placebo group will also give important information regarding the progression of a mastitis not treated medically.

Discussion

The results from the experiment may show; either a) no significant difference in effect between homeopathic treatment and placebo, or b) homeopathic treatment shows better effect than placebo.

If homeopathic treatment shows an effect in treating infectious diseases in animals there are some further considerations to be made before implementing it as a part of the animal healthcare of the farm; that is:

- The effect of homeopathy compared to the effect of traditional veterinary medical treatment.

- The total benefits of using homeopathy compared to traditional veterinary medicine, according to animal welfare, economics, withdrawal of products etc.

- Who should treat animals by homeopathy? The owner, homeopath or veterinarian? Practising classical homeopathy requires good knowledge of the remedies and good skills in reading symptoms in animals.

Furthermore, the knowledge about environmental factors as a part of a disease problem is important to keep in mind.

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Development of health advisory service in organic dairy herds

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Abstract

The Organisation for Danish Biodynamic and Organic Milk Producers has initiated a project with the goal to build a framework for a formalised veterinary health advisory service for organic farmers. During the initial stages of the project local agricultural advisors were included as the third important partner in the local co-work around each farm. In this contribution the project is presented and expectations of project outcomes are presented.

Introduction

In Denmark, veterinarians and farmers can join a health advisory service framework. Farmers with monthly veterinary health advisory service visits in their herd, are allowed to administer antibiotics for post-treatments of dairy cows. First time treatment of dairy cows always has to be done by a veterinarian. Organic farmers are not allowed to have antibiotics for post-treatment of dairy cows. Consequently, they cannot make this health advisory service contract with their veterinarians. This appears a paradox: Organic herds explicitly focusing very much on prevention of disease and health promotion, are not allowed to sign the only formalised Danish health advisory service contract with their local veterinarian.

This fact, in combination with the fact that a number of organic dairy farmers wanted to focus on their herd in a more broad-spectered and inter-disciplinary approach, initiated a combined development and research project with the main objective to develop a formalised framework for a health advisory service specifically for organic farmers. In each herd the farmer and his/her sparring partners (the local veterinarian and the local agricultural advisor) are stimulated to find ways to create a health advisory system suitable to each farm. Twenty organic farmers will participate in this project during a two years period in a step-wise learning process. Eight farmers started in February 1999, and partly based on their experiences twelve new farmers will enter the project from October 1999. In addition, twenty control herds are included in order to picture the 'background' of organic dairy production in herds not directly influenced by health advisory service. Health status is measured through data collection and one visit from a project veterinarian. Furthermore, twenty control herds will be evaluated from data alone, when the project is finished. Results from all three groups of herds will be discussed as a result from the project.

Material and methods

Forty herds participate in the project, of which twenty actively take part in health advisory service, and twenty participate as 'control herds'. Epidemiological studies are made during the study period, and development of health status over time will be described. Comparisons will be made between the 'advisory service group' and the 'control group'. Systematic differences will be described in relation to the health advisory service.

Qualitative research interviews and project participants and participant-observations during health advisory visits will be carried out. Focus will be on the process of health advisory service and the dialogue between the partners.

The project group

The project is an action research approach, where the development of the health advisory service system is based on local on-farm development. This means that the farmer and his local veterinarian and agricultural advisor have to formulate an agreement on how to perform health advisory service in this specific herd. The local process is supported and followed by a team of from Danish advisory service (Danish Agricultural Advisory Centre represented by Peter S. Enemark, and Danish Dairy Board represented by Hans J. Andersen), research institutions (Danish Institute of Agricultural Sciences represented by Mette Vaarst, Troels Kristensen and Egon Noe; The Royal Veterinary and Agricultural University represented by Stig Milan Thamsborg and Ph.D. student Torben Bennedsgaard). The project leader is the chairman of the Danish Association of organic and bio-dynamic milk producers, Torben Stjernholm, supported by DVM, Ph.D. Carsten Enevoldsen, who gives veterinary support and carry out data analyses for the participating herds, and Thorkild Nissen from the Danish Centre for Organic Farming, taking care of administration, contact to herds, and supporting the process. In addition, the organic farmers' organisations and the Danish Veterinary Association are represented in project meetings. Conclusively, the project group is relatively broad and able to focus on a wide spectre of areas in the project.

Experiences, preliminary results and areas for further discussions

Focus areas in advisory service agreements

Farmers were asked to formulate a plan for their own herd and what they wanted to focus on, together with their local veterinarian and agricultural advisor. The following seemed to be the main focus areas among the first eight participating herds:

- Somatic cell counts and mastitis

- Insufficient energy intake indicated by lactation curve patterns and milk yield differences between first and later lactation cows

- Drying off strategy and procedure

- Summer grazing, especially for young calves

Building up a farm specific health advisory contract

Eight herds participated from February 1999 in the project. In October 1999, twelve new herds were included in the project. This allowed the experience built up by the first eight farmers to be actively implemented in the health advisory service in the new herds.
Agreements on how to perform health advisory service in the first eight herds was very different between herds, both with regard to focus areas and with regard to ways communication. The following advice were given when evaluating the process for the first eith farmers:

- As a first step, goals for the herd and health advisory service should be described.

- Analysis of data from the herd and a critical review of the herd and the farmer's experience of critical areas are valuable tools in the initial part of the process.

- The farmer should at any time be the driving force. This ensures that action is implemented in the herd.

- An inter-disciplinary approach is regarded as necessary. This does not necessarily mean 'large group meetings', but also exchange of information, reports and results from the herd.

- Most of the experiences mentioned above have involved time-consuming steps for the partners involved! Finding a way to communicate and getting to know the strong and less strong areas of each others' fields of expertice and work took much time, but was new and exciting for most people.

Expected outcomes of the project

The main outcome of the development project is expected to be a framework for health advisory service in organic herds in Denmark, which can be accepted by relevant organisations and that can be adjusted to the conditions in each herd. A manual with examples from project herds will follow this framework and is expected to stimulate and guide action in each herd. The research project will produce two main types of results: first, a Ph.D. thesis based mainly on epidemiological studies in the project herds. The subject of this Ph.D. thesis is health, disease and medication strategies in organic dairy farming. Secondly, the process of developing herd specific advisory service will be analysed and described in a way that will contribute to the understanding of how health advisory service is carried out in practice. Finally, the experience and knowledge of the participants will increase, and oral presentations in e.g. farmers' and veterinarians' communities will be important products from this study as well.

Animal health and welfare aspects in organic dairy production systems - experienced practice during conversion to organic farming

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Abstract

A synthesis of knowledge project was carried out during the late summer 1998 to June 1999 with the objectives to describe the conversion to organic farming as experienced by people connected to the dairy herd (the farmers themselves, their veterinarians and agricultural advisors). Special focus was put on animal health and welfare and the use of medication. 15 qualitative semi-structured interviews and 3 group focus interviews were carried through during the autumn-winter 1998, and a panel of veterinary and agricultural scientist experts met three times during the winter spring 1998-99.

The organic calves are in focus as example of the discussion about understanding animal welfare in organic herds. The calves were mentioned as the most critical field in the organic herd. Disease problems, group housing, outdoor stay and cow-calf relations during the first 24 hours post partum are all areas which are mentioned in the legislation for organic farming. The idea of combining a 'natural life' with 'a life under human care' was discussed. It was suggested that animal welfare may contain some special characteristics in organic production. One of these could be an effort to let them live a 'natural life' as far as possible. This may have some practical consequences for how animals are kept. The basic responsibility for the animals in organic husbandry is discussed as a key area for animal welfare, with calves as a prominent example.

Introduction

Organic dairy production has increased dramatically in Denmark during the past few years. In some regions the number of organic herds is growing rapidly, and the farmers' sparring partners (i.e. the advisory service and veterinarians) are being increasingly confronted with the organic production systems. Consequently, veterinarians have paid increasing interest in the organic production method. They have generally raised critical questions to the daily practice and effort to live up to the basic idea about good animal welfare in organic herds.

Good animal welfare conditions are generally mentioned as a major goal in organic farming. An increasing number of reports on animal welfare problems in organic farming systems and in connection to conversion to organic farming must consequently cause major concern. It is relevant to discuss whether animal welfare problems are connected to goals or legislation rules in organic farming, or rather to management routines and the farmer's ability to take care of his animals under organic production conditions.

In order to direct this discussion into a number of relevant perspectives, a project was carried out under the management of the Research Centre for Organic Farming in Denmark. This project was called 'Synthesis of knowledge on animal health, welfare and use of medication during conversion to organic farming'. The goals were to describe and identify areas of specific interest for the discussion about animal welfare in organic farming with regard to animal health, welfare and use of medication during the conversion period.

In the following, organic calves will be taken as example of a critical field of organic farming systems. The organic calf herd has been an area of major concern in the organic herd and has even been mentioned as 'the group of losers'. The basic organic goal of letting animals live a 'natural life' as far as possible will be discussed as the idea of combining a 'natural life' with 'a life under human care' with special focus on the outdoor stay. Communication between the farmer and the farm advisors (especially the veterinarian and the agricultural advisor) is one very relevant area of future development in order to solve some of these problems.

Material and methods

This project is based partly on qualitative interviews and partly on meetings between experts in different fields of organic husbandry and organic farming.

During late summer 1998, 15 individual qualitative semi-structured interviews of veterinarians and agricultural advisors were carried through. During the winter 1998-99, three group focus interviews of farmers were carried through (19 farmers representing 16 different farms). An expert group of veterinarians and agricultural scientists met three times during the winter spring 1998-99 in order to discuss the results of the interviews and to develop a theoretical basis for solving some of the animal welfare problems made visible through the interviews. Relevant themes were identified for future development in organic herds, and guidelines were given as practical advice, needs for future advisory service and research.

Results

In the following, a brief summary of the interviews and the results of the expert panel discussion about outdoor stay of calves will be given.

Health and disease as described in interviews with veterinarians and advisors

In general, no or few changes were described in health status connected to conversion. No systematic differences were described with regard to udder health, but many veterinarians, advisors as well as farmers had experienced a decline in clinical metabolic diseases. No dramatic or abrupt change in treatment pattern was actually experienced, but the interviewed veterinarians showed concern for a theoretical emerging 'non-treatment-policy'.

Conversion to organic farming has during the past 4-5 years often been connected with changes in housing system and in herd size (larger herd). Changes in health status if described were pointed out as connected to ’structural and technical changes in the herd’ and not to the conversion to organic production itself.

The calves were described as a sincere problem area with special focus on group housing, need for suckling (causing suckling on group mates), and grazing at a young age. The problems were clearly and consistently described by a majority of both veterinarians, agricultural advisors and farmers.

The outdoor stay of the calf as a part of ’a natural life’

The intentions of the organic standards were identified as strongly related to ’a natural life’. The understanding of ‘natural’ is complex and involves several philosophical considerations. Very briefly, a natural life is connected to a number of positive as well as negative possible experiences (positive as e.g. the access to food and milk ad libitum, fresh air and social life; negative such as bad weather and climatic conditions and loss of mother). In a farming system, the positive parts of ‘nature’ should be implemented as a part of ‘the culture’, so to speak, and combined with human care and attention.

The outdoor stay of the calf was particularly mentioned as a very critical part of the calves’ life, but also mentioned as something ‘worth working for’, since calves seem to enjoy it very much. Some explanations for unsuccessful grazing systems for young calves were identified through the interviews and the following discussions in the expert group:

- In a natural life, calves are grazing together with cows. All calves are more or less the same age and form a stable group (season calving). They have access to milk ad libitum until late weaning, and the flock has the possibility to move to other pastures when the available grass is decreasing.
- This ‘natural life’ is far from the life on farms, where calves very often are grazing the same pasture just outside the cow house (close to the farm in order to ensure the farmer’s attention). The flocks are dynamic, with a continuous flow of calves into and from the flock. During the first years when this early grazing was applied calves were more or less expected to live off the grass, which is completely wrong.
- Calves in conventional herds are normally not very time consuming. They are much more time consuming in a grazing system i.e. the time it takes to see them every day.
- Flexibility should be allowed, e.g. due to poor weather conditions during summer.

The dialogue between the organic farmer and his partners

The veterinarian and the agricultural advisor can be described as the partners of the farmer. The dialogue between them during conversion seemed to be very much coloured by a lack of understanding for the basic goals for organic farming. The farmer was searching for this understanding and, at the same time, searching for solutions on practical problems, and the veterinarians did not have much experience with organic farming, and did not understand the goals. The agricultural advisors often were more specialised in organic production and covered a larger geographical area. They were consequently more updated with regard to organic legislation and practice, and they could give advice based on experiences from organic herds. A number of concrete examples in the interviews underlined the necessity to involve veterinarians and agricultural advisors more actively in the conversion process, e.g. by making a plan for conversion of the herd, similar to current conversion plans for the fields.

Discussion

Health and disease as described in interviews with veterinarians and advisors

The interviewed persons described their own experiences with conversion to organic farming (either their own farm or their clients). These may be influenced by their attitude to organic farming and to their own role in the farming system. The interesting parts of this study is consequently the discussion about the experience and how dialogue, understanding, communication and development within the organic farming system could be improved. Facts about the change in e.g. disease treatments should be further illuminated through epidemiological studies. One should be relatively critical to the time aspects in this conversion, as described by the interview persons in this study: changes in the herd and herd health may occur first after a time-span longer than the one described in this study.

The outdoor stay of the calf as a part of 'a natural life'

The discussion about 'natural' versus 'cultural' is far too complex to be discussed in-depth in this contribution. Nevertheless, outdoor stay for young calves can be discussed as a relevant opportunity to give the young animals in a herd valuable and positive experiences which may improve animal welfare. As the experiences in these interviews indicate, grazing calves demand new management routines which are more time consuming and call for closer follow-up than calves housed indoor in single boxes. Management factors, adjustment to new procedures and misinterpretations of the standards may have influenced the experiences during the first years of this practice.

Discussions regarding critical situations i.e. calves developing disease or climatic conditions critical for young calves should be kept separate from discussion regarding a natural life for the 'healthy calf', since it is the duty of the farmer and his partners to intervene in any critical situation and provide the calf with sufficient human care (housing, food, isolation etc.). Such actions in crisis situations should not be restricted by any legislation.

The role of the partners of the organic farmer?

Many veterinarians had been confronted with organic farming and farmers converting to organic farming during the past few years. The farmers may have needed support and advice, but in certain areas – such as outdoor stay of young calves nobody seemed to have any experience. Some of the partners seemed very sceptical towards the organic standards, and did not understand the goals of the production system. The standards and the goals were very often described as 'one'. It is, however, possible to be open to the goals of organic farming but critical towards the standards. It may be very difficult to give advice regarding how to fulfil goals one basically does not understand, especially when these also may remain unexpressed in the farmers mind and not given words during the first period of conversion.

Conclusion and future perspectives

The experiences described and analysed in this so-called 'Synthesis of knowledge' study has created a basis for broader understanding of the conversion process, especially the interplay between the so-called 'technical conversion' and the 'mental conversion' of the organic dairy herd. A number of areas has been identified with regard to practical farming, advisory service and research which should be further developed in the future. Animal welfare aspects have been analysed and discussed with particular focus on calves and the 'good life of a calf' in organic farming based on experienced practice.

The results of this study is published in a Danish DARCOF-Report (in press; in Danish), edited by Kristensen & Thamsborg (2000), and a manuscript for international publication is in preparation.

Self-supply of feed on organic dairy farms in Denmark

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Abstract

In case studies from 1990 to 1998 on 20 organic dairy farms an average level of self-supply of 83% organic feed was found. The organic ideal is 100% organic feed supplied by locally grown crops. This self-supply of 100% is not unrealistic in relation to the nutrient balance on the farm. However, if feeding is based solely on home-grown feed it is difficult to meet the nutrient requirements of a high yielding cow. This is especially true for the content of amino acids absorbed in the intestine (AAT), fatty acids, starch and the fill of the ration.

Introduction

The present Danish rules claim that at least 85% of the energy fed per cow per day should be *organic*. However, the basic idea of The Danish Organic Farming Organisation is to aim at a level of 100% organic feed in the ration and according to the new EU rules the ration must become 100% organic within the next 5 years.

Furthermore, the basic idea of organic farming is to supply the livestock on a farm with feed from locally grown crops. The present Danish rules, however, provide wide frames for the farm's *self-supply* of organic feed.

Material and methods

In our investigation, the level of self-supply with home-grown organic feed on the farm is defined as a theoretical self-supply. It is calculated as the total crop production in the fields divided by the total feed used for the cow herd during the same year of production running from May to April. This definition makes it possible for a farm with a calculated self-supply of feed of 100% to sell cereals and buy conventionally grown concentrates instead, resulting in 85% organic feeding only.

The actual farming practice and the resulting level of self-supply have been described in case studies over the period from 1990 to 1998 on 20 farms with organic milk production with results from 2 to 9 years from each farm (Mogensen et al., 1999; Jensen & Kristensen, 1998; Jensen et al., 1997). The average level of self-supply was estimated as a simple average of all observations. Variations between farms within a year are shown as 25 and 75% quantiles and the variation within a farm between years as standard deviation (Mogensen et al., 1999).

Simple analysis of correlation was made for level of self-supply and different production variables on data from these case studies farms. The between farm correlation was calculated on an average from each of the 21 farms. The within farm correlation (based on one result per farm per year) was calculated on the residuals after running a generalised linear model: variable = farm from all observations per farm per year (N=106).

Data from the case studies were used to make a model for a typical organic dairy farm with a self-supply of home-grown organic feed of 85% and import of 15% conventionally grown rape seed cake. So the resulting feeding is 85% organic. A prototype of a farm with a 100% self-supply of home-grown organic feed and no exchange of feed with the surroundings, was formulated on basis of the case study farms and more partial results regarding feeding (Mogensen et al., 1998). The resulting feeding is 100% organic. Some of the calculation process is facilitated by a dynamic simulation model 'SAMSPIL' (Hansen et al., 1996) by means of which the interaction between feeding level, herd size, manure production and application, and crop production can be calculated.

Results and discussion

Actual level of self-supply on private farms with organic milk production

Different production variables with relation to self-supply are shown in Table 1. An average of 83% of the feed consumption of the dairy herd was supplied by homegrown organic feed on 20 dairy farms from 1990 to 1998. However, one fourth of the farms, the one with the highest level of self-supply, produced at least 90% of the necessary feed, whereas it was below 73% of the necessary feed on the fourth of farms with the lowest level.

The average acreage in crop rotation was 1.20 ha per cow with an average crop yield of 5044 Scandinavian Feed Unit (SFU) per ha. Each cow had an average intake of 5511 SFU and a milk yield of 7158 kg Energy Corrected Milk (ECM) per year.

Table 1 Average level of production variables on 20 Danish dairy farms 1990-98 (Mogensen et al., 1999)

	Average	25% quantile	75% quantile	Standard variation
		variation between farms		variation between years
Self-supply, %	83	73	90	9
Crop yield, SFU per ha [1)]	5044	4494	5450	608
Acreage, ha per cow [1)]	1.20	1.03	1.37	0.11
Feed intake, SFU/cow/ year	5511	5176	5863	236
Milk yield, ECM/cow/year	7158	6623	7607	208

1) in crop rotation

Differences between farms

Each farm is represented by the average of each production variable, for example self-supply. On farm 1 the average is 88% for 9 years' observations. Correlation between production variables from different farms is seen in Table 2 above the diagonal. It was found that farms with a high acreage per cow also have a high level of self-supply as seen from a positive correlation of 0.6 in Table 2. When a farm has more land per cow it is easier, theoretically, to produce more of the feed needed per cow on the farm.

Farms with a high acreage per cow have a lower average crop yield per ha. This can probably be explained by the fact that when there is more land in addition to land needed for feed production there is land for growing more cereals for sale. As cereals have a lower average yield per ha (4,100 SFU/ha) than clovergrass (5,600 SFU/ha) and whole crop (4,300 SFU/ha)(Mogensen et al., 1999), an increased part of cereal in the crop rotation will decrease the average crop yield. Finally, the lower stocking rate means a lower amount of manure available per ha.

There was no significant correlation between the feeding level per cow or milk production per cow and the level of self-supply between farms.

Table 2 Correlation regarding self-supply between farms and within farms

		Between farms correlation's (average per farm N=21)				
Within farm correlation		**Self-supply, %**	**Crop SFU/ha**	**Acreage ha/cow**	**SFU/cow**	**Milk yield per cow**
(residuals on all observations N=106)	self-supply, %		NS	r = 0.6	NS	NS
	crop SFU/ha	r = 0.6		r = - 0.5	NS	NS
	Acreage, ha/cow	r = 0.3	r = - 0.3		NS	NS
	SFU/cow	NS	NS	NS		r = 0.9
	Milk yield per cow	NS	NS	NS	r = 0.7	

(NS for P>0,05)

Differences between years (within farm)

Each production variable is represented by one result per year per farm. For each farm we wanted to see whether there was any correlation between changes in the different production variables between years. For example at farm level, whether changes in level of self-supply one year are correlated to changes in crop yield the same year (it is logical that an increase in crop yield will increase self-supply if number of cows and ha is unchanged). Instead of running the analysis of correlation separately for each farm – a correlation analysis on the residuals (from the generalised linear model: production variable = farm) is used for all years observation for all farms. Thereby, is put together all the individual correlation analysis from each farm on the same scale (by use of residuals) for all farms. These correlations are shown below the diagonal in Table 2.

On the individual farm, a higher self-supply was found in years with a high average crop yield per ha. Also, in years with a low number of cows per ha the level of self-supply was increased even though the crop yield per ha decreases when the number of cows per ha is decreased (Table 2). There was no significant correlation between the feeding level per cow or milk production per cow and the level of self-supply between years on each farm. Apparently, in years with a low level of self-supply, the farmer compensates so that the overall result is that neither feeding level nor the resulting level of milk production per cow is affected (Table 2).

Modelling 100% self-supply with home-grown organic feed on dairy farms

If a self-supply with homegrown organic feed of 100% is to be achieved, considerable adjustments must be made on the present typical farm. If the feeding is to be based solely on home-grown organic feed - typically clovergrass, whole crop silage and barley - this will result in feeding plans with a lower content of AAT and fatty acids than stated in the Danish recommendation. Thereby, the expected production per cow will decrease considerably (Kristensen, 1997; Hermansen, 1993).

Let us pretend that **Farm 1** in Table 3 represents a typical organic Danish dairy farm of today. The theoretical level of self-supply is 85%. The herd is fed 85% home-grown organic feed and 15% conventionally grown rape seed cake is imported. The size of the farm is assumed to be 100 ha sandy soil with irrigation. All the grown crops are used for feeding, and together with a 15% conventional feed import, this results in an average feeding level of 5,550 SFU/cow/year and a herd size of 75 cows. The cows are assumed to be Danish Holstein with a milk yield capacity of 8,000 kg ECM. According to the Danish system, the feed intake capacity will be of 6,6 fill (Strudsholm et al., 1992). However, for organic feeding practice of a longer period with fixed amounts of supplement feed and a higher level of clovergrass in the ration, the intake capacity is assumed to be of 7.0 fill (Jensen, 1997). All rations are balanced with energy concentration fed ad libitum. The bull calves are sold at birth, the heifer calves at an average age of 27 months and 41% of the cows are replaced every year. The crop rotation is a typical 5-year rotation with 40% clovergrass, 40% barley with rye grass and 20% barley/pea undersown. No manure is imported to the farm. The average feeding ration per cow per year, the resulting milk yield, crop yield and fertilisation are shown in Table 3. In Table 4 is given the feeding plan in more details.

Farm 2 and 3 are two prototypes of farming with 100% self-supply of home-grown organic feed, 100% organic feeding and no import of manure. To compensate for the lack of feed import, crops with a high yield potential are introduced in the crop rotation. Fodder beets and clovergrass have a higher expected yield than barley. Therefore, the area with clovergrass is increased on farm 2 and 3, and fodder beets are included on farm 3. On farm 3 it is possible with no import of feed or manure to increase the number of cows as compared to farm 1. The change in crop rotation results in a higher level of roughage in the ration on farm 2 and thereby decreases the energy level per cow (Table 3) because of the higher fill in roughage.

When the rations are highly based on roughage, the feeding level per cow becomes very sensitive to the quality of the grown silage (kg dry matter/SFU). On the model farms, contents of 1.33 kg dry matter/SFU for clovergrass silage and 1.45 kg dry matter/SFU for whole crop silage are assumed according to the average level found in 13 organic farms from 1990 to 1993 (Kristensen & Kristensen, 1995). Because of the lower level of energy in the ration per cow on farm 2, the utilisation (average % of SFU utilised) of feed is increased. The high-energy concentration in beets makes it possible to feed the cows on farm 3 100% organically at the same energy level as on farm 1. However, as the recommendation for AAT and fatty acid is not fulfilled for farm 2 and 3, a decrease in the yield is expected (Kristensen, 1997; Hermansen, 1993) The change to 100% self-supply decreases the total milk production on the farm by 16% on farm 2 and 4% on farm 3.

A self-supply of 100% has some environmental advantages as indicated by the nitrogen balance in Table 3. The input to the nitrogen balances comes from purchased feed, N fixation in clovergrass and peas and from deposition. Output comes from the sale of meat and milk. With a self-supply of 100%, the surplus per ha will decrease as no feed or manure is purchased. However, the fixation is increased because of a higher share of clovergrass in the crop rotation and, at the same time, there is a smaller output from milk. For comparison, there was a variation in surplus of N from 69 to 148 kg N per ha on the 12 farms with case studies in 1997/98 (Mogensen et al., 1999).

Table 3 Models for a typical dairy farm with 85% self-supply (farm 1) and farms with 100% self-supply (farm 2 and 3)

	Farm 1	Farm 2	Farm 3
Cows	75	75	77
Ha	100	100	100
Self-supply, %	85	100	100
Feeding, SFU/cow/year	5,550 [4]	4,950	5,550
Grass silage	954	1,714	1,406
Grass pasture	1,665	1,660	1,660
Whole crop silage	670	783	483
Straw	88	14	21
Barley	1,351	776	325
Fodder beet	0	0	1,535
Rape cake seed, conventional	821	0	0
Utilisation of energy (SFU),%	85,9	89,8 [2]	85,9
Milk yield, kg EKM/cow/year	7,070	5,900	6,620
Expected milk yield reduction [3]			
- energy level >< farm 1	0	-1296	0
- energy utilisation >< farm 1	0	+ 482	0
- AAT >< 90 g/SFU	0	- 222	- 145
- fatty acids >< 30 g/SFU	0	- 134	- 305
Total reduction >< farm 1	0	- 1170	- 450
Crop rotation, % of the acreage			
Clovergrass	40	60	50
Barley	40	20	17
Barley/pea undersown	20	20	21
Fodder beet	0	0	13
Net crop yield, SFU per ha			
Clovergrass	5,900	5,662 [5]	5,633 [5]
Barley w. rye grass	3,300+390 [6]	3,300+390	3,200+390
Barley/pea undersown	3,500+390	3,700+390	3,500+390
Beet	-	-	10,100
Fertilisation, kg total manure N/ha [1]			
Clovergrass	0	13	0
Barley	151	151	100
Barley/pea undersown	75	140	75
Beet	-	-	351
Total kg N supplied	7,530 [7]	6,620	7,670 [7]
Nitrogen surplus, kg N/ha	88	82	65

1) from manure – it is assumed that 55% is available for the plants
2) a decrease of 1,000 SFU/cow/year results in a 6.46% higher feed utilisation (Kristensen, 1997)
3) because of a lower AAT or fatty acids content or a lower energy (SFU) level:
a decrease of 0.3 kg ECM milk per g reduction in AAT/SFU below 90 g AAT/SFU and
a decrease of 3% in kg milk, 4% in kg fat, 1% in kg protein per 10 g reduction in fat acids per SFU below 30 g/SFU
a increase of 1,000 SFU/cow/year result in 6.46% lower feed utilisation (Kristensen, 1997)
4) the average feeding level of SFU/cow/year on the 20 organic dairy farms from 1990 to 1998 (Mogensen et al, 1999)
5) clovergrass yield in 3rd year field only has an expected yield of 86% of 1st and 2nd years' yields (Nielsen, 1995)
6) from main crop + grass in the autumn
7) the difference between farm1 and 3 is du to 2 cows more on farm 3 and different composition of the feeding ration

Table 4 The feeding ration for the high yielding cows on farms 1, 2 and 3 and during the winter (180 days) and summer seasons at pasture (185 days).

SFU/cow/day	FARM 1		FARM 2		FARM 3	
	winter	summer	winter	summer	winter	summer
Whole crop	2.6	1.4	0	4.3	0	2.2
Grass silage	6.0	0	10.1	0	7.5	1.1
Grass	0	9.3	0	9.3	0	9.3
Straw	0	0.3	0	0	0	0
Barley	5.4	3.0	3.9	1.4	1.3	0.9
Beat	0	0	0	0	7.7	3.0
Rape cake seed, conventional	2.5	2.5	0	0	0	0
g fat/SFU	36	37	24	23	13	20
g AAT/SFU	90	93	85	87	87	90
g starch/SFU	230	131	166	157	49	86

Conclusion – Actual research

Self-supply with home-grown organic feed is one of the actual research topics at the Danish Institute of Agricultural Sciences. In the research programme "Demonstration and development of new organic production systems" one of the subjects is milk production based on solely home-grown organic feed. What we want to investigate is the effect on cows' production and health when 100% organically fed. Furthermore, we want to change the crop rotation to include other crops, which might consider the nutrient need of the cow. This research will be based on case studies and on farm feeding experiments.

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Danish organic dairy cattle production systems – feeding and feed efficiency

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Abstract

The average herd size in organic dairy farms with dual-purpose breeds is 74 cows, with a milk production of 7,022-kg milk, 4.10% fat and 3.45% protein. The feed efficiency was significantly higher in a group of 14 organic herds (88.7%), compared to 20 conventional herds (85.3%). Within the organic herd the level of energy intake, number of calvings, live weight and peak yield explained 74% of the variation in the feed efficiency. The feed conversion rate was significantly affected by energy intake, milk persistency and peak yield. The analysis of the variation within the organic group of herds indicated possibilities to improve the efficiency in organic dairy farming.

Introduction

Organic milk production is a well-established production in Denmark with more than 5% of the milk delivered from organic herds. The variation within the organic production system in feeding, production intensity and efficiency is large, meaning that on the individual farm there is a potential for optimising the production within the framework of organic farming. One of the main ideas behind organic farming is to utilise the resources efficiently. Efficiency can be measured at different levels, such as farm scale, globally etc. and by different variables like fossil energy, manure etc. In this paper we will focus on the feeding of the dairy cows and the efficiency by which the energy in the feed is converted to milk.

Organic production systems

Information from the milk recording and breeding associations is collected in a central database. Table 1 presents some information from conventional and organic commercial herds with cows of dual-purpose breed, typically Danish Holstein. The average herd size is largest on the organic farms, 74 against 58. Milk production and milk fat content is somewhat lower on organic than on conventional farms. The difference must be related to factors like feeding, milking and general management, as the breeding value for milk production is independent of farming system. These effects are of the same attitude as found in an earlier study (Kristensen & Kristensen, 1998), and the same trend is seen in herds with Jersey cows.

Table 1 Organic and conventional herd production results in Denmark, average of dual purpose breed, from milk recording data 1997/98 (Anonymous, 1999)

Production system	Organic	Conventional
Number of herds	240	7,791
Herd size, number of cows	74	60
Milk production, kg milk/year	7,022	7,534
Milk composition, fat %/protein %	4.10/3.45	4.21/3.42
Somatic cell count, 1000/ml	258	239
Breeding value[1], kg milk fat	0	2

1) Deviation from average within breed

The actual farming practice and the resulting production have been described in case studies over a period from 1990 to 1998 on 20 farms with organic milk production with results from 2 to 9 years from each farm. Table 2 shows some of the results from an analysis of these data. For further details, see Mogensen et. al.,1999.

Table 2 Organic dairy cattle production, results from 20 farms over 2 to 9 years (Mogensen et. al., 1999)

	Average	Variation between farms (quantiles)	
		25% lowest	75% highest
Crop production			
Average yield, SFU/ha	5,044	4,494	5,450
Grass-clover yield, SFU/ha	5,668	4,921	6,025
- percent of area in rotation	52	44	60
- percent clover in sward	44	36	50
Feeding, annual SFU/cow			
Total feed intake	5,511	5,176	5,863
- roughage	3,424	3,042	3,987
- cereals	1,231	1,012	1,442
Herd production, annual per cow			
Milk yield, kg ECM	7,158	6,623	7,607
Live weight gain, kg	37	23	50

The average crop production from the area in rotation was 5,044 SFU[1] per ha. The variation between farms, given by the 25 and 75% quantiles, was 1,000 SFU per ha. The variation is influenced by different proportions of crops with different yield potential, like clover-grass and barley, different soil types and general management on the farms. Clover-grass is grown on more than half the area and with an average production of 5,600 SFU per ha. By visual registration the clover content was estimated to 44% of the total amount of herbage mass. For the feeding, clover-grass is the most important energy and protein source. Clover-grass makes up more than half the total energy intake in the summer period and in the winter period clover-grass silage covers an average of 2/3 of the total roughage intake.

It is also characteristic that the organic dairy cows are given large amounts of cereals, more than 1,442 SFU per cow per year, in the 25% of the herds.

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[1] SFU: Scandinavian Feed Unit. 1 SFU is energy equivalent with 1 kg barley.

Feed efficiency

An analysis of the feed efficiency in organic versus conventional herds and some further analysis within the organic group were made in order to investigate the efficiency in relation to feeding, production and management practices.

The analysis was based on data collected in the period 1990 to 1993 in 14 organic and 20 conventional herds. The data represent 98 winter periods (1/11 to 30/4) in which feed intake on cow herd basis was recorded in detail. In Table 3 data have been multiplied by 2, in order to get some more recognisable figures. Within the organic group there was a higher proportion of Jersey and also a higher proportion of loose housing compared to tie stall systems. This influences the value of some of the variables in Table 3.

First some definitions:

Feed efficiency. The sum of standard energy requirements (Strudsholm et al., 1992) for maintenance, reproduction, live weight gain and milk production in percentage of the total feed intake.

Feed residual. Total intake minus standard requirements regulated for maintenance, reproduction, live weight gain and milk production in percentage of the total feed intake, but corrected for the expected reduction in feed efficiency caused by a higher feed intake (Østergaard, 1989). The results are standardised to 0 within breed.

Milk per SFU. Milk production as energy corrected milk (ECM) divided by total intake of SFU.

Table 3 Description of the materiel used to analyse factors affecting feed efficiency

System	Organic		Conventional	
Number of observations	40		58	
	mean	SD	mean	SD
Efficiency[1)]				
Feed efficiency, %	88.7	5.4	85.3	4.0
Feed residual, SFU	-80.5	300.0	55.5	328.2
Milk per SFU , kg	1.36	0.12	1.30	0.12
Production				
Milk, kg ECM per year	6,627	744	7,043	863
Peak yield, kg ECM	23.0	2.8	25.7	2.8
Persistency, %	86.5	2.9	82.4	3.4
Live weight gain, kg per year	27	38	40	40
Average live weight, kg	488	96	540	76
Feeding				
Total energy intake, SFU	4,917	702	5,445	535
Amount of barley, % of SFU	21	9	5	6
Amount of roughage, % of SFU	39	16	29	15
Reproduction				
Calving, number per cow	1.21	0.22	1.11	0.32
Replacement rate, %	38	14	38	14

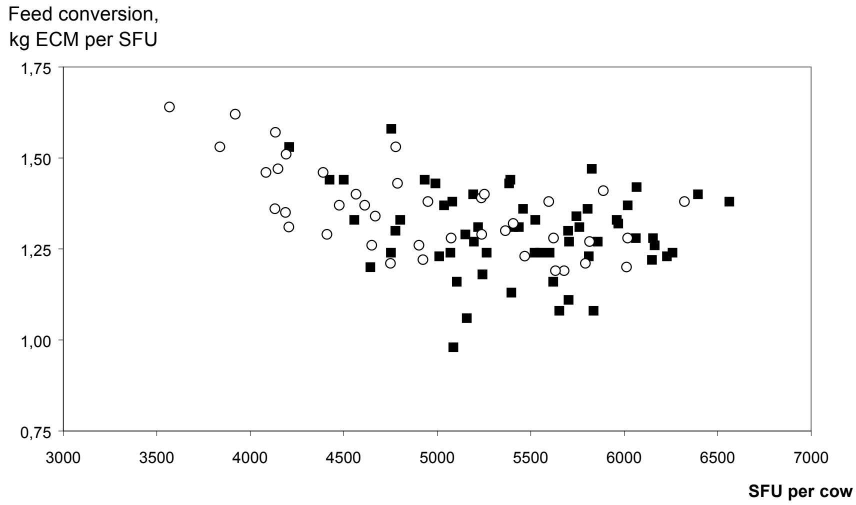
1) Definition is given in the text

The feeding strategy in the organic herds differed slightly from the conventional. The energy intake in early lactation was lower, 1 to 2 SFU per cow daily, but the content of protein and other nutrients per

SFU was independent of the farming system. The lower energy intake is a result of a lower level of concentrates as the energy concentration in the roughage is almost the same (Kristensen & Kristensen, 1998). The flat-rate feeding strategy is used in both farming systems, with a herd specific amount of concentrates given to all cows in early lactation irrespectively of daily milk yield. The length of the flat-rate period is typically longer, up to 36 to 40 weeks after calving in the organic herds, compared to typically 24 weeks in the conventional herds.

For milk production the efficiency of the dairy cow is related to the level of net energy intake (Kristensen & Aaes, 1989). This is due to a reduction in the digestibility, especially of the cell wall substances, with an increasing feeding level. This reduction is partly compensated for by decreased losses of energy in methane and urine. The observed difference between herds in feed efficiency, having taken the feed level into consideration, may therefore be related to factors like rumen fermentation, non-additive energy value of the individual feeds and the utilisation of the metabolizable energy for (to) the different production expenditures.

The different efficiency variables plotted against the feed intake in the herd are shown in Figure 1.



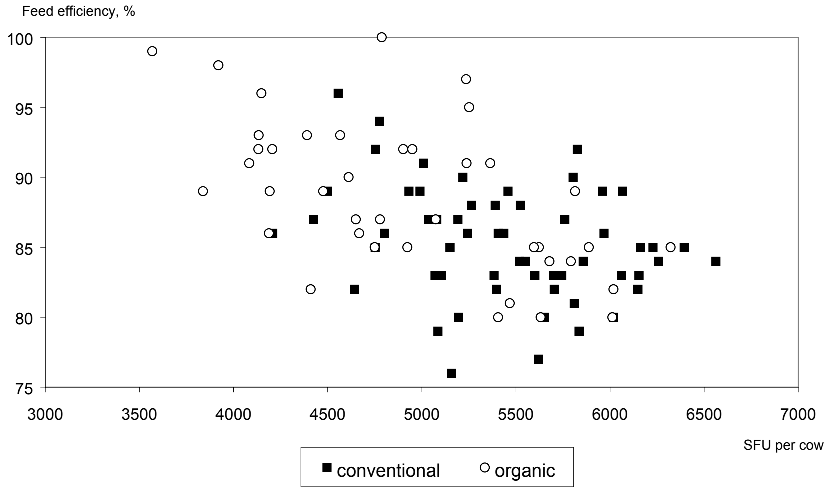


Figure 1 Feed efficiency and feed conversion rate in conventional and organic dairy herds in relation to feed intake

The correlation is strongly significant for the feed efficiency and feed conversion rate (milk per SFU), but not significant for feed residual. This could be expected as the latter to some extend is corrected for the general effect of feeding level.

The effect of farming system on the three efficient variables, feed efficiency, feed residual and milk per SFU, was analysed in a regression analysis with farming system, housing system and breed as class variables. The results of the analysis are given in Table 4.

Table 4 The feed efficiency and feed conversion rate analysed in relation to production system, LSMEANS

System	Organic	Conventional	*P-value	LSD	R^2
Feed efficiency	88.7	85.8	< 0.01	0.9	0.16
Feed residual	-80	+82	< 0.01	62	0.07
Milk per SFU	1.36	1.32	0.04	0.02	0.43

* model y = breed, housing system, production system

The efficiency was significantly higher in the organic system than in the conventional systems for all three ways of measuring efficiency in the dairy herd. In the organic farming system, the feed efficiency was 2.9 percentage points higher than in the conventional system, whereas the feed residual intake after correction for difference in the actual level of intake was 162 SFU lower and the production of milk was 0.04 kg ECM higher per SFU in intake (Table 4).

As seen from Table 3 and by the low R^2 value from the system analysis in Table 4, there is a large variation in efficiency within the farming system not related to different breed or housing system. This variation between organic herds was analysed by considering herd-related factors that might influence the efficiency. Looking across the three efficiency variables, seven factors were significant in the regression analysis for one or more of the dependent variables. All factors were treated as continuous variables.

The result of the analysis is given in Table 5, by the level of significance, with a non-significant level of P>0,05, and the estimate of the regression coefficient for the significant factors. The models explained 69 to 80% of the variation.

Table 5 Factors affecting the efficiency within the organic dairy herd, significance and estimates from regression analysis

Factor	Feed efficiency		Feed residual		Milk per SFU	
	Sign.	Estimate	Sign.	Estimate	Sign.	Estimate
Feed intake, SFU/cow	< 0.01	-0.013	< 0.01	0.575	< 0.01	-0.185
Calving, number/cow	< 0.01	-9.899	0.04	423	NS	
Replacement rate, %	NS		0.05	-5.66	NS	
Live weight, kg	< 0.01	0.052	NS		NS	
Yield persistency, %	NS		NS		0.04	9.16
Peak yield, kg ECM	0.05	0.75	< 0.01	-83.2	< 0.01	40.0
Amount of roughage, % of SFU	NS		0.03	-5.20	NS	
Model						
R^2	0,74		0,69		0,80	
SD	3,1		186		58,8	

The level of feed intake had a significant, negative effect on all three-efficiency variables, also for residual feed. A large number of calvings had a negative effect on feed efficiency and feed residual. This could illustrate that the feeding management in the period around calving is difficult and with a higher level of problems with health. A high replacement had a positive effect on the feed residual as perhaps a result of fewer days with dry cows in the herd. The feed efficiency was highest in herds with big cows after correction for effect of different feeding level. A high peak yield was always related to a higher efficiency and a high persistency was related to a higher milk conversion rate.

Conclusion

The variation in production results within the organic herd illustrates the different ways of farming and level of management. In order to be more specific in research and consultancy work it is important to increase the understanding of the background for the farm specific variation.

A high efficiency in conversion of plant products, like clover-grass and cereals, into milk and meat is important within all farming activities and even more important in organic farming. The feed ration and the way of feeding within the organic farming system lead to a higher efficiency than in conventional farming. The analysis of variation within the organic system indicates that other strategies, focusing on a lower annual feed intake and a higher calving interval, could be a way of increasing the efficiency.

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Fodder beets and potatoes as a replacement for grain in dairy cow diets

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Abstract

Root crops might be of great value, especially for the organic dairy farmer. It is likely that roots and potatoes fed to dairy cows could help to improve energy and protein supply as well as nitrogen balance. Also from the future perspective of less use of potential human food in animal feeding, as well as from a crop production point of view they would be beneficial. Practices for organic growing and for the handling needs to be improved. The need for processing and cleaning prior to feeding should be examined. In a research project at the Swedish University of Agricultural Sciences, the aspects of feeding potatoes and roots to dairy cows are investigated, with emphasis on the possibilities to improve protein utilisation. In this paper the background and the principles of the research project are elaborated.

Improving protein supply and nitrogen balance

Organic farming systems with dairy cows are usually based on leguminous forage crops, such as clover and lucern. The nitrogen binding ability of these crops gives a necessary input of nitrogen in the system. Leguminous forage is characterized by a high content of crude protein and also by a high rumen degradability of this fraction. This will often create an excess of nitrogen in the rumen, in the Nordic protein evaluation system known as high PBV values. The nitrogen excess appears as ammonia peaks in the rumen and as high plasma levels of urea, which can be detected by analysis of milk or blood. Finally, the nitrogen is excreted in urine and a considerable part might after that be lost from the system by ammonia emission during storing.

The high content of soluble nitrogen in leguminous forage should not be regarded only as a problem, but rather as a potential source of protein for the animal. This protein source could decrease the need for protein concentrates. However, its degree of utilisation is depending on the composition of the total ration and also on the diurnal timing between different feeds (Herrera-Saldana & Huber, 1989, Sinclair et. *al*, 1995).

If the animal should be able to utilise the ammonia released in the rumen, it must be converted into microbial protein by growth of the ruminal microbial population. To achieve this, a carbohydrate source must be available for the rumen microbes. The most used carbohydrate source today is grain starch. Roots and potatoes are alternate carbohydrate sources, that might increase microbial protein synthesis by the specific properties of their carbohydrate fractions. The sugar of roots is available on a short term basis and would give rumen microbes a chance to utilise ammonia peaks for growth. Roots also contain the structural carbohydrate pectin, a highly digestible fiber component mainly responsible for the dietary effects of beet pulp. The storage carbohydrate in potaotes is starch, but it differs from grain starch in some aspects. The degradability rate is slower for potato starch than for grain starch which might be due to their different physical properties. The grain starch is distributed as small granules in the kernel, while potato starch forms much bigger granules with a size of up to 0.1 mm. If sugar from roots could serve as an instant fuel for rumen microbes, potato starch would instead be a slowly available source of carbohydrates that could help to maintain a microbial population between feedings

Improving energy supply

Intake of forage as well of total dry matter is usually increased with roots in the ration (Roberts, 1987, Gruber 1992). Increased intake will then improve the possibility to cover the energy demand of high yielding dairy cows. Metabolisable energy (ME) values for fodder beets in litterature, as reviewed by Gruber (1992), ranges from 11.73 to 13.00 MJ/kg dry matter (DM). From experiments with dried beet pulp, it has been suggested that beet pulp can replace barley on an equal dry matter basis and that the lower ME value for beet pulp in feeding tables do not reflect the true conditions (Sheehan & Quirke, 1982, Huhtanen, 1987). Even if fresh fodder beets has a large fraction of sucrose, which might be utilised to a somewhat lower degree in the rumen than the other digestible constituents, it is reasonable to consider barley and fodder beets as interchangeable energy feeds on a dry matter basis.

Potatoes are usually assigned an energy value slightly higher than that of fodder beets (Daccord, 1984, Fodertabeller för idisslare, 1995). Jans (1989) found no significant differences between potatoes and fodder beets, concerning intake and milk yield, when used as a partial replacement of concentrate for lactating cows. Potatoes may, from the aspect of energy supply, also be regarded as interchangeable with barley on a dry matter basis and with a potential to increase total energy intake when partially replacing grain.

Less use of potential human food

The energy and protein recovery in dairy production today is approximately 25 % and 30 % respectively. However, in this calculation, it is not taken in account whether the feed could be used as human food or not. If the ratio between human food produced by the cow and potential human food consumed by the cow is used instead, it is possible to get a recovery over 100 % with a roughage based diet (Webster, 1993).

A dairy cow ration with this goal should be based upon roughage, supplemented mainly with by-products not suitable for human consumption. Today, the supplement consists to a major part of grain. In a situation with a great need to increase human food production, it is likely that more roots and potatoes would be grown for human consumption because of their superior yield compared to grain. This would also give rise to more by-products, such as wrong sized or damaged roots and potatoes, as well as different kinds of residues from processing. These by-products could, together with a legume rich silage, form a ration for dairy cows that would satisfy the energy and protein requirements for a considerable milk yield. To increase the milk yield, the protein supply could then be improved by addition of a small amount of rapeseed by-products.

Even if fodder beets are grown instead of grain on good arable land, they could still be regarded as a way to increase the food production. Their high yield will mean that less land is needed for production of feed, than if feed grain was grown instead. This is especially the case, if also the root tops could be well utilised in animal feeding.

When grain cannot be grown on the farm

There are regions in the Nordic countries that are not suitable for grain production because of climatic conditions. In many of these regions, it is possible to grow potatoes and also some of the less demanding root crops. With these crops, dairy farmers might have a possibility to produce milk almost entirely on home-grown feed, even if grain cannot be grown on the farm

Roots and potatoes in crop rotation

In many organic crop rotations, a row crop such as roots or potatoes would be valuable. Row crops gives an opportunity for mechanical weeding. The ability of roots to keep growing in the autumn means that plant nutrients slowly released from manure and degraded crop residues will be well utilised.

The greatest problem encountered in organic root production is maybe the weed control at the early stage of growth. The technique developed for organic sugar beet production may be adapted also for fodder beets. The recently started experiment in Denmark with pregermination procedures for root crops could provide organic farmers with the new tool needed to simplify growing (DARCOF, 1999)

What kind of processing is needed?

The most important reason for the decreased utilisation of root crops among dairy farmers is probably the laborious handling, storing and feeding practices connected with it. The fear that soil contamination could be detrimental to animal health and milk quality is another factor that might discourage dairy farmers from using these alternate feeds. Ulveslie & Saue (1965) investigated the effect of dry cleaning and chopping roots before feeding them to dairy cows. The milk production was in this experiment not affected at all by the different treatments, in spite that the daily intake of soil from the uncleaned roots was 2.2-2.6 kg/d. The chopping shortened the eating time with 10 %. Albeit the production level was considerably lower than the milk yield of today and that demands on milk quality has increased, the experiment still shows that it might be possible to feed roots to dairy cows without any processing at all.

The research project at Kungsängen Research Center

If the assumed beneficial effects of roots and potatoes should be used to their full extent, more research is needed as a complement to earlier results and knowledge from practical farming. In 1998, the 3-year project *Milk production from leguminous forage, potatoes and roots*, started at the Swedish University of Agricultural Sciences, Kungsängen Research Center, Uppsala. As the project includes aspects of animal health, it is run in cooperation with scientists from the Veterinary Faculty. The main goal of the project is to form a scientific basis for a dairy production system that utilises the nitrogen in leguminous forage efficiently and will only rely on crops suitable for human consumtion to a minimum extent. Special attention is paid to protein supply by an efficient production of microbial protein and to the possibilities to improve nitrogen balance. Other topics that are covered in the project are:

- Intake potential and energy supply
- Whether roots and tubers favour anabolic or catabolic metabolism in dairy cows
- What milk yield can be obtained with a diet of forage, roots and tubers

The first experiment in the project was an *in vitro* study of microbial protein production, where fodder beets and potatoes were compared with grain as carbohydrate sources (Eriksson, 1999). The results indicated a specific effect of rumen fluid from cows adapted to a potato diet and a new *in vitro* experiment has recently been made to verify this effect. A pilot study of the protozoa's role in rumen degradation of potato starch has also started.

Three *in vivo* experiments are made so far in the project, but are not evaluated yet. In the first experiment, the individual choice and intake of fodder beets and potatoes was recorded for 23 cows. The effects of the different intakes on microbial protein production and nitrogen excretion were assesed by milk and urinary parameters. Six of the cows were then used for a second experiment, where they still recieved the same diets, but with fodder beets and silage fed simultaneously so that the effect of synchronising nitrogen and carbohydrate release could be studied.

The third *in vivo* experiment was of change-over design with 12 cows and three diets. It included milk yield and intake as well as metabolic status measured by blood parameters. For eight of the cows, total collection of urine and faeces was performed so that the nitrogen balance and digestibility with the different diets could be determined. Four cows were fitted with ruminal cannulas and were used for studies of rumen metabolism.

Further experiments that are planned are production and fertility trials lasting for the major part of lactation and also studies of rumen metabolism *in vivo* and *in vitro*.

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Effect of organic fodder on prevention of milk fever

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Abstract

The relation between cations and anions (DCAB = dietary cation anion balance) in the cows' diet in the dry period is connected to prevention of milk fever. One can expect a different value of DCAB in organic fodder than in fodder produced in the conventional way, and earlier studies of organic farms in Norway have documented that cows in organic herds have less milk fever compared to the overall average incidence of milk fever in Norway. The project will analyse whether fodder produced on organic farms is responsible for the preventive effect on milk fever. The collection of data started autumn 1999 and will continue until spring 2001. The project is part of a larger programme called "Alternative veterinary medicine and biological plant protection " at the Norwegian Centre for Ecological Agriculture (NORSØK). The project period is July 1998 to March 2003.

Background and objectives

Earlier studies of organic farms in Norway have documented that cows in organic herds have less milk fever compared to the overall average incidence of milk fever in Norway [1]. Milk fever appears most frequently in high-yielding cows. In organic husbandry the production level is often lower than in conventional husbandry [1]. This could therefore be one reason for less milk fever in organic herds. On the other hand there is an increasing risk for milk fever connected to increasing age, and the cows' average age in organic herds is higher than the overall average age [1]. This should therefore result in more milk fever in organic herds. Numerous publications have demonstrated that feeding of cows in the dry period with diets high in cations, especially Na^+ and K^+, tends to induce milk fever. Feeding cows with diets relatively high in anions, primarily Cl^- and SO_4^{2-}can prevent milk fever [2]. In organic farming no inorganic fertilisers are used. This may result in low content of K in the plants and with that a low content of K in the fodder. There is also often more diversity of plants (clover, herbs, "weeds ") in an organic meadow than in a conventional meadow. Plants vary in their uptake of different elements. One can therefore expect a different relation between cations and anions in organic fodder than in fodder produced in the conventional way. An important parameter used to measure the relation between cations and anions is the dietary cation-anion balance (DCAB). The DCAB can be calculated by taking the sum of the meq/kg feed of dietary Na^+ and K^+ minus the meq/kg feed of Cl^-. A method for determining whether an animal is responding to a negative or small value of DCAB in the diet is to monitor the pH of its urine. This project will analyse whether the fodder produced on organic farms is responsible for the preventive effect on milk fever.

Method

Data will be collected on sixteen farms: eight organic farms and eight corresponding (climatic, geographic, farm management) conventional farms. From each farm seven cows will be selected. Fodder given to the cows in the dry period will be analysed for Na^+, K^+ and Cl^-, and the botanical composition and development stage of the roughage will be determined. The value of DCAB will be calculated and compared to values of pH in the cows' urine. The cows' urinary pH will be measured in the cows' dry period, using pH-papers. The fodder will also be analysed for other minerals (Ca, Mg, P, Mn, Fe, Cu, Zn and Mo) to get a wider picture of the fodder ration. The cows' body condition score in the dry period will also be measured.

Results

The collection of data started this autumn (1999) and will continue until spring 2001. The first preliminary results will therefore be available in the course of 2001.

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Evaluation of animal welfare on organic dairy farms in Finland

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Abstract

The evaluation of animal welfare on organic dairy farms was carried out in connection with the first Finnish research study on animal healthcare and welfare in 1996 to 1998. 26 organic dairy farms took part in the research, including 20 tie-stall barns (332 cows) and 6 loose-housing systems (209 cows). They formed 36% of the organic dairy farms and 46% of the cows certified with *Luomuliitto* (Finland's Ecological Animal Production Standards) in 1996. Survey visits to the farms were conducted during early spring and autumn. Housing, feeding and health data was collected. The data from housing conditions and cattle health was used for estimating the Animal Needs Index values.

The two Austrian Animal Needs Indexes developed by Bartussek were used for the first time in Finland. The holistic approach considers five important husbandry components: possibility of movement, social contact, condition of the floors, stable climate and stockman's care (Bartussek, 1997). The Animal Needs Index value was determined with dairy cows according to TGI 35K/1995 and TGI 35L/1995. A few changes were made to accommodate the indexes to Finnish circumstances. The Animal Needs Index value on Austrian organic farms should be 21 points at least (for old cow barns) or over 24 points (for new cow barns). The longer version, TGI 35L/1995, proved to be more practicable in Finland than the shorter version, TGI 35K/1995. Determined according to TGI 35L/1995, 81% of the farms passed the point level needed for organic animal husbandry, but according to TGI 35K/1995 only 31% passed the limit.

Introduction

Consumers are more and more interested in the origin of their food and the methods how it is produced. Public pressure concerning farm animal welfare is also very great in many European countries (Broom, 1992). Animal health, welfare, vitality and longevity belong to the goals of organic farming. Proper organic farming includes not only appropriate feeding with farm-grown fodder, but also changed breeding goals, better housing systems, enabling animals to perform their inborn natural behaviour and a commitment to disease prevention by the caretaker (Boehncke and Krutzinna, 1996; Boehncke, 1997).

From an ethical point of view, animals also have dignity. As such they deserve to be treated according to the requirements of the species to which they belong. This special status of farm animals should be as important to organic farmers as a responsible and gentle treatment of the soil and plants. (Fölsch and Hörning, 1996.)

The welfare of an individual animal can be judged by its state as regards to its attempts to cope with its environment (Broom, 1986). The methods which animals use to try to maintain control and to cope with difficulties include a range of physiological and behavioural responses (changes in heart rate, adrenal action, movements which reduce pain and actions which result in avoidance of excessive cooling) (Broom, 1992). Welfare varies from very poor to very good and will fluctuate during the animal's life (Broom, 1992; Fraser and Broom, 1997). The subjective feelings of an individual are also an important aspect of its welfare (Broom, 1992). Poor welfare occurs in situations in which the effects on the animal are so adverse that there is reduced fitness or clear indications that fitness will be reduced, i.e. the animal is stressed (Broom, 1992).

Different methods are developed to estimate animal welfare. Physiological measures (heart rate and adrenal cortex activity), behavioural measures (reduced activity, unresponsiveness, self-narcotising, stereotyping), immunological measures (immunosuppression), injury and disease (the extent of body tissue damage and the degree of disturbance of physiological and behavioural processes), fitness measures (mortality risk, growth and reproduction) and preference assessment (preference tests) are used (Broom, 1992). Welfare should not be defined solely in terms of subjective experiences, but a wide range of measures should be used (Broom, 1992). Numerous flexible systems for judging farm animal welfare have been developed (Schlichting and Smidt, 1984; item, 1987; Kohli and Kämmer, 1984; Zeeb, 1985; Bock, 1990; Irps, 1985). At the moment, however, the two judgement systems, TGI 35 developed by Bartussek (1988, 1991, 1997) and TGI 200, developed by Sundrum et al. (1994), are mainly in use in Austria and Germany (Amon et al., 1997).

The Animal Needs Index (ANI)

Beginning in 1985 an "Animal Needs Index" ANI (German; Tiergerechtheitsindex, TGI) has been developed (Bartussek, 1991). ANI is a pragmatic and only partly scientific system, based on a consensus of the people involved, which indicates the level of how an animal can perform its inborn natural behaviour in different housing systems. ANI matches the large variety of situations in practical farming better than a compulsory list of single conditions. It helps reduce conflicts between farmers' situations and consumer expectations (Bartussek, 1997). It has been officially used in Austria since 1995, mainly in controlling husbandry systems in organic farming and proprietary articles. By the end of 1997 more than 20 000 stables were investigated in Austria (Bartussek, 1997). The ANI has proved to be practicable and satisfactory (Bartussek, 1991; 1997).

The holistic approach assesses the welfare of animals by considering five important husbandry components: possibility of movement, possibility of social contact, condition of the floors, stable climate (including light and noise) and stockman's care. Scoring leads to a sum of points. These ANI values represent different categories of animal welfare along a continuum from not animal friendly to animal friendly. Before the estimation is done, the minimum standards relating to housing conditions and biological and ethological needs should be achieved. If minimum standards are not achieved the ANI values are settled with reservation. The fault in the animal housing system must be removed (Bartussek, 1997; Amon et al., 1997). The Animal Needs Index value on Austrian organic farms should be 21 points at least (for old cow barns, approximately 55% of the sum of points) or over 24 points (for new cow barns, over 60% of the sum of points).

Material and methods

The evaluation of animal welfare on organic dairy farms was estimated in connection with the first Finnish research study on animal healthcare and welfare in 1996 to 1998. 26 organic dairy farms took part in the research, with a total of 541 cows. They formed 36% of the organic dairy farms and 46% of the cows certified with *Luomu-liitto* (Finland's Ecological Animal Production Standards) in 1996. There were 20 tie-stall barns (332 cows) and 6 loose-housing systems (209 cows). Survey visits to the farms were done during the early spring and autumn of 1997. Cattle health was studied through existing health reports of the herd, questionnaires and physical examination of the animals and the housing conditions were controlled. Feeding data was also collected.

The welfare of the animals was evaluated according two Austrian Animal Needs Indexes, TGI 35K/1995 (Bartussek et al., 1995) and TGI 35L/1995 (Anon., 1995), developed by Bartussek. The shorter version, TGI 35K/1995, ranges from 5 to 35 points. The version, TGI 35 L/1995, is more specific, with a range of minus 10 to plus 45,5 points. TGI 35 L/1995 is used in monitoring organic animal husbandry in Austria. A few changes were made to accommodate the indexes to Finnish circumstances. Because of the small herd size in Finland, all animals were included in the estimation and not only a quarter of the animals that had the worst housing conditions, as is done in Austria. The minimum standards used in this estimation were: Finnish animal protection legislation (Eläinsuojelulaki, 1996; Eläinsuojeluasetus, 1996; Anon., 1997b), regulations concerning housing conditions of animals by the Ministry of Agriculture and Forestry (Anon., 1996a;1996b) and Finland's Ecological Animal Production Standards (Anon., 1997a).

Results

Possibility of movement

TGI 35K/1995 gives points according to the time animals stay in a free-range or limited exercise area. The longer version, TGI 35L/1995, examines loose-housing systems and tie-stalls separately. It takes account of the total area for movement (space per animal), ease of lying down and standing up, opportunity for outdoor exercising and pasturing. In tie-stalls, TGI 35L/1995 also determines the size of lying boxes and latitude of the tying system. This field gave on average 3.7 points according to TGI 35K/1995 and 5.3 points according to TGI 35L/1995 (Table 2).

In summer cows are put out to pasture. Grazing season in Finland (3.5 months) is shorter than in Central Europe, but usually cows are allowed to stay out during daytime for about 5 months. For that reason we didn't use specific numbers regarding how many days cows are grazing during the summer months, but the amount of days of possible grazing according to region (whole grazing season, 2/3 of the grazing season, 1/3 of the grazing season). During winter, 73% of the farms let the animals out at least two or three times per week (Table 1).

Table 1 Winter exercise of cows on organic dairy farms.

Times/Week	Stables %	Number of tie stall barns	Number of loose housing systems
0	4	0	1
1	23	6	0
2 - 3	50	11	2
3 - 4	8	1	1
4 - 5	4	1	0
5 - 6	0	0	0
6 - 7	11	1	2
Total	100	20	6

Table 2 Animal needs indexes, TGI 35K/1995 (K) and TGI 35L/1995 (L). The sum of points within each field of influence gives the ANI value.

Field	Possibility of movement		Social contact		Condition of the floors		Stable climate		Stockman's care		ANI value	
Stables	K	L	K	L	K	L	K	L	K	L	K	L
1	3	5,5	3	5	4	5	4	4,5	6	6	20,0	26,0
2	3	5,5	3	5	4	4	4	4,5	5	4,5	19,0	23,5
3	3	4,5	3	4,5	4	4,5	5	4,5	7	6,5	22,0	24,5
4	3	4,5	3	4,5	4	4,5	4	5	6	5,5	20,0	24,0
5	3	4,5	3	4,5	1	1	4	5,5	5	4	16,0	19,5
6	3	5,5	3	4,5	3	4	2	4	6	5	17,0	23,0
7	3	5	3	4,5	3	2,5	3	4,5	7	7	19,0	23,5
8	3	5	3	4,5	3	3	3	4	7	7	19,0	23,5
9	3	4	3	4,5	4	3,5	4	5	6	6	20,0	23,0
10	3	5	3	4,5	4	4	4	5	7	6,5	21,0	25,0
11	5	7,5	5	7,5	5	4,5	2	4	7	7	24,0	30,5
12	3	4,5	3	3,5	3	5	2	4	5	4,5	16,0	21,5
13	3	5	3	4,5	3	5	4	3,5	6	6	19,0	24,0
14	7	9,5	7	9	6	6	5	6	7	6,5	32,0	37,0
15	3	3,5	3	3	4	5	4	6	6	5	20,0	22,5
16	3	4	3	3,5	3	3,5	4	5,5	5	4	18,0	20,5
17	5	8,5	5	7,5	5	5	3	4	7	7	25,0	32,0
18	7	10	7	9	5	4,5	7	7	6	5,5	32,0	36,0
19	5	5	5	7	4	3	2	3	6	5	22,0	23,0
20	3	4	3	4,5	2	3	2	3,5	5	4	15,0	19,0
21	5	5	4	5,5	4	4,5	6	6	6	5,5	25,0	26,5
22	3	5	3	4,5	4	4	4	5,5	7	6,5	21,0	25,5
23	3	4,5	3	4,5	4	5	2	3	5	4,5	17,0	21,5
24	3	5	3	4,5	4	5	2	4	6	5	18,0	23,5
25	3	4,5	3	4,5	2	3,5	2	3,5	5	4	15,0	20,0
26	5	2,5	5	4	4	4,5	2	4	4	2	20,0	17,0
AV.	3,7	5,3	3,7	5,1	3,7	4,1	3,5	4,6	6,0	5,4	20,5	24,4
MAX	7	10	7	9	6	6	7	7	7	7	32	37
MIN	3	2,5	3	3	1	1	2	3	4	2	15	17
STDEV	1,3	1,7	1,2	1,6	1,0	1,0	1,4	1,0	0,9	1,2	4,3	4,8

Possibility of social contact

TGI 35K/1995 gives points according to box type (different areas for feeding and resting behaviour) and the time animals stay in a free-range or limited exercise area. The longer version, TGI 35L/1995, examines total area for movement (space per animal), consistence of the herd, opportunity for outdoor exercising and pasturing. This field gave on average 3.7 points according to TGI 35K/1995 and 5.1 points according to TGI 35L/1995 (Table 2).

Condition of the floors

TGI 35K/1995 gives points according to the softness of the rest area and the firmness of walking area. TGI 35L/1995 examines softness, cleanliness and firmness of the resting area and quality of the floor in activity areas and passages. Attention is paid to outdoor exercise areas, slatted floors in loose-housing systems and passages in tie-stalls. The field gave on average 3.7 points according to TGI 35K/1995 and 4.1 points according to TGI 35L/1995 (Table 2). Stable number 5, in the table, got only one point because of slippery and partly dirty boxes in a tie-stall without any bedding material.

Stable climate

TGI 35K/1995 gives points according to ventilation, stable type and outdoor exercise time. TGI 35L/1995 pays attention to lightness of the stable, ventilation, draught and access to outdoor areas. The field stable climate gave on average 3.5 points according to TGI 35K/1995 and 4.6 points according to TGI 35L/1995 (Table 2).

Stockman's care

Both index versions examine the same areas: tidiness of the feeding area and water bowls, condition of stable equipment, equipment-caused injuries, skin condition, cleanliness of the animals, claw condition and health of the animals. The points given differ between versions, with the shorter version, TGI 35K/1995, giving more points. This field gave on average 6.0 points according to TGI 35K/1995 and 5.4 points according to TGI 35L/1995 (Table 2). As an exception to the other fields, the stockman's care gave the same amount or more points in all stables. The greatest difference was points given to stable 26.

The Animal Needs Index value

The sum of points averaged 20.5 according to TGI 35K/1995 and 24.4 according to TGI 35L/1995 (Table 2). The sum of points was greater in estimation according to TGI 35 L/1995, except for loose-housing system number 26. That stable got more points, according to TGI 35K/1995, in the fields of possibility of movement, possibility of social contact and stockman's care.

When looking at the different fields of the ANI value, the TGI 35 L/1995 gave on average 1.6 points more in the field of possibility of movement, 1.4 more points for possibility of social contact, 0.4 more points for condition of the floors and 1.1 more points for stable climate. Stockman's care gave 0.6 points more on average according to TGI 35K/1995. Figure 1 shows the different fields of the ANI-values and figure 2 provides the ANI numbers of the stables.

Access to an exercise area or pasture belong to three different fields of determination. They can form 27% of the points of the ANI number (12.5 points in TGI 35L/1995). If animals have not access to outdoor exercise, the sum of the ANI will be low. When collecting information for this research, Finland's Ecological Animal Production Standards had not settled standards for outdoor exercise during winter time. Today dairy cows are put out to pasture or exercise area during summer time and at tie-stall barns they should get out at least three times per week (weather conditions permitting) in winter time (Anon. 1997a).

The Animal Needs Index value on Austrian organic farms should be 21 points at least (for old cow barns) or over 24 points (for new cow barns). The longer version, TGI 35L/1995, proved to be more practicable in Finland than the shorter version, TGI 35K/1995. Determined according to TGI 35L/1995, 81% of the farms (21 stables) passed the level needed for organic animal husbandry, but according to TGI 35K/1995, only 31% (8 stables) passed the limit (Figure 3). Table 3 shows the evaluation according to environmental naturalness, satisfaction of animal needs and animal welfare

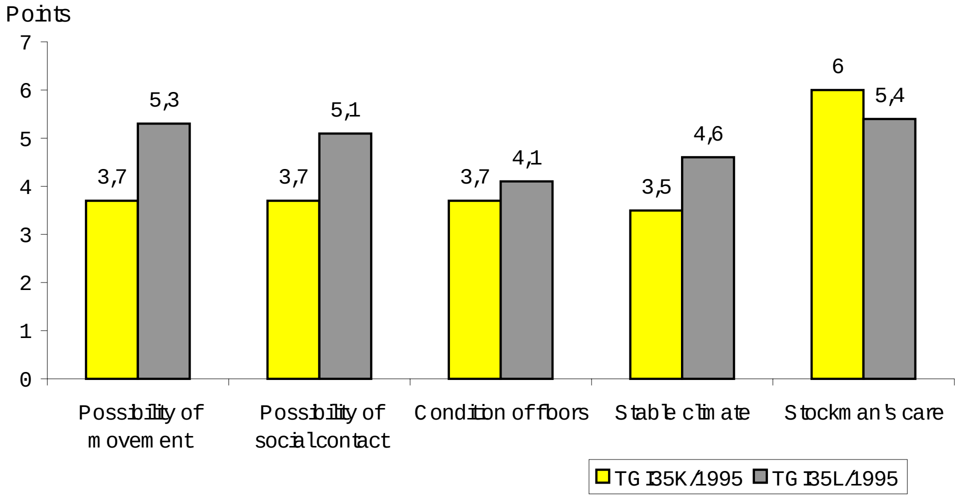

Figure 1 Average points in the five fields of the Animal Needs Index.

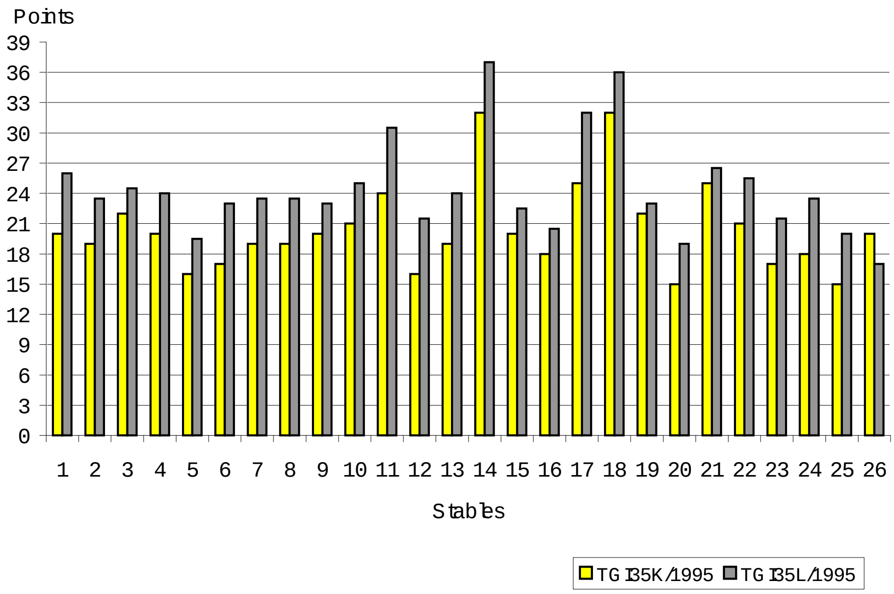

Figure 2 The Animal Needs Index values according to TGI 35K/1995 and TGI 35L/1995. Stables number 11, 14, 17, 18, 19 and 26 are loose-housing systems.

(Bartussek, 1991). Determined according to TGI 35K/1995, 57.7% of the stables were evaluated as follows: not near to nature, little adequate for animal needs, medium welfare standard: behavioural deprivation, and slight damage. According to the more specific version, TGI 35L/1995, only 15.4% of the stables got the same evaluation and 50% of the stables were estimated as near to natural, fairly adequate for animal needs, quite good welfare standard: behavioural restrictions, no damage. In loose-housing systems animals are able to perform most inborn behavioural needs and that is why loose-housing systems usually get more points than tie-stall barns. Still, according to this estimation two loose-housing systems (stables numbers 19 and 26) did not pass the limit required for organic dairy farms.

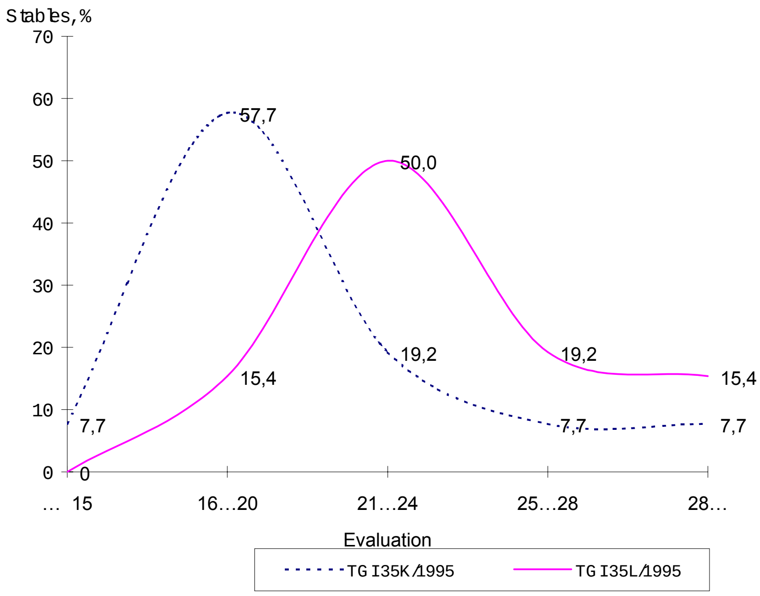

Figure 3 The stables evaluated according to TGI 35K/1995 and TGI 35L/1995.

Table 3 Stables according to ANI numbers.

ANI number	TGI 35K/1995 Number of stables	%	TGI 35L/1995 Number of stables	%	Evaluation (Bartussek, 1991)
< 11	0	0.0	0	0.0	Unnatural, industrial, not at all adequate for animal needs, extremely poor welfare standard: behavioural suffering, severe damage
11-15	2	7.7	0	0.0	Far off nature, barely adequate for animal needs
16-20	15	57.7	4	15.4	Not near to nature, little adequate for animal needs, medium welfare standard: behavioural deprivation, slight damage
21-24	5	19.2	13	50.0	Near to natural fairly adequate to animal needs, quite good welfare standard: behavioural restrictions, no damage
25-28	2	7.7	5	19.2	Natural, adequate to animal needs, high welfare standard
>28	2	7.7	4	15.4	Natural, very adequate to animal needs, very high welfare standard

Discussion

According to this determination, the difference between the two versions was rather great. The same stable can be estimated as "not near to nature" or "near to natural" depending on what method is used. That is why it is not possible to compare the housing conditions and animal welfare of one farm to another if it is not estimated according to the same method. There are also some sectors that should be added to the estimation. Organic farms are run according to the regulations of organic livestock production, where animal welfare, through housing conditions, nutrition, breeding, free-range exercise areas and human care, is taken account. However, an ordinary farm with high levels of concentrates in feeding can get higher ANI numbers in an estimation. In that case it is impossible for a consumer to draw conclusions from animal welfare on the grounds of an ANI number. It might be useful to also include some fields concerning feeding in the estimation.

The human-animal relationship is one of the most important factors influencing animal health and welfare in housing systems (Boehncke, 1997). Bartussek's original version estimated human care by herd size or working time (Bartussek, 1991). The field of stockman's care has been further developed, however, and the human-animal relationship is now estimated indirectly via animal health and cleanliness and the condition of the equipment and animals. Many parts of the five fields are subjectively estimated, for instance the cleanliness of the animals. So persons working in the monitoring of livestock systems should be trained in order that the deviation between people can be diminished (Amon et al., 1997).

For more objective results, different types of measuring equipment should be available. For instance, stable gasses can be measured with infusion tubes and the light level with photometers.

Conclusion

The evaluation of animal welfare on organic dairy farms was estimated for the first time in Finland. The estimation gave encouraging results, concerning how housing can be evaluated from the animals' point of view. Finland's geographical location and how this influences the different fields of the Animal Needs Index should still be taken into account; the index must accommodate Finnish circumstances. The Animal Needs Index draws attention to the importance of animal welfare and more animal friendly housing systems. The index would also be suitable in Finland for monitoring husbandry systems in organic farming and would assure a higher market value for organic or proprietary articles. As part of the quality systems of agriculture it could satisfy the interests of producers, advisors and consumers.

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Effects of concentrate level in organic milk production

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Abstract

The effects of concentrate supplementation, LOW and HIGH, were studied during the whole lactation in an organic herd of 20 spring calving cows. Concentrates accounted for 5% and 25% of annual total energy intake in LOW and HIGH, respectively. Basal diets were grass silage *ad libitum* and restricted allowance of hay and green fodder silage. Cows in both groups consumed large amounts of roughage. Due to the different concentrate supplementation the daily intake of energy and protein was higher for the HIGH than for the LOW treatment. HIGH concentrate supplementation gave significantly more daily and total production of milk compared to LOW. The LOW and HIGH level cows dried off after 246 and 269 days, respectively, yielding 3767 and 5133 kg ECM in total. Milk composition was not significantly effected by concentrate level, but due to higher production the yield of fat, protein and lactose were significantly higher in HIGH versus LOW. The consumption of concentrates was 4.9 and 21.4 FEm per 100 kg ECM for the LOW and HIGH, respectively. The energy and protein intake in relation to production were close to standard recommendation in early lactation. However, in late lactation cows in both groups were in a high positive energy and protein balance, which is in accordance with the observed increase in live weight.

Introduction

The research project "Resource utilisation in organic and conventional systems with crop and dairy production" is carried out at the Agricultural University of Norway (NLH) in the period

1998-2002. The objective is to improve resource utilisation in dairy production by studying the flow of primarily energy and nitrogen along the production chain; from crop production on the field to the production of milk and meat. As a part of the project, an organic and a conventional farm unit are run at NLH with different management intensities. In each farm unit production experiment with dairy cattle are carried out each year. In the organic unit different levels of concentrate is studied, because the effect of particular low supplementation is an important issue in Norway. Most farms are small and have less favourable condition for growing grain. Hence, the farmers buy some conventional produced concentrates. However, this practice will be changed. According to the new EU regulation on organic production, livestock must only be fed organic produced feeds in the future (Anonymous, 1999). Consequently, organic dairy producers either has to buy high prized organic produced concentrates or base their milk production on home-grown forage. This paper summarise the effect of two levels of concentrate on feed intake, milk production and feed utilisation in the organic herd the first experimental year.

Material and methods

The organic farm unit has a total of 21 ha which includes a crop production area of 15 ha and a pasture area of 6 ha. The herd consists of 18-20 dairy cows of Norwegian Red Cattle (NRF) and 4-5 calves for replacement each year. In the indoor period the cows are kept in a loose housing system with separate manure storage. Except for a small amount of imported protein concentrate, the farm unit is self-sufficient with organic grown feeds.

The first production experiment started in January 1998 with 20 cows in first to fifth lactation. Eighteen cows calved in the period from January to April, one cow calved in May, and one in June.

The cows were randomly allotted to two treatments with different pre-planned concentrate supplementation, LOW and HIGH, from three weeks before expected calving and throughout the lactation (Table 1). During the indoor periods, before and after grazing, all cows were offered the same forage ration of grass-/clover silage *ad libitum*, together with restricted amounts of hay and ensiled green fodder.

During the in-door period forage and concentrate intake, animal live weight and milk production was recorded automatically for each cow by means of individual transponders. Feed intake from every single meal was measured for each feed and cow during 24 hours.

The single meal for each feed were then summarised per day and cow and constitutes the basic data for feed intake. Individual live weight and milk production was recorded twice a day. Mean weight and total milk production per day and cow were then calculated and used as the basic data for these two parameters. During milking twice a week aliquot samples of milk from each cow was taken and pooled to a weekly sample per cow and analysed for fat, protein and lactose by use of an infrared spectrophotometer (Milcoscan 255A).

Table 1 Pre-planned allotment of concentrates (kg day^{-1}) during lactation for treatment HIGH and LOW.

		During lactation, days after calving						
		Indoor				Grazing	Indoor	
	Before calving	0-30	30-60	60-90	90-120	120-240	240-270	270-300
LOW								
- Barley	0.5	2.0	1.5	1.0	-	-	-	-
- Protein	0.5	1.0	0.5	-	-	-	-	-
HIGH								
- Barley	2.0	6.0	5.5	5.0	4.5	2.0	2.0	2.0
- Protein	1.0	2.0	1.5	1.0	0.5	1.0	1.0	1.0

During the grazing period recording of milk production and chemical composition of milk followed the same procedure as in the indoor period. All cows were weighted two times during grazing.

Concentrates were given manually according to Table 1. No measurement of pasture intake is included in this paper. However, energy intake on pasture was estimated from milk production, live weight and concentrate supplementation.
Feed energy is expressed in feed unit for milk (FEm), where FEm=1000 VEM according to van Es (1978), and feed protein as amino acid absorbed in the intestine (AAT) and protein balance in the rumen (PBV) according to the Nordic system for protein evaluation (Madsen et al., 1995).

The offered forages had high energy value but rather low and variable crude protein content (table 2). The protein content was generally lower in silage fed during early lactation than in the one fed after grazing in late lactation. The fermentation quality of silage was satisfactory (figures not shown).

Table 2 Mean chemical composition and nutritive value of major feeds

	DM	CP	NDF	DOM	AAT	PBV	FEm
	%	G kg^{-1} DM					(kg^{-1}DM)
Silage							
Grass clover, spring	27.0	127	509	700	69	-0.2	0.89
Grass clover, autumn	24.7	130	443	742	68	1.9	0.96
Rape ryegrass, spring	18.3	109	387	790	68	-20.0	1.05
Concentrate							
Rolled barley	86.9	113	275	819	102	-48	1.08
Protein mixture	88.6	363	143	864	231	115	1.15

In the statistical analysis mean values per week and cow for the recorded and derived variables were used. The data was subjected to analysis of variance using GLM procedures (SAS, 1998). Non-significant differences are denoted NS, and significant differences by + (10%), * (5%), ** (1%) and *** (0.1%).

Results and discussion

Total intake of FEm from calving to the next was 3579 in LOW and 4663 in HIGH (Figure 1). The difference is due to concentrate level, as the total forage intake was similar in the two groups. The main proportion of the ration in both treatments was conserved forage and pasture that made up 95% and 75 % of total intake in LOW and HIGH, respectively. Concentrates accounted for only 5% in LOW and 25% in HIGH. The concentrates supplemented to the LOW fed cows were lower than usually found on organic farms in Norway, while HIGH got somewhat more (Ebbesvik, 1994; Strøm & Olesen, 1998).

Daily intake of energy (FEm) and protein (AAT) throughout the lactation was higher for the HIGH than for the LOW treatment (Table 3). In early lactation this is mainly due to different concentrate supplementation, as there was only a small difference in forage intake between the two groups. In late lactation the difference in total feed intake between treatments was smaller, and the amount and difference in forage consumption higher. The generally low level of concentrate supplementation in this experiment may explain the high forage intake and low substitution rates (Østergaard, 1979).

In early lactation PBV intake in both treatments was lower than recommended (Madsen et al., 1995). However, the low ration PBV value does not appear to have influenced the forage intake negatively.

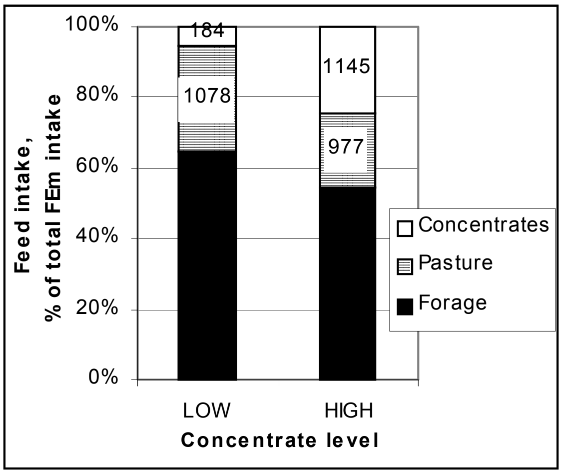

Figure 1 Absolute and relative values for ration composition (FEm) in the LOW and HIGH concentrate supplementation from calving to the subsequent lactation.

Table 3 LSMEANS for daily feed intake during different periods in the lactation

	Treatment		Significance
	Low	High	
Lactation weeks 1-14 (before grazing)			
Total, FEm d^{-1}	13.8	16.7	-
Forage, FEm d^{-1}	12.1	11.4	NS
Concentrate, FEm d^{-1}	1.7	5.3	-
AAT, g d^{-1}	1131	1497	-
PBV, g d^{-1}	-223	-270	-
Lactation weeks 25-35(after grazing)			
Total, FEm d^{-1}	14.8	16.4	-
Forage, FEm d^{-1}	14.8	13.4	NS
Concentrate, FEm d^{-1}	0	3.0	-
AAT, g d^{-1}	1049	1340	-
PBV, g d^{-1}	-17	60	-

HIGH concentrate supplementation gave significantly more daily and total production (kg) of milk and ECM compared to LOW (Table 4). Milk composition was not significantly altered by concentrate level. Due to higher milk yield, the production of fat, protein and lactose were significantly increased in HIGH versus LOW. The lactation period was relatively short in both treatments, especially in LOW. Thus, the lowest concentrate supplementation resulted in a reduced total ECM production both as a consequence of lower daily milk yield and a shorter lactation period.

Total milk production was relatively low in both treatments. In addition to low concentrate levels, the high proportion of cows in first lactation has probably contributed to this result (Table 4).

Table 4 LSMEANS for total milk yield, milk composition, live weight and concentrate allowance in the two concentrate treatments

	Treatment		Significance
	Low	High	
No. of cows	9	10	
No. of cows in 1st lactation	4	5	
Days in production	246	269	NS
Milk total, kg	3998	5419	**
Milk, kg d^{-1}	14.4	18.4	***
Milk fat, %	3.84	3.90	NS
Milk protein%	3.23	3.30	NS
Milk lactose %	4.56	4.50	NS
Milk total, kg ECM	3767	5133	**
Milk kg ECM d^{-1}	13.7	17.6	***
Milk fat total, kg	148	202	**
Milk protein total, kg	122	170	**
Milk lactose total, kg	184	246	**
Weight, 1st week after calving	509	513	NS
Weight in lactation	505	511	NS
Concentrate, FEm 100kg $^{-1}$ ECM	4.9	21.4	-
Milk production on pasture, %	41	35	NS

The amount of concentrate (FEm) consumed per 100 kg produced ECM was 21.4 in HIGH and 4.9 in LOW (Table 4). The figure for LOW is less than the average found in a case study of organic milk production in Norway (Strøm, 1997).

Life weight the first week after calving and the average in lactation were similar in the two treatments. Cows, irrespective of treatment, lost some weight during the first part of lactation and gained considerably during late lactation with only minor changes during the grazing period.

Intake and balance of energy (FEm) and protein (AAT) in relation to production of ECM in early and late lactation are shown in Table 5. In early lactation daily consumption of FEm and AAT per kg ECM was quite similar in the two treatments and near to standard recommendations. This is reflected in the energy and protein balances that were close to equilibrium. In late lactation the picture was altered in that the cows in neither LOW nor HIGH responded in ECM production to the given energy and protein. This resulted in high consumption of FEm and AAT in relation to ECM production and a high positive energy and protein balance. This is in accordance with the increase in live weight observed in late lactation.

A positive energy and protein balance in early lactation together with a moderate peak milk yield may explain that there were no incidences of ketosis or milk fever.

Table 5 LSMEANS for feed intake in relation to milk production

	Treatment		Significance
	Low	High	
Lactation weeks 1-14 (before grazing)			
FEm kg^{-1} ECM[a]	0.50	0.54	NS
AAT, g kg^{-1} ECM[b]	42	51	NS
Energy balance, FEm day^{-1}	0.4	1.6	NS
Protein balance, AAT g day^{-1}	-80	106	NS
Lactation weeks 25-35 (after grazing)			
FEm kg^{-1} ECM[a]	0.93	0.90	NS
AAT, g kg^{-1} ECM[b]	64	76	NS
Energy balance, FEm day^{-1}	5.4	5.9	NS
Protein balance, AAT g day^{-1}	243	423	*

[a] FEm kg^{-1} ECM = (Total FEm intake – FEm maintenance requirement)/kg ECM
[b] AAT, g kg^{-1} ECM = (Total AAT intake – AAT maintenance requirement)/kg ECM

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