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Organic pig production in free range systems

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Preface

According to different consumer surveys, a considerable market potential is forecast for organically produced pork. However, supply clearly lags behind demand. Compared to other areas, organic pig production is of minor relevance in organic agriculture in almost all European countries and is still in its beginnings. There are many reasons for this which also differ from country to country. Beside a lack of market transparency as well as an insufficient marketing structure, there are severe problems with regard to the conversion of conventional pig units into organic units. Among other factors, the traditional housing systems with fully-slatted floors cannot be used in organic pig production. Rebuilding and new buildings based on the indoor and outdoor areas prescribed in the EEC-Regulation (2092/91) are very expensive. Thus, organic free range systems might be a fundamental alternative to keeping pigs indoors.

While in some countries free range systems for sows are well established, only little experience and knowledge are available concerning the production of fattening pigs in outdoor systems. The objective in a project funded by the German Federal Ministry of Consumer Protection, Food and Agriculture through the Federal Agency for Agriculture and Foods, was to identify problems within free range systems and to provide strategies for its improvement. Free range systems for fattening pigs have to take into account various aspects at the same time. Therefore only a system-oriented approach seems to be adequate to deal with the problems. Thus, an interdisciplinary workshop was organized within the above-mentioned project in December 2003. The objectives were to provide an overview of the many different aspects and problems and to discuss possible solution strategies. The following papers are based on this workshop. The contributions are intended to provide comprehensive information on the current state of the art and to support the development of free range systems for fattening pigs with regard to the increasing demand for organic pork.

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Integration of organic pig production into land use

J. E. Hermansen [1]

Introduction

Livestock often plays an important role – besides supporting income for the farmers – in obtaining some of the principle aims in organic farming i.e. diversified production and supporting biological cycles within the farming system. However, some main conflicts may appear in how and to what degree the different aims can be obtained. In relation to livestock, conflicts may appear in the most appropriate keeping practice related to consideration of the basic aspects of their innate behaviour on one hand, the risk of pollution from the production on the other and, in addition, the aim of producing in sufficient quantities. These possible conflicts are reflected in the compromises set in national or EU regulations on organic farming. The regulations, however, often develop after an intensive debate where, sometimes, you may get the impression that livestock production may be acceptable but not desirable in organic farming, at least for some species. In the long term, it therefore seems important that production systems are developed so that different sorts of livestock production can contribute directly to a steadily increasing fulfilling of the organic ideals on a national scale or at farm level. This is in particular true as regards pig production.

Andresen (2000) puts words to the idea saying that the view on livestock should be changed from considering them as being passive (receivers) to active parts of the sustainable development of production systems. More focus should be put on the (various) capabilities of the animals and less on the "requirements" of the animals. The challenge is then to give conditions so that the livestock can optimize the value of their various capabilities rather than to control the animal in the environment. The emphasis on animal performance then shifts from mere feed conversion to functional efficiency in the farming system. This leads to new parameters for evaluation.

In contrast to milk and beef products organic pork were not on the top five list in any of 18 European Countries (Michelsen et al 1999). There is no reason to believe that this difference is caused by a difference in the consumers' preferences. It is more likely that the difference is related to the fact that it is far more difficult for the farmers to change the production system for pigs compared to production systems for cows and other ruminants in a way that gives a harmonious balance between the different aims of organic farming.

The aim of this paper is to highlight some of the prospects and constraints for an integration of pig production into land use based on the Danish experience so far.

Typical pig production systems

Some main requirements within EU as related to pig production are that pigs should have access to grazing for at least some part of the year. Though, finishers can be housed in barns if they have access to an outdoor run in at least 80% of their lifetime. The weaning age for piglets should be at least 40 days.

In different countries or different certification bodies, stricter rules can be implemented. So, several ways of organic pig production take place due to different practice as well as different regulations in different countries. The typical way in Denmark represents some of the major challenges to be met for the development of the organic pig production. Typically, sows are kept in outdoor systems all year round (Figure 1 and 2) and pigs are moved to an indoor pig unit with an outdoor yard when they are weaned at seven weeks of age. This system was stimulated by a simultaneous development of outdoor systems for conventional sow production as indicated in Table 1. Since 1996, the number of sows housed outdoors has doubled and the organic production has increased fourfold. However, as it appears from Table 1, stagnation in organic pig production seems to take place. The number, 74,000, of finishers is only less than 0.3% of the total Danish pork production of approximately 23 mill. per year. This underlines the underdevelopment of this sector in Denmark.

Because it is part of the organic regulations to have the sows on pasture for at least 150 days during summertime and a number of conventional farmers had positive experiences with keeping their sow herds outdoors all year round, the Danish organic producers choose this system too. In this way, they have only one production system for their sow herd instead of having both, a system for summer housing and a system for winter housing. The layout of the paddocks depends on soil type and the available land at the individual farm. The paddocks are normally moved to a new field every spring, often in a two-year crop rotation - one year with barley with an under-sown grass-ley and one year with sows on pasture. The stocking rate is adjusted to an excretion

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of 140 kg N in pigs manure per ha and year (often practised as 280 kg N/ha every second year).

The way of production may be different in other countries. In some countries, the sows are mainly kept at pasture in the summer period. On the other hand in Sweden, it is mandatory to keep also finishers on grass in the period May-September in organic systems. Several challenges exist related to management for sows and finishers, respectively, which will be elaborated on in the following.

Sow production

Only limited data on the overall productivity of the outdoor organic sows are available. Investigations over a 4-year period from four organic herds gave production results on a per-litter basis, which in the last part of the investigation period was almost comparable to the 25% best results from Danish indoor herds, i.e. for organic and conventional herds, respectively.

- Born alive/litter: 11.8 versus 12.1
- Weaned/litter 9.8 versus 10.8

(Lauritsen et al., 2000; Larsen, 2001). Number of litter per sow was lowest in the organic system, partly because of a longer weaning period (seven-eight weeks compared to four-five weeks) and partly because of poorer reproduction results. Larsen & Jørgensen (2002) found in non-organic, outdoor herds that the reproduction results were comparable to results from indoor systems indicating that poor production results are not related to the fact that sows are kept outside *per se*. A possible explanation for the poorer reproductive performance observed in organic herds may be related to the longer lactation period in which some sows come in heat followed by an irregularity after weaning.

Figure 1: Outdoor lactating sows in the summertime

Figure 2: Outdoor sow herd in the wintertime

Table 1: Scale of outdoor and organic pig production in Denmark, 1996-2002

Year	Outdoor			Organic		
	Herds, n	Breeding animals, n	outdoors, %	Herds, n	Sows, n	Finishers produced, n
1996	451	19,839	1.9	210	1,073	18,000
1997	1,059	28,021	2.5	335	1,726	20,000
1998	1,264	36,735	3.1	448	2,966	47,000
1999	1,234	39,096	3.3	535	4,084	63,000
2000	1,171	39,612	3.4	483	3,344	64,000
2001	1,080	41,209	3.5	400	3,939	62,500
2002	961	41,969	3.5	-	4,078	74,000

Sows on grass

One of the major concerns in keeping sows on grass in intensively managed production has been the potential environmental impact due to high excretions of plant nutrients, especially N and P in the manure.

To a wide extent, the environmental impact of outdoor pig production is related to the amount of nutrients in the supplementary feed for the pigs and the stocking density. Recent investigations have shown a surplus of 330-650 kg N per ha of land used for grazing sows on organic farms (Larsen et al., 2000). Although this level is lower than the one found on average in conventional outdoor sow herds, the present nutrient surplus definitely represents an environmental risk. The adverse consequence of this is considerable losses from grazed pastures and undesirably low nutrient availability in the rest of the crop rotation. Nitrogen losses due to outdoor pigs are related to nitrate leaching (Eriksen, 2001), ammonium volatilization (Sommer et al., 2001) and denitrification (Petersen et al., 2001

In Denmark, the sows kept outdoors are ringed to prevent them from rooting and damaging the sward. In the UK, Soil Association prohibits ringing of sows, and from September 2001, ringing is prohibited in The Netherlands, too (Mul and Spoolder, 2000). However, even though the sows are ringed, a clearly seasonal pattern of grass cover/grass height has been found under Danish conditions (Larsen and Kongsted, 2000). Also, the placing of a ring in the snout of sows prevents the sows from carrying out rooting, which is one of the sows' basic behaviours, by creating pain for the animal. This is in disagreement with organic ideals for animal husbandry and should be avoided, if possible.

In a Danish investigation (Eriksen, personal communication), the effect of ringing and short term stocking density for pregnant and lactating sows on vegetation cover and risk for leaching of N is being investigated now. The overall stocking rate evaluated on the basis of expected excretion of N from the sows (equivalent to an expected load of 280 kg N/ha) and calculated on a yearly basis was similar in all treatments. Sows were given either an approximately 360 m^2 or 180 m^2 per sow across a 20-week or 10-week summer period. The preliminary results showed that the ring did not affect the grazing behaviour, but to some extent prevented rooting/damaging the grass cover in the paddocks with pregnant sows. In the nursing pens, ringing had no significant effect if each sow was given an area of 360 m^2. At 180 m^2 per sow (only unringed), the vegetation cover was much lover.

However, the relation between ringing and content of highly soluble N in the soil was not that simple. In fact, no clear effect of ringing was found at the paddock level. On sample plot level, a negative correlation between vegetation cover and content of highly soluble N in the soil was found in the paddocks for pregnant sows but not for lactation sows.

These results indicate that ringing probably should be considered more as a way of maintaining grass sward without necessarily affecting the leaching and in consequence be evaluated as a relevant option in this context.

Rearing of growing pigs in pig houses with access to outdoor areas

As regards construction of pig houses with access to outdoor runs, Møller (2000), Olsen (2001) and Olsen et al. (2001) investigated the influence of the type of indoor floor (deep-bedded and partly slatted floors), the size of outdoor run and a partial cover of the outdoor run on production and behaviour. In all cases, the stables were naturally ventilated and the floors of outdoor runs were solid (concrete). Overall, very good production results were obtained in these systems, >900 g daily weight gain, low feed consumption and a lean content of approximately 60%. Aggression levels among pigs were low and the indoor climate was good with a low concentration of ammonia, carbon dioxide, and dust. This was partly a result of the fact that most of the manure (>80%) was placed on the outdoor run. This resulted in a low straw consumption compared to other systems based on deep litter.

In the experiments mentioned above, no reference was made to non-organic production. Hansen et al. (2001) did so including focus on almost all aspects of meat and sensory quality. Treatments included non-organic production in the same environment as the organic production except that access was given to neither outdoor run nor roughage. In three other treatments, organic concentrates were given without access to roughage or with access to two different types of roughage and, at the same time, a reduced level of concentrates. Some of the main results are given in Table 2.

Table 2: Production results and carcass characteristics in growers fed organic or conventional concentrates *ad lib.*, or restricted amounts of organic concentrates together with silage *ad lib.* (after Hansen et al., 2001).

Concentrates:	Conventional (*ad lib*)	Organic (*ad lib*)	Organic (70% of *ad lib*)
Silage:	No	No	Yes
Outdoor area:	No	Yes	Yes
Daily gain, g	999	935	728
Feed conversion, SFU[1)]/kg gain	2.99	3.09	2.96
MJ per kg gain	23.1	23.9	22.8
Lean content, %	60.6	60.4	61.6
In muscles			
Intramuscular fat, %	1.6	1.5	1.2
Vitamin E	3.13	3.15	2.81
Tenderness	8.7	8.6	7.5
In fat			
Saturated FA, %	41	40	39
Monosaturated FA, %	45	43	42
Polyunsaturated FA, %	14	15	18
Iodine value	68.3	72.2	74.6

1) Scandinavian Feed Units for pigs

The organic production resulted in a slightly reduced daily gain and a slightly increased content of polyunsaturated FA in the fat, whereas no differences were observed in lean content, tenderness, and vitamin E content in the muscles. Restricting concentrates gave the same results as in the investigation of Danielsen (2000) in relation to lean content and tenderness i.e. higher lean content and a reduced tenderness. In addition, a marked reduction in intramuscular fat and vitamin E content in muscles and a higher content of polyunsaturated FA in fat were observed. Also (not shown), organic feeding and access to outdoor run led to a higher proportion of ham muscles in the carcass. These results are much in line with the results of Millet et al (2003) who found that organic housing lead to a higher muscle and back fat thickness.

In the Danish experiments mentioned soybean meal was the primary source of protein. It appears that even in this situation the organic feeding, and especially if fed restrictively, resulted in an increased content of polyunsaturated FA. At present and perhaps also in future, alternative protein sources will be used because of the ban on GMO-products and products resulting from a fat extraction with chemical solvents. Hereby, probably more fat-rich sources will be considered. The above-presented results indicate that it will be important in this situation to consider harmful effects on the 'fat-quality' of the pork.

Growing pigs at pasture

The rearing of organic growing pigs in barns with an outdoor run, which is the common practise in several European countries, is heavily constrained by the fact, that building costs are considerable higher than for conventional production systems due to higher requirements for area etc. At the same time, it may be questioned if pigs reared under such conditions comply with the consumer’s expectations to organic farming. This calls for a reconsideration of the appropriateness of the system.

Several investigations indicate that growth rate obtained in outdoor systems can be comparable to the growth rate at indoor production (Lee et al., 1995, Andresen et al., 2001 Gustafson & Stern, 2003). However, variable feed conversion rates have been obtained. In summer period, a feed conversion comparable to indoor conditions have been obtained in some investigations (Sather et al., 1997), whereas in other periods of the year or in other investigations a higher feed consumption per kg gain have been reported (Stern et al., 2002; Sather et al., 1997).

Although the growing pig can consume grass and other herbage up to 20% of daily day matter intake (Carlson et al., 1999), the overall contribution to the energy supply of the pig when fed *ad lib* with concentrates mixtures is normally much lower, ranging from 2-8%. This means that most feed needs to be concentrates given to the pigs at pasture and consequently high risk of environmental impact can be expected unless measures are taken to counter act this.

At the moment, we are investigating strategies combining grazing and rearing in barns from the perspective to reduce risk of environmental impact and at the same time allow the growing pigs to have plenty of space when they are young and most active. Five strategies are being investigated:

1. Piglets are moved indoor at weaning and fed *ad libitum* until slaughter
2. Piglets stay on pasture and are fed restrictively (70% of expected *ad lib* intake) with concentrates until 40 kg live weight, followed by *ad libitum* feeding in a barn pen
3. Piglets stay on pasture and are fed restrictively with concentrates until 80 kg live weight, followed by *ad libitum* feeding in a barn pen
4. Piglets stay on pasture until slaughtering and are fed restrictively in the whole period
5. As treatment 4, but the growers are fed *ad libitum* until slaughtering

The preliminary results show a normal growth rate (app. 750 g daily gain) and no marked differences between the pigs fed *ad libitum* outdoor or *ad libitum* indoor. However, the feed intake per kg gain outdoor was increased by 13% when fed *ad lib*. On the other hand, outdoor kept pigs, which were restricted in energy intake (strategy 4), had the same feed conversion rate as the indoor treatment (1) and in addition a significantly higher lean content (approximately four units), but growth rate was of course reduced (16%). A very interesting finding was in the strategy with restricted intake in outdoor kept pigs until 80 kg live weight followed by *ad lib* indoor (strategy 3). The strategy resulted in a feed conversion rate comparable to indoor feeding and the overall daily gain was only reduced by 10-15% compared to *ad lib* feed indoor.

These results indicate that there are options that can be used in order to get very good production results from outdoor kept finishers.

With the stocking rate applied (100 m^2 per outdoor pig kept from 20 kg to 100 kg live-weight) however, all vegetation was destroyed (Figure 3). Complementary measurements on risk for N-leaching will elucidate the environmental risks in the systems, but these data are yet not available. However it seems as if a choice have to be made i.e. using a considerable lower stocking rate than used in this experiment to keep a good vegetation cover or to accept the rooting and try to take advantage of it.

Figure 3: Growing pigs at pasture at a high stocking rate

Future systems based on integration in land use

Several ways for at better integration of pig production in the land use should be considered.

As regards pregnant sows, which can be handled in relatively large flocks, one perspective could be to base feed intake on forage. There is no doubt that forage can constitute a very large part of the nutrient requirement for pregnant sows. In addition, it has been shown that co-grazing sows and heifers reduce the parasite burden of the heifers and result in an overall better sward quality compared to grazing separately (Roepstorff et al., 2000; Sehested et al., 2003). The live weight gain and the estimated grass intake for heifers and pregnant sows grazing together or separately are shown in Table 3 and in Figure 4 the larvae infection in the grass sward is shown. It appears that both sows and heifers had a higher daily gain when grazed in the mixed systems although only the difference in the growth rate for heifers was significant in each experiment. It can also be observed that the sows' grass-intake corresponded to half of the energy requirement. The peak of larvae infection of importance for the heifers per kg grass DM was in the mixed system only half of the infection in the separately grazed systems. Serum pepsinogen levels in blood samples of the heifers confirmed the lower infection rate in the mixed grazing systems. No difference in parasite burden as regards the sows was observed.

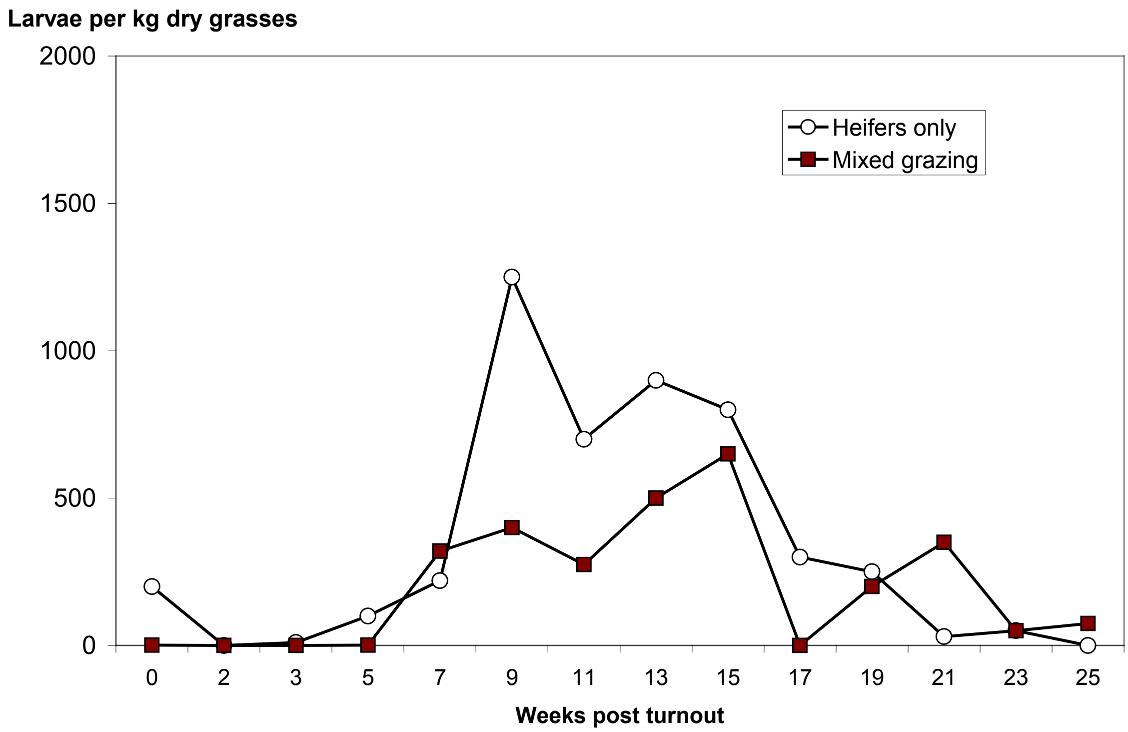

Figure 4: Numbers of infective O. ostertagi larvae per kg dry grass on two pastures grazed by heifers only or by a mixed herd of pregnant sows and heifers (after Roepstorff et al., 2000)

Table 3: Growth and estimates grass intake for grazing heifers and pregnant sows grazing separately or mixed (average of two experiments; Sehested et al., 2003)

Grazing system	Separately	Mixed
Heifers (per heifer and day)		
Live weight gain, g	866	1063
Grass intake, NE, MJ	41.1	52.5
Sows (per sow and day)		
Daily live weight gain, g	512	557
Supplementary concentrates, NE, MJ	11.0	11.0
Grass intake, NE, MJ	10.3	10.8

Another strategy for pregnant sows and growers could be to take advantage of their rooting inclination in the land cultivation. Stern & Andresen (2003) found in experiments with growing pigs at pasture that grazing and rooting were most frequent on newly allotted areas (three-six m^2 per pig daily) compared with transfer and dwelling areas. Also defaecation and urination were most frequent in newly allotted areas. At a reduced level of supplementary feed, a higher frequency of rooting appeared. These results suggest that it is possible through management measures like allocation of new land, feeding strategy, and movement of housing and feeding facilities to have a stratified land cultivation and nutrient load on the land. In fact, Andresen et al. (2001) demonstrated that the rooting could replace a mechanical treatment and even result in a higher crop yield of the following crop.

Andersen et al. (2000) and Jensen et al. (2002) have proposed a system handling both sows and finishers in small de-centralized units. Each unit consists of a climate tent placed upon an area protected against leaching (Figure 5). A layer of sea shells is put on a bio-membrane and covered with a layer of straw, upon which the climate tent is constructed. The idea is that four-six sows are farrowing in the unit. At weaning, the sows are moved to another tent and the finishers stay in the unit. In periods where there is a crop to be grazed or a need for a controlled tillage of the soil, the pigs – whether sows or finishers – are allowed access to the field. This way, a considerable part of the manure produced can be colleted and used elsewhere in the farming system and the risks of excessive leaching of nutrients can be diminished.

Figure 5: One unit pen in climate tents (Andersen et al., 2000)

At present this system is being tested and further developed. Growth and nutrient management is functioning very well. However, there is still some way to go in order to have farrowing functioning well and to have an acceptable workload in the system.

Conclusion

The most common outdoor systems for pigs used in intensive managed organic production have some important drawbacks in relation to environmental impacts (risk of N leaching and ammonia volatilisation) and animal welfare (nose-ringed sows). There is a need for a radical development of the systems. There is a need to search for systems where the outdoor/free range systems (for the sake of the livestock) are constructed and managed in a way whereby the livestock at the same time exert a positive influence on other parts of the farming systems. Major elements to be considered are the ability of pig to forage and hereby fulfil their nutritional needs, the ability of the pigs to contribute to land cultivation and the importance of diversified livestock rearing in order to reduce parasite burden. These elements need to be further explored as a basis for future system development.

Summary

The development in organic livestock production can be attributed to an increased consumer interest in organic products while, at the same time, farmers are interested in converting to organic production methods – often stimulated by governmental support or subsidies. It is important that the organic production systems can fulfil the expectations of each of these stakeholders if the organic livestock production is to increase further. This is in particular important if the organic pig production should move from the present niche-production to a real player in the food marked, like in the case of beef and milk.

In the regulations for organic farming, the aspect of allowing a high degree of natural behaviour of the livestock is among others translated in the requirement that livestock in certain periods of their life or of the year should be allowed to graze or have access to another outdoor area. The most common outdoor systems for pig used in intensively managed organic production have some important drawbacks in relation to environmental impact (risk of N-leaching and ammonia volatilisation), animal welfare (nose-ringed sows) and workload and management constraints.

With the starting point in the present experience in such systems, it is argued that there is a need for a radical development of the systems. There is a need to search for systems where the outdoor/free range systems (for the sake of the livestock) are constructed and managed in a way whereby the livestock at the same time exert a positive influence on other parts of the farming systems. There is evidence that pregnant sows can fulfil their nutritional needs to a large extent by grazing, that co-grazing sows with heifers can diminish the parasite burden of the heifers, and that the pigs' inclination for rooting can be managed in a way that makes ploughing and other heavy land cultivation more or less superfluous. These elements need to be further explored as a basis for future system development.

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Behaviour, performance and carcass quality of three genotypes of growing-finishing pigs in outdoor pig production in Austria: A pilot study

S. Laister[1] and S. Konrad[1]

Introduction

Apart from low production costs in terms of buildings and equipment, outdoor pig production provide benefits in relation to animal welfare (DEERING & SHEPHERD 1985). Animal welfare is of considerable and increasing importance from a social, political, ethical and scientific point of view (SCOTT et al. 2001) Consumers more and more request accurate information about the conditions in which animals are kept (WEMELSFELDER & LAWRENCE 2001). In response to these demands an increasing number of breeding sows is already being kept outdoors, especially in the UK, France and Denmark (WATSON & EDWARDS 1997). However, in Austria outdoor pig production still is of little importance.

In 2000 the private foundation for animal protection "Four Paws Austria" and a private food trade company started a joint project on organic outdoor pig fattening. This pilot study primarily aimed on applied research questions.

Research Objectives

Currently, there is limited information available on the behaviour of outdoor finishing pigs from modern genetic lines and more robust lines. The latter are generally expected to be more adapted to outdoor conditions. Therefore, the project aimed at answering the following questions:

- Are there differences between different genetic strains with regard to behaviour, performance and carcass quality under outdoor conditions?
- Is one genotype suited more than others for outdoor conditions?

Animals, Materials and Methods

Animals: In total 47 fattening pigs (female and castrates) of three different breeds (Austrian Large White [LW, n = 16], Austrian Hybrid [NN Pietrain x Large White x Landrace; AH, n = 15], and Landrace x Duroc [LD, n = 16]) were studied from June to October 2000. The pigs have been raised on different organic farms in Austria in housing systems with littered lying areas and outdoor yards. The average initial live weights were 34 kg (24-45 kg), 31 kg (21-46 kg) and 13 kg (7,5-17 kg) for LW, AH and LD pigs, respectively.

Study area: The enclosure of in total 2.4 ha was divided into three paddocks (one for each genotype), which included the same habitat features (Figure 1). In the western part, the paddocks were bordered from the wallow – a streamlet running through the area in north-south direction. Further east, a poplar area followed. Between these areas near the wallow the feed and water troughs were located. At the border between the poplar forest and an adjacent pine tree area the bedded shelter/sleeping huts were placed. Close to the huts a straw bale was offered in each paddock as resting area during the day. The thick pine tree area formed the eastern part of the paddocks.

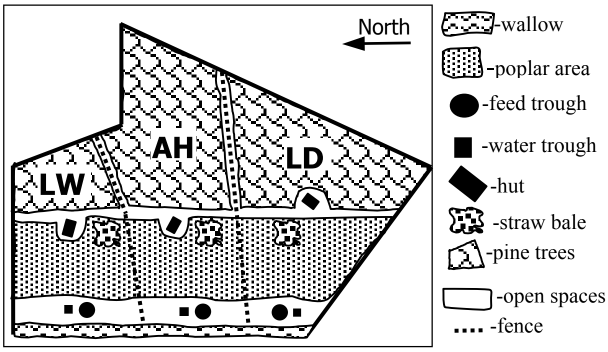

Figure 1: Description of the experimental area

Management: Since the enclosure itself didn't provide relevant amounts of feed, the pigs were fed a commercial organic finishing diet *ad libitum*. Each paddock included a covered feeding station including three feed troughs to enable simultaneous feeding. To reduce unfavourable competition during feeding the troughs were subdivided with crossbars. All pigs were weighed at the beginning (june 5th) and in the middle (august 11th) of the fattening period as well as at the day of slaughtering. Due to the spread of starting weights the "all in - all out" principle could not be realized and slaughtering took place continuously at a live weight of approximately 125 kg.

Behavioural observations: per group 12 pigs were observed using continuous focal-animal sampling for three days in total at about three week intervals (beginning of September, end of September, mid of October). The observations lasted for 10 h during the day and were carried out during three consecutive days each. The weather conditions during one observation run were similar for all groups. The mean temperatures during the observations ranged from 12.0 °C in the shady areas to 18.5 °C in the sun. Maximum and

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minimum temperatures in the sun were 24 °C and 13 °C and in the poplar forest 23 °C and 6 °C.

Behaviour was recorded using a PSION PLC workabout according to the following definitions of behaviour categories and locations

Behaviour categories:

- Feeding: feed intake at the troughs,
- Drinking: drinking water from the water trough and from the wallow,
- Exploring: actively examining, sniffing, rooting, biting, chewing any organic material or other structures,
- Resting: lying on side or sternum,
- comfort behaviour: wallowing, scratching, rubbing, stretching, shaking,
- Locomotion: walking, galloping or running without exploratory/rooting behaviour,
- Play behaviour: carrying branches, leaves etc., jumping, running after each other, friendly nosing,
- Agonistic behaviour,
- Eliminative behaviour,
- Others: sitting, social behaviour.

Locations:

- Wallow area: streamlet and surrounding slopes,
- Feeding area: feed troughs and surrounding area between wallow and poplar trees,
- Drinking area: water troughs and adjacent surrounding,
- Poplar forest,
- Straw bale,
- Hut,
- Open spaces: sunny places between poplar forest and pine tree area,
- Pine tree area.

Data were analysed using the procedure GLM, (SAS) taking genotype, pig and day of observation into account.

Results and Discussion

Behaviour

Time budgets: There were no significant differences in the time budgets of the three genotypes. Each group spent between 67 % and 69 % of the observation period resting, exploratory behaviours were shown during 17 % to 21 %, and 5 % to 8 % of the day were spent feeding at the trough (Figure 2). These results were in concordance with GUY et al. (2002). Fattening pigs fed *ad libitum* in outdoor paddocks spent between 70 % (SCIARRA & HUBER 1998) and 78 % (INGOLD & KUNZ 1997) of the observation day resting. However, in the latter study observations started already at 5:00 a.m. With regard to exploratory/rooting behaviours, SCIARRA & HUBER (1998) found average durations of 12.7 %. These behaviours might have been shown less than in the present study because the pigs were kept on harvested fields which offered less variety of structure/habitat than in this study. According to VAN PUTTEN (1993), pigs use about 33 % of the day for foraging and feed intake.

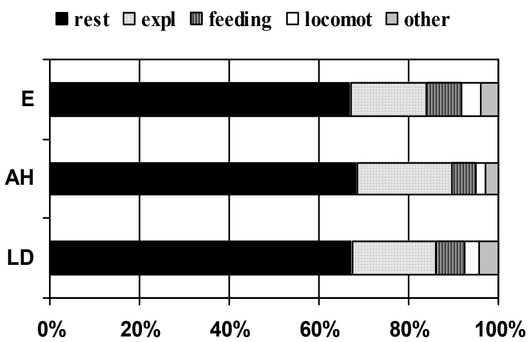

Figure 2: Average daily proportions of different behaviour categories

However, regarding the average frequency of locomotion events, AH pigs showed significantly less locomotory behaviour ($p = 0.001$) (Figure 3). The duration of locomotion also tended to be lower in the LW group (LW: 4.1 %, AH: 2.1 %, LD: 3.3 %).

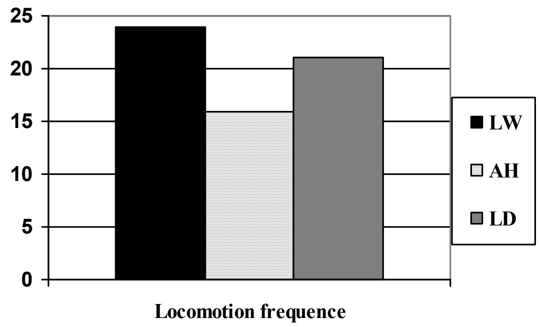

Figure 3: Average daily frequency of locomotion

The investigation also showed differences between the genotypes when relating the observed proportions and frequencies of behaviours to the locations in the paddock.

Resting behaviour: AH pigs spent 43 % of the resting time during daylight (siesta session and other short resting breaks) in the shelter hut, whereas the LW and the LD groups preferred other places. LW pigs spent 50 % of the resting time in the straw bale under the poplar trees. The LD group spent 40 % at sunny places (clearing and wallow slopes) and 28 % in the poplar area (Figure 4). This corresponds to descriptions of the European wild boar which chooses not always the same resting place but changes resting locations according to weather conditions. On warm days feral pigs rest at sunny places and clearings of a pine tree forest whereas on hot days the pigs search for cool and shadowy places in a high forest (MEYNHARDT 1988). Feral pigs also differentiate between sleeping nests during the night and resting places during daytime. In domestic pigs, VAN PUTTEN (1993) observed a high variation of sleeping places also during daylight.

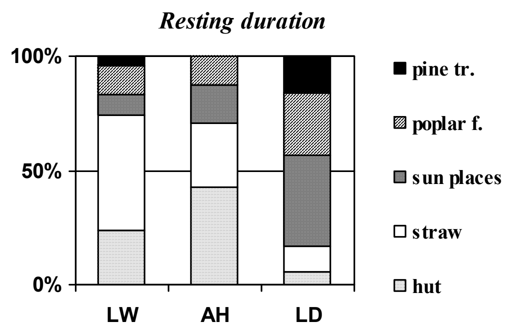

Figure 4: Duration of resting behaviour at different locations in % of total resting duration.

Although it would have been expected that the pigs would tend to rest at cool and shady places, only the LD pigs used the pine tree area to a higher extent (16 %); the LW group rested there at least for 6 % of the total resting time.

Observing outdoor pigs during summer MEINDL (2000) found that the animals changed their resting places up to 50 times per day. Apart from a shelter hut also a wooden area and sunny places were used.

Figure 5 shows the proportion of resting frequencies at different locations indicating significant differences between the genotypes. The AH group never used the pine tree area but significantly most often chose the littered hut for resting.

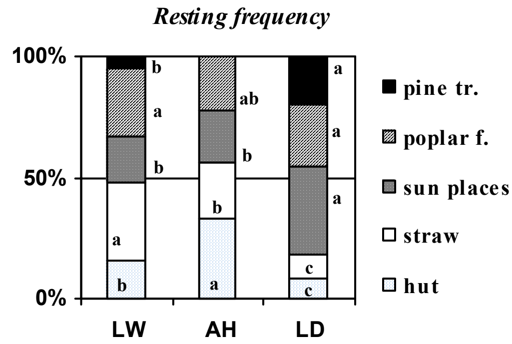

Figure 5: Relative distribution of resting frequencies at different locations

Exploratory behaviour: Pigs are exploratory animals which spend a considerable amount of time moving between parts of the enclosure and examining distant and close habitats (STOLBA & WOOD-GUSH 1989). In this study, the different genotypes showed similar amounts of exploratory behaviour. A considerable amount of the exploratory behaviour took place in the wallow area (LW: 32 %, AH: 39 %, LD: 30 %) (Figure 6). According to INGOLD & KUNZ (1997), moist and wet places stimulate rooting. Significant proportions of the exploratory behaviour were also spent in the poplar forest (LW: 26 %, AH: 37 %, LD: 24 %). LD pigs however spent the highest amount of the exploration time (40 %) in the pine tree area. LW pigs also used this part of the enclosure (19 %) whereas AH pigs were observed exploring only during 5 % of the total exploration time in this area. The analysis of the frequencies revealed similar results (Figure 7). The LD group showed 21 % of total exploration bouts in the pine tree area, the AH genotype only 3 %.

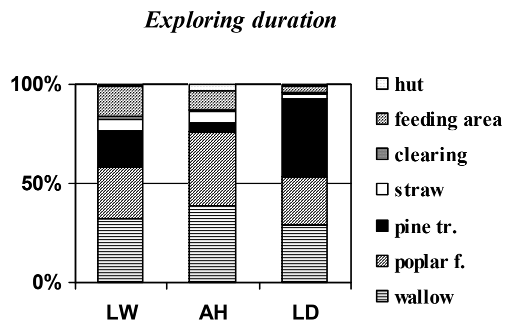

Figure 6: Proportion of duration of exploratory behaviour at different locations

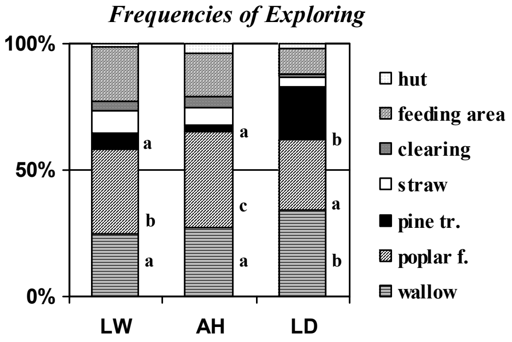

Figure 7: Relativ distribution of frequencies of exploratory behaviour at different locations

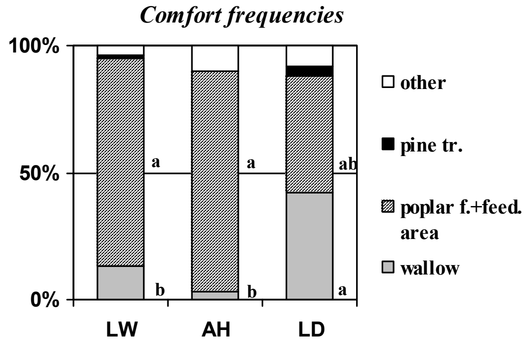

Figure 9: Frequencies of comfort behaviour in % of total comfort frequence.

Comfort behaviour: The total proportion of comfort behaviour during the observation period amounted to 0.3 %, 0.3 % and 0.6 % for LW, AH and LD, respectively. LW and LD pigs spent 66 % and 73 % of the total comfort behaviour wallowing in the streamlet whereas the AH group stayed in the wallow only for 3 %. 94 % of this group's comfort behaviour consisted of scratching and rubbing near the feed troughs and in the poplar area (Figure 8). Regarding the frequencies of comfort behaviour (Figure 9), the LD genotype used the wallow significantly more often compared to the other genotypes ($p < 0.001$).

The most important patterns of comfort behaviour in pigs are rubbing and wallowing, the latter fulfilling two purposes. On the one hand, the mud bath shall free the pigs from ectoparasites and itches, on the other hand it contributes to the animals' thermoregulation (ZERBONI & GRAUVOGL, 1984). The authors also stated that an increased rubbing and self-scratching is negatively correlated with the hygiene status of the skin. However, there was no evidence that the AH pigs suffered from bad skin condition causing higher incidences of these types of comfort behaviour.It remains unclear why in the present study the AH pigs didn't use the wallow to a higher extent although the temperatures regularly exceeded 20°C during the observation days.

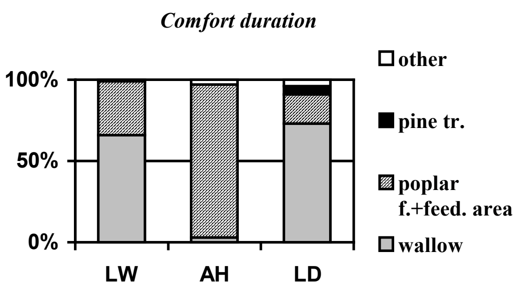

Figure 8: Proportion of comfort behaviour at different locations in % of total comfort duration.

Performance and Carcass Quality

The AH genotype had the lowest average daily weight gain (LW: 732.0 g, AH: 641.7 g, LD: 805.8 g; $p < 0.01$; initial weights taken as covariate into consideration) (Table 1). There were no significant differences between LW and LD pigs. In concordance with BRANDTNER (1990) the LD pigs tended to have higher live weight gains than the LW group. In general, the performance level in this study is similar to other outdoor studies (COSTA 1988; ANDERSSON et al. 1990; INGOLD & KUNZ 1997).

In the three genotypes, the final live weight, carcass weight and carcass dressing percentage did not show significant differences whereas the lean meat content (LMC) of the AH group (57.7) was significantly higher than in LD (53.1) and LW pigs (52.3).

Table 1: Performance and carcass quality

Item	LW	AH	LD	
	- - - - - LS-means		- - - -	P
Live weight, kg	122.8	116.1	133.9	0.071
Growing time, d	133.2	140.9	133.2	0.292
Weight gain, g/d	732.0^a	641.7^b	805.8^a	0.007
Carcass weight, kg	96.9	96.7	97.4	0.840
Carc. dressing %	79.3	79.0	79.7	0.810
LMC, %	52.3^b	57.7^a	53.1^b	0.005
Comm. standard	3.0^b	1.8^a	2.8^b	0.005

As expected from a negative correlation between LMC and IMF (SCHWÖRER, 2001), the AH genotype showed a markedly lower IMF content and higher grilling loss (Table 2). In concordance with FISCHER et al. (2000) LD pigs had the highest IMF content. Drip loss did not differ significantly. Sensory analysis also did not reveal any significant differences.

Table 2: Meat quality and sensory analysis

Item	LW	AH	LD	
	- - - - - LS-means - - - -			P
IMFC, %	2.0[a]	1.5[b]	2.3[a]	0.015
Drip, %	3.7	4.1	4.6	0,354
Grilling loss, %	19.1[b]	23.7[a]	22.7	0,015
Tenderness, Points	3.7	3.2	3.6	0.390
Juiciness, Points	4.8	4.3	4.7	0.241
Taste, Points	4.3	4.3	4.3	0.993

Conclusions

The results of this pilot study comparing the behaviour of Large White (LW), Large White x Landrace x NN Pietrain (AH) and Landrace x Duroc (LD) genotypes in an outdoor environment showed significant differences between the groups in the way they used the various habitat features. In general, the LD pigs showed the most diverse behavioural patterns relating to the offered variety of structures. In comparison to the AH genotype, LD and LW pigs used the distant pine tree area to a higher extent. This may indicate a better adaption of robust genotypes to more extensive and manifold outdoor conditions. Differences in locomotion were also found. However, further research is necessary before any conclusions regarding the most suitable genotype for outdoor pig production can be drawn. Especially the rearing conditions of the pigs should be taken into account.

Because of the local topographical conditions it was not possible to divide the research area into three paddocks with exactly the same size resulting in a smaller pine tree area for the LW pigs. Yet there is no evidence that this influenced the usage of this area.

Since the pigs derived from different organic farms their starting weights were very inhomogeneous. Analysing the differences in the fattening performance the initial weights had to be considered as a covariate. The AH genotype was inferior with regard to daily weight gain, intramuscular fat content and grilling loss. However, the AH group showed the highest lean meat content and, as a result, gained better commercial standard scores. Feed consumption and feed conversion ratios could not be calculated due to the lack of individual feed intake data.

Future prospects

After this pilot study great efforts have been made to establish an organic outdoor brand label and to put outdoor pig production into practice on a considerable number of organic farms. From 11-2002 until 11-2003 1700 outdoor pigs were fattened on 13 Austrian farms but 33 % did not comply with the commercial demands (LMC ≥ 57, $pH_1 \geq 6$, carcass weight 78-105 kg). This may have several reasons (e. g. little practical experience, lack of specialised advisory capacities). However, an alternative pricing system - including production process quality and/or IMF content - is necessary in the near future in order to support organic outdoor pig production in Austria.

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Performance, carcass and meat quality of different pig genotypes in an extensive outdoor fattening system on grass clover in organic farming

F. Weissmann[1], G. Biedermann[2] and A. Klitzing[2]

Introduction

Until now there have only been a few examples in organic livestock production where fattening pigs have been integrated as a part of the crop rotation. Outdoor keeping on grass clover in the crop rotation could be an interesting solution in terms of animal welfare, environmental aspects and economic performance (Weissmann, 2003). The objective of the present study was an estimation of different genotypes under extensive fattening conditions in an organic outdoor system in respect of some aspects of fattening performance and carcass and meat quality.

Materials and methods

The trial took place at the experimental organic farm of the Institute of Organic Farming of the Federal Agricultural Research Centre in Trenthorst, Germany. The whole farm and the keeping and feeding system of this trial are in accordance with Regulation 2092/91/EEC and IFOAM Basic Guidelines.

Keeping

The fattening period was divided into an outdoor and an indoor period. The outdoor period lasted from 12th May to 21st October 2003. A total of 5.2 ha of grass clover were divided into 4 paddocks with the aid of solid and flexible pens. The fattening pigs were offered 3 wooden huts (3 m x 4 m) with an adjustable awning between two huts and wallows in a rotational grazing system. The 4 paddocks were linked with a feeding paddock where weighing also took place. The indoor period lasted from 21st October to 11th November 2003. The remaining fattening pigs were housed in a loose house with deep litter.

All the fattening pigs were kept together in a single group during the fattening period.

Feeding

The feeding ration consisted of coarse meal made up of farm grown cereals and grain legumes with an intended content of 12.5 MJ ME and 145 g crude protein per kg air dried matter. No optimisation was carried out concerning the amount of the amino acids Lysin and Methionin and their relation to the energy content. Neither supplementary mineral feed nor vitamins were offered.

All animals had simultaneous access to wooden troughs and were manually fed. The daily amount of feed was calculated in accordance with the feeding standards of the *Deutsche Landwirtschafts-Gesellschaft* (DLG, 1991) for an intended level of about 600 g daily weight gain. Grass clover was offered *ad libitum* but not taken into consideration either in terms of consumed amount or of feed quality.

Drinking water was offered *ad libitum* in both periods.

Animals

A total of 60 fattening pigs of different genotypes and sex were kept (Tab. 1).

Each of the 5 genotypes came from a different farm. The genotypes Pi x GLW x GLR, Pi x Du x GLR and Pi x AS were of organic origin whereas the genotypes Du x GLR and Du derived from conventional farms. Du x GLR were male siblings of crossbreed sows whereas Du were castrates not used as sires in crossbreeding programs. Therefore the allocation of sex was inhomogeneous.

Deworming of all fattening pigs took place around time of delivery. Bulk faeces samples were obtained for inspection of endoparasites 3 times during the fattening period. On the day of delivery all animals received a first vaccination against swine erysipelas (diamond-skin disease) which was repeated 4 weeks later.

Experimental design and analysis

The fattening period started on the day of delivery (May 12th 2003) when all animals came on grass clover, and ended indoor on 11th November 2003 with slaughter of the last 3 animals the next day.

Initial live weight (LW) ranged between 27 kg LW and 45 kg LW. Slaughtering was intended at 115 kg LW and ranged between 109.5 kg LW and 125.0 kg LW. All animals were individually marked with electronic ear tags.

Every 4 weeks all the animals were weighed with an electronic pig scale in the feeding paddock. After the weighing, the daily amount of feed was revised if necessary. When the first pig reached its slaughter maturity, weighing occurred each Tuesday morning to determine animals for slaughter (> 114kg LW) and the final live weight for the calculation of the daily weight gain. Those pigs came indoors with feed withdrawal in the afternoon but with *ad libitum* access to drinking water.

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Table 1: Allocation of genotypes and sex (n)

Sire	Dam (sire x dam)	Notation	Castrates	Females	Total
Pietrain	German Large White x German Landrace	Pi x GLW x GLR	3	7	10
Pietrain	Duroc x German Landrace *	Pi x Du x GLR	10	10	20
Pietrain	Angler Saddleback	Pi x AS	7	3	10
Duroc *	German Landrace *	Du x GLR	10	- -	10
Duroc	Duroc	Du	10	- -	10

* Sow of genotype Du x GLR is a *Schaumann*® breeding product

On Wednesday morning pre-slaughter fattening pigs were weighed once more in order to determine both live weight loss and dressing rate, and in order to fix the individual carcass identification (numeral punch). The subsequent transport to the abattoir of about 20 min was carried out by the personnel of Trenthorst. The resting period at the abattoir was 45 min to 60 min.

Slaughtering took place in a commercial abattoir (Nordfleischzentrale Lübeck) after CO_2 stunning. Determination of PSE-status (pH_{45} between the $13^{th}/14^{th}$ rib), weighing, and carcass classification by FOM (Fat-O-Meater) was about 45 min after slaughter according to commercial procedures.

On Thursday the data on carcass and meat quality were collected according to the routine of the *Deutsche Leistungsprüfungsanstalten* (ZDS, 2000). Neither the determination of intramuscular fat content nor the determination of sensory meat quality are part of these procedures.

The present paper deals with the following aspects of fattening and carcass performance:

- Fattening performance: Daily weight gain, feed conversion ratio, live weight loss
- Carcass performance:
  - Carcass quality: Dressing rate, lean meat content (FOM)
  - Meat quality: PSE-status (pH_{45}), meat colour (meat lightness by *optostar*)

The feed conversion ratio was calculated over all fattening pigs as the total amount of feed in relation to the total amount of body weight gain.

The measurement of meat colour took place by *optostar* 24h p.m. at the 13^{th} rib (*M.l.d.*) of the dried cut about 5 min to 10 min after cutting (ZDS, 2000).

Statistical procedures

SPSS 12.0 for Windows was used for statistical analysis.

Statistical analysis for daily weight gain (dwg) follows the model:

$$Y_{ijk} = \mu + GEN_i + SEX_j + (GEN \text{ x } SEX)_{ij} + b_1 (LWB_{ijk} - \overline{LWB}) + b_2 (LWE_{ijk} - \overline{LWE}) + e_{ijk}$$

Statistical analysis for lean meat content (lmc), PSE-status (pse) and meat colour (mc) follows the model:

$$Y_{ijk} = \mu + GEN_i + SEX_j + (GEN \text{ x } SEX)_{ij} + b_3 (CW_{ijk} - \overline{CW}) + e_{ijk}$$

where

Y_{ijk}	observation variable: dwg, lmc, pse, mc
μ	overall mean
GEN_i	fixed effect of the i th genotype (i = 1, 2, 3, 4, 5)
SEX_j	fixed effect of the j th sex (j = 1, 2)
$(GEN \text{ x } SEX)_{ij}$	interaction genotype i * sex j
b_1 , b_2 , b_3	linear regression coefficient on LWB, LWE, CW, respectively
LWB_{ijk}	live weight of the k th animal at the beginning of the fattening period
$\overline{LWB}$	average live weight at the beginning of the fattening period
LWE_{ijk}	live weight of the k th animal at the end of the fattening period
$\overline{LWE}$	average live weight at the end of the fattening period
CW_{ijk}	carcass weight of the k th animal
$\overline{CW}$	average carcass weight
e_{ijk}	random error

Results and discussion

Tab. 2 shows the results of the feed analysis. There were two different types of concentrates which differed in the fraction of grain legumes due to the lack of field beans. Feed A was offered from May until August, feed B was offered from August until the end of the trial. On the occasion of feed preparation about every 10 days, an aliquot retain sample was gained and collected to create an aliquot bulk feed sample for feed A and B respectively.

Table 2: Characterisation of concentrates

Item	Feed A May – Aug.	Feed B Aug. – Nov.
n	1	1
Composition		
Winter wheat, %	70	70
Field pea, %	15	30
Field bean, %	15	- -
Contents		
Dry matter (DM), g / kg	888	888
Metabolizable energy, MJ / kg DM	15.5	15.9
Crude protein, g / kg DM	151	146
Lysin, g / kg DM	8.1	8.1
Methionin, g / kg DM	1.8	2.0
Crude fibre, g / kg DM	43	36

Data show that the intended contents of ME and CP were almost achieved. On the basis of the contents of Lysin and Methionin, especially in the first period (May – August), neither outstanding growth rates nor augmented lean meat contents were to be expected.

In spite of the extremely sunny and warm summer there were no problems with sunburn. It is particularly remarkable that even the genotypes without pigmentation such as Pi x GLW x GLR, Pi x Du x GLR, and Du x GLR had no problems even at the very sensitive back of the ear. First of all it seems to be an effect of the fully functional and well-accepted wallows (Laister, 2002).

In an analogous fattening trial in 2002 at Trenthorst there were severe problems with sunburn due to the lack of functional wallows (Weissmann, 2002).

During the whole fattening period there were no problems with endoparasites. All bulk samples of faeces and the autopsy of two animals (see below) showed negative results. This is a main effect of deworming and of keeping on grass clover as an unaffected part of the crop rotation, where (re)contamination seems impossible (Weissmann, 2003). This moving of grass clover and animals for many years within crop rotation over the land is completely contrary to outdoor keeping on permanently stocked areas such as pasture or paddocks adjacent to the stable, even when they are divided and stocked at temporal intervals.

Three animals were lost. Two pigs (Du x GLR, Du) had to be emergency slaughtered a short time after the second vaccination against diamond-skin disease due to severe joint problems. The subsequent autopsy diagnosed swine erysipelas with severe injuries of different joints. No endoparasites were found. A third animal (Du x GLR) was lost at the end of the fattening period due to an accident with a tractor.

Thus a total of 57 animals were analysed for fattening performance, lean meat content and PSE-status. Due to the disappearance of one carcass (Du x GLR) subsequent to classification, 56 carcasses remained for analysis of meat colour.

Fattening performance

A survey of selected characteristics of fattening performance gives Tab. 3.

Table 3: Aspects of fattening performance (n = 57)

Item	Mean	SD	SD%
Initial live weight, kg	36.6	5.1	14.0
Final live weight, kg	116.4	3.6	3.1
Live weight loss, %	2.2	1.4	62.5
Feed/meat conversion ratio, kg/kg	5.1		
Fattening period, d	156.6	15.7	10.0

Initial live weights showed a huge variation. Consequently a requirement satisfying individual feed offer was more or less impossible. Apart from this, trough feeding provoked evident feed losses (the amount was not measured!). On the basis of these findings, the feed conversion ratio was very high (Tab. 3).

A mean fattening period of 157 days (Tab. 3) indicated an extensive fattening regime. The resultant daily weight gain was significantly ($p \leq 0.05$) influenced by initial and final live weight, genotype and sex (see statistic model). The consequent resultant values are shown in Tab. 4.

Tab. 4: Daily weight gain (g/d) in relation to genotype and sex

	Pi x GLW x GLR		Pi x Du x GLR		Pi x AS		Du x GLR	Du
	Sows	Castrates	Sows	Castrates	Sows	Castrates	Castrates	Castrates
n	7	3	10	10	3	7	8	9
LSQ	484^{b}	552^{a}	475^{b}	505^{b}	475^{b}	503^{b}	578^{a}	538^{a}
S.E.	19	27	16	16	26	17	19	17

Different letters indicate significant differences at level $p \leq 0.05$

With a range between about 500 – 600 g daily weight gain, the data of Tab. 4 demonstrate an acceptable level of fattening intensity, i.e. daily weight gain was in accordance with an extensive outdoor fattening regime. Among the feed and feeding associated effects, group size and the extremely warm summer period could have accounted for the existing level of daily weight gain (Bremermann, 2001).

The data also show the well-known superior fattening ability of castrates according to findings of e.g. Biedermann et al. (2000). Concerning the females there were no differences between rather intensive genotypes like Pi x GLW x GLR and Pi x Du x GLR or the rather extensive genotype Pi x AS.

Carcass quality

In Germany the full price is paid in the range of 84 kg - 100 kg carcass weight according to corresponding classification (lean meat content). Data (Tab. 5) show that some of the carcasses failed to meet this economically important lower limit of 84 kg.

Tab. 5: Aspects of carcass quality (n = 57)

Item	Mean	SD	SD%
Carcass weight, warm, kg	86.6	3.4	4.0
Dressing rate, %	76.1	1.8	2.4

The mean dressing rate of 76 % (Tab. 5) was below the level of around 80 % which is common in intensive concentrate-rich fattening systems. This indicates that on the one hand the offer of grass clover could have led to an augmented development of the intestinal tract and on the other hand that more adipose carcasses provoke augmented cuts of adipose tissues. During the cuts for classification mainly abdominal and pelvic fat is removed. This last mentioned interpretation is supported by the data concerning the lean meat content of the fattening pigs (Tab. 6).

Tab. 6: Lean meat content (%) in relation to genotype and sex

	Pi x GLW x GLR		Pi x Du x GLR		Pi x AS		Du x GLR	Du
	Sows	Castrates	Sows	Castrates	Sows	Castrates	Castrates	Castrates
n	7	3	10	10	3	7	8	9
LSQ	54.8^{a}	50.6^{bcf}	54.3^{a}	50.6^{bc}	52.8^{ac}	48.6^{be}	47.5^{de}	48.2^{def}
S.E.	0.8	1.3	0.7	0.7	1.3	0.8	0.8	0.8

Different letters indicate significant differences at level $p \leq 0.05$

The data of Tab. 6 show rather poor lean meat contents compared with carcass-quality dominated intensive fattening systems. However, the findings were basically congruent with the chosen fattening intensity and the fact of the dominance of castrates, mainly of the last three genotypes.

The significantly higher lean meat content of Pi x GLW x GLR and Pi x Du x GLR emphasises the superiority of the carcass quality of specialised modern fattening crossbreed genotypes, especially with Pietrain as sire (Biedermann et al., 2000). It was not astonishing that less intensive old breeds such as saddleback pigs, even crossed with Pietrain, showed worse results (Pi x AS). Du x GLR and purebred Duroc, particularly as castrates, showed insufficient carcass quality due to their role as mating partners in crossbreeding.

On the other hand, as shown in Tab. 6, augmented lean meat contents of the first two genotypes were due to the presence of sows in these groups. Sows have a higher protein synthesis rate than castrates and this causes higher lean meat contents (Volk, 2003).

Meat quality

Meat quality was described in terms of PSE-status (measured as pH_{45}) and meat colour (measured as meat lightness by means of *optostar*) as seen in Tab.7. Due to homogeneous allocation, the presentation of data was not divided for females and castrates.

Tab. 7: Aspects of meat quality in relation to genotype

	Pi x GLW x GLR	Pi x Du x GLR	Pi x AS	Du x GLR	Du
PSE-status (pH_{45}) of M.l.d. ($13^{th}/14^{th}$ rib)					
n	10	20	10	8	9
LSQ	6.3^{a}	6.4^{ab}	6.5^{b}	6.4^{ab}	6.4^{ab}
S.E.	0.1	0.1	0.1	0.1	0.1
Meat colour (meat lightness by *optostar*) of M.l.d. (13^{th} rib)					
n	10	20	10	7	9
LSQ	68.8^{a}	70.5^{a}	68.1^{a}	70.2^{a}	77.4^{b}
S.E.	2.1	1.5	2.1	2.6	2.6

Different letters indicate significant differences at level $p \leq 0.05$

There were no PSE problems on the basis of pH_{45}. This finding was in accordance with the measurement of electrical conductivity (EC) 24h p.m. (results not presented). Values of pH_{45} and EC_{24} of M.l.d. for exclusion because of PSE suspicion are < 6.0 and ≥ 6.00 respectively (Weissmann und Honikel, 1998). High *Optostar* values stand for dark-coloured meat, low values for light-coloured meat. Values below 60 indicate susceptibility for PSE, values above 80 are associated with DFD conditions (ZDS, 2000). The data in Tab. 7 represent the favoured range of meat lightness as reported by Haas et al. (1997). For the genotype Duroc, a higher value i.e. relatively dark meat colour and slightly augmented pH_{24} is normal and not necessarily associated with DFD (Laube, 2000). There were no DFD-cases ($pH_{24} > 6.0$; Fischer, 2001) of M.l.d. and ham with pH_{24} of 5.53 ± 0.08 (5.37 – 5.72) and 5.57 ± 0.08 (5.44 – 5.91) respectively (detailed results not presented).

Conclusion

According to the extensive feeding regime, the fattening performance was characterised by acceptable daily weight gains (castrates quite high, sows quite low) but an unacceptable feed conversion ratio.

The carcass quality showed inconsistencies: whereas the lean meat content of castrates was definitely too low, the sows showed good to acceptable lean meat contents in relation to the capacities of intensive and extensive genotypes respectively.

The meat quality in terms of PSE-status and meat colour showed good results for all genotypes and sexes.

To achieve a better congruence between fattening and carcass performance it is concluded that the feeding strategy could easily be enhanced by (slightly) higher contents of grain legumes and by phase-associated feeding in terms of protein-energy-content and the amount of feed. A separation of castrates and sows could be advantageous.

The analysis of intramuscular fat content and sensory meat quality will show whether these findings are of such an outstandingly high value that they can justify and compensate adipose carcasses as these cannot be sold in marketing systems which rely almost exclusively on quantitative carcass qualities such as lean meat content.

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Fattening pigs in an outdoor system as a part of the crop rotation within organic farming: Growth performance and carcass yield

A. Farke[1] and A. Sundrum[1]

Introduction

Although benefits and options of keeping pigs in free range systems have been described in different European countries (Van der Wal, 1993; Watson & Edwards, 1997), this production method is not very common in Germany. Correspondingly, only few practical and scientific experiences with this production method are available.

The aim of the project was to identify problems related to organic pig fattening under free range conditions. There were several open questions in terms of pig performance and variation in carcass quality, possibilities for substituting concentrates with different home grown feeding crops as "herbage on demand" and animal health status under outdoor conditions in the summer and winter period. Furthermore, the question arises whether different genotypes of pigs show different performance and carcass quality in an outdoor system.

Materials and methods

In the years 2002/2003 a study with outdoor fattening pigs was carried out at the experimental farm of the University of Kassel. Five different treatments were implemented at different seasons: two in Winter/Spring 2002/03 (W02) and three treatments in Summer/Autumn 2003 (S03). Treatments differed additionally in relation to the crops grown on the paddocks and the amount of concentrates. Pigs were kept on paddocks with either Turnip (*Brassica rapa rapifera*) (**T**), Ryegrass (**R**) Jerusalem Artichoke (*Helianthus tuberosus L.*) (**J**) or barley stubble (**S**). The size of the area used by the pigs was adapted to the standards of the organic association of BIOLAND, prescribing a limit in relation to nutrient input of 110 kg of nitrogen (N) per ha per year respectively 10 fattening pigs per ha per year. The size of the paddocks was determined in relation to the number of pigs and the duration of the fattening period.

The fattening period was divided in two phases: the growing period from 30 to 70 kg live-weight (LW) and the finishing period from 70 to 120 kg live-weight. Changes from the growing to the finishing phase went along with changes of the paddocks. In addition to the forage offered on the paddocks, pigs were fed concentrates as pellets in troughs (see Figure 1). Two types of concentrates were offered: In the growing period pigs were fed a diet containing 14.2 MJ metabolisable energy (ME) and 17.3 % crude protein (CP) per kg DM. During the finishing period the pigs were offered a diet with 14.6 MJ ME and 16.0 % CP per kg DM. The amount of concentrates offered per pig and day was determined in relation to the season and the crops available on the paddocks. 100 % of concentrate represented the amount of nutrients as recommended by GfE (1987) for fattening pigs with an average daily live-weight gain (ADG) of 750 g kept under indoor conditions.

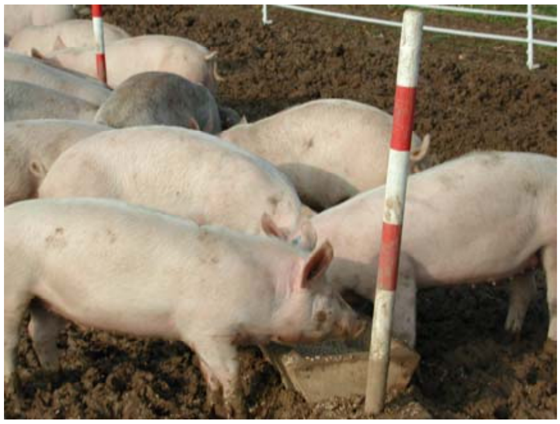

Figure 1: Pigs at the feed trough

In the study three genotypes were used:

- (a) = (Hampshire x Pietrain) x (Duroc x German Landrace) = (Ha x Pi) x (Du x GL),
- (b) = Pietrain x (Large White x German Landrace) = Pi x (LW x GL) and
- (c) = Pietrain x (Duroc x German Landrace) = Pi x (Du x GL).

One treatment consisted of 40 pigs (20 castrates and 20 females). Within each treatment two different genotypes were used. The experimental design of the study is presented in Table 1.

For statistical reasons, the t-test procedure of SPSS for windows (version 10.0) was used to assess differences between and within treatments.

Results and discussion

Growth performance

The daily live-weight gains (ADG) [g] in the fattening period in the different treatments are presented in Fig. 2. On average, the outdoor pigs achieved a mean ADG of about 740 g. This growth

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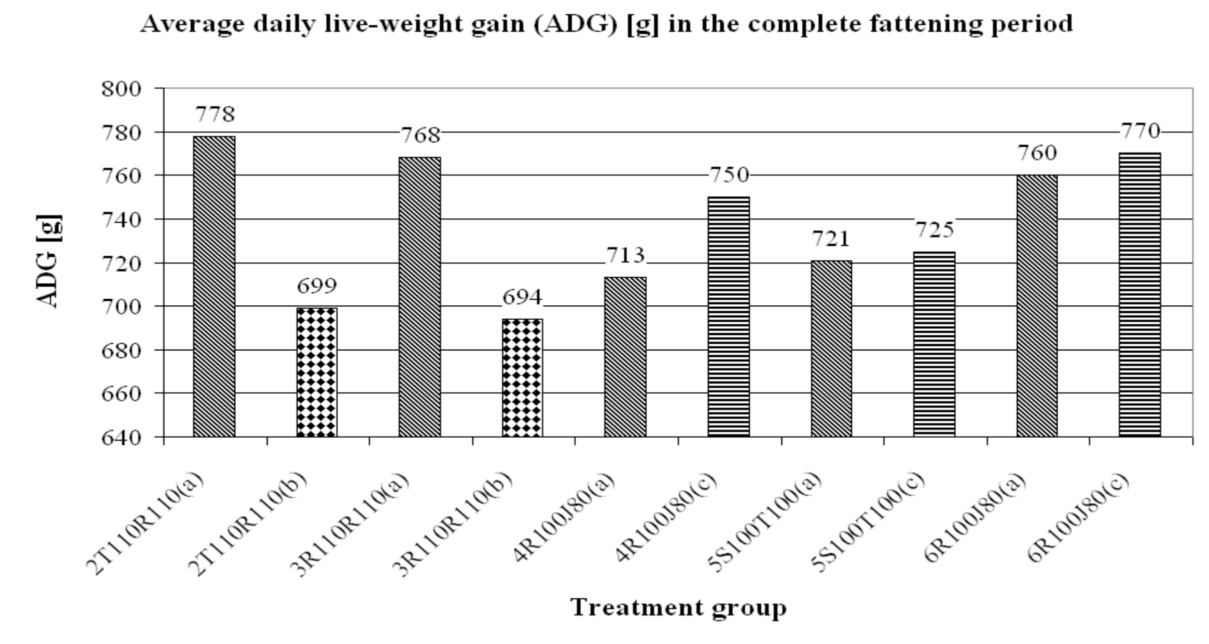
Table 1: Experimental design

Treatment	2	3	4	5	6
Treatment groups	2T110/R110(a) 2T110/R110(b)	3R110/R110(a) 3R110/R110(b)	4R100/J80(a) 4R100/J80(c)	5S100/T100(a) 5S100/T100(c)	6R100/J80(a) 6R100/J80(c)
Season	- - - - - - - - - - Winter - - - - - - - - - -		- - - - - - - - - - - - - - - Summer - - - - - - - - - - - - - - -		
Growing period (GP)					
Crop condition	Turnip (T), frosted	Ryegrass (R), winter stadium	Ryegrass (R), growing	Barley stubble (S)	Ryegrass (R), dried
Concentrates	110 %	110 %	100 %	100 %	100 %
Duration	9 weeks (49.-05.CW*)	9 weeks (49.-05.CW*)	7 weeks (22.-28.CW*)	9 weeks (32.-40.CW*)	8 weeks (32.-39.CW*)
Finishing Period (FP)					
Crop condition	Ryegrass (R), winter stadium	Ryegrass (R), winter stadium	Jerusalem Artichoke (J), all green parts usable	Turnip (T), very late	Jerusalem Artichoke (J), stems & tubers usable
Concentrates	110 %	110 %	80 %	100 %	80 %
Duration	13 weeks	13 weeks	11 weeks	10 weeks	11 weeks

(a) = (Ha x Pi) x (Du x GL); (b) = Pi x (LW x GL), (c) = Pi x (Du x GL)
* CW = calendar week



Forage crops:	T = Turnip; R = Ryegrass; J = Jerusalem Artichoke; S = Stubble
Genotypes:	(a) = (Ha x Pi) x (Du x GL); (b) = Pi x (LW x GL), (c) = Pi x (Du x GL)

Figure 2: Average daily live-weight gain (ADG) [g] in the complete fattening period in relation to the different treatments and genotypes

performance was similar to the results, that have been reported by Stoll (1994) for outdoor production on pasture. In the study by Schneider und Walter (1996) outdoor pigs reached 729 g ADG while the control group kept indoors achieved only 679 g ADG. Bremermann (2001) found even 844 g ADG over the whole fattening period for outdoor pigs compared to 788 g ADG for pigs reared and fattened under indoor conditions.

In treatment 2T110/R110 (Turnip + 110 % concentrates during the growing period and Ryegrass + 110 % during the finishing period) the genotype Pietrain x (Large White x German Landrace) had a significantly lower ADG ($p > 0.005$) than the genotype (Hampshire x Pietrain) x (Duroc x German Landrace) (699 g vs. 778 g). In treatment 3R110/R110 (Ryegrass + 110 % concentrates during the growing and the finishing period) the genotype Pietrain x (Large White x German Landrace) again showed a significantly lower growth performance compared to Duroc crosses (694 g vs. 768 g). There were no significant differences in average daily live-weight gain between the genotypes in the other three treatments. The genotype Pietrain x (Duroc x German Landrace) reached with 770 g ADG its best results in treatment 6R100/J80 (Ryegrass + 110 % concentrates during the growing period and Jerusalem Artichoke + 80 % concentrates during the finishing period). Despite the fact that the amount of available concentrates was clearly reduced in the finishing period, these pigs reached similar results in performance compared to the pigs fed with 100 % concentrate. Obviously the pigs were able to metabolise nutrients offered by the Jerusalem artichoke on the paddock.

The results indicated that (Hampshire x Pietrain) x (Duroc x German Landrace) and Pietrain x (Duroc x German Landrace Pietrain) had a certain advantage over the genotype Pietrain x (Large White x German Landrace) under the conditions of the experiment. Reasons for the difference in growth performance could possibly also be due to differences in the rearing conditions of the pigs and in possible differences in the potential to acclimate to outside conditions.

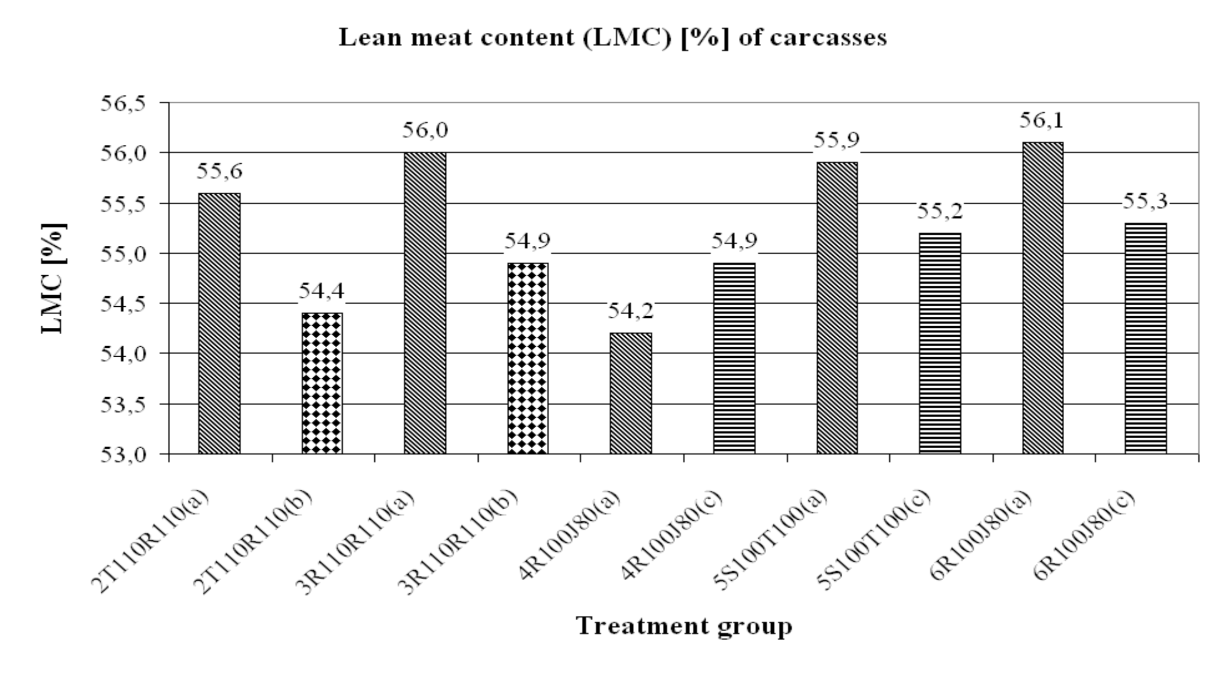
Carcass yield

Lean meat content (LMC) of the carcasses in the different treatments and in relation to genotypes are presented in Figure 3. On average the outdoor pigs achieved a carcass yield with a lean meat content (LMC) of about 55 %. There were no significant differences in LMC between the different genotypes.

In several studies no differences were found in LMC between pigs fattened under outdoor and indoor conditions (Van der Wal, 1993; Haidn, 1999). On the other hand, Durst and Willeke (1994) reported a lower LMC (1 - 2 %) for the outdoor pigs compared to those fattened indoors. The authors see the accumulation of fat for insulation in winter time as the main reason for the difference in carcass yield. Additionally, a higher back fat thickness in pigs was found when pigs were kept outdoors compared to those fattened indoors (Engler, 1994; Weber, 1996).

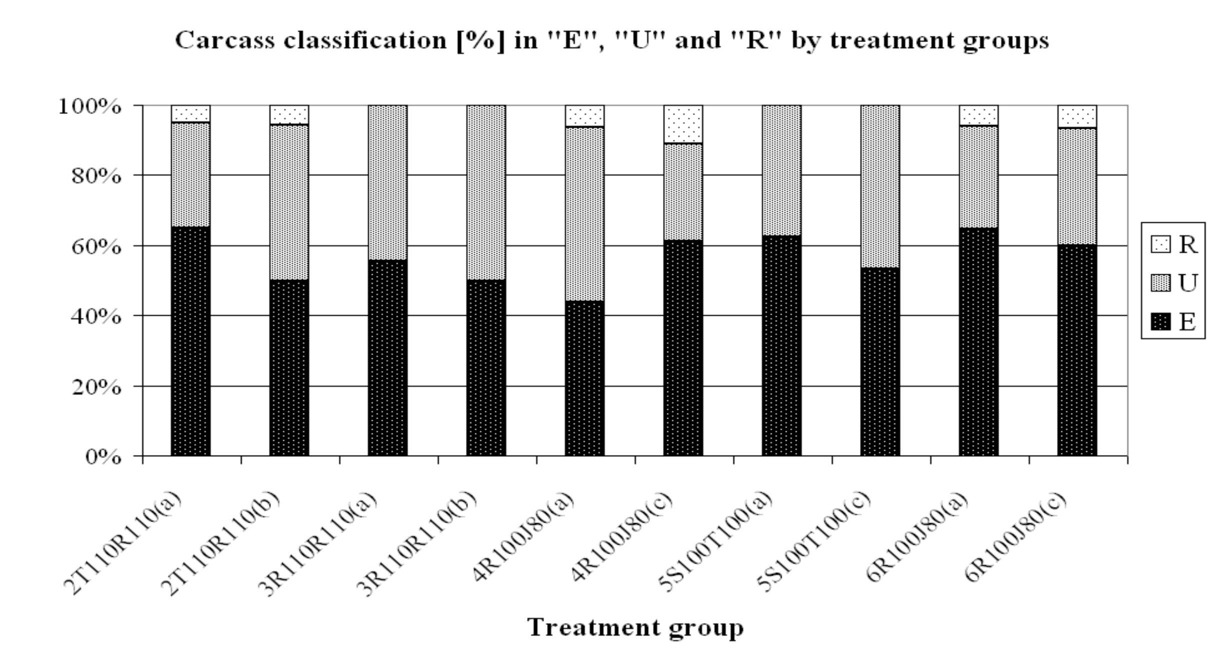
Results of the carcass classification by the EUROP-system in the different treatments and in relation to the genotypes are shown in Figure 4. The allocation of carcasses into category 'E' (LMC ≥55 %) differed between treatments and genotypes. With 43.8 % the lowest proportion of carcasses allocated to category 'E' was found in the treatment group 4R100/J80(a) with the genotype (Ha x Pi) x (Du x GL). On the other hand, the highest percentage (65.0%) was gained with the same genotype in treatment group 2T110/R100(a) (Turnip + 110 % concentrates during the growing period and Ryegrass + 110 % concentrates during the finishing period). Additionally, the genotype (Ha x Pi) x (Du x GL) reached high proportions of carcasses in category 'E' as well as treatment group.6R100/J80(a) with 64.7 % and treatment group 5S100T100(a) with 62.5 %. The results indicate that carcass yield was primarily influenced by the availability of nutrients. Results in this study concerning carcass yield in free range systems were much better than the results reported by Bremermann (2001), In this study only 10.7 % of the carcasses from outdoor pigs reached a LMC above 55 %.

In all treatment groups the carcasses of the female pigs got a higher classification than the carcasses of the castrates. Between 60 and 100 % of the females of the different groups achieved class 'E'. On the other hand, the main proportion of castrates was classified in category 'U' (LMC 45-50 %). Detailed information about the carcass classification of females and castrates is presented in Table 2.



Feeding crops: T = Turnip; R = Ryegrass; J = Jerusalem Artichoke; S = Stubble
Genotypes: (a) = (Ha x Pi) x (Du x GL); (b) = Pi x (LW x GL), (c) = Pi x (Du x GL)

Figure 3: Lean meat content (LMC) [%] of carcasses in the different treatments and in relation to genotypes



Feeding crops: T = Turnip; R = Ryegrass; J = Jerusalem Artichoke; S = Stubble
Genotypes: (a) = (Ha x Pi) x (Du x GL); (b) = Pi x (LW x GL), (c) = Pi x (Du x GL)

Figure 4: Carcass classification [%] in “E”, “U” and “R” in the different treatments and in relation to genotypes

Table 2: Carcass classification (EUROP system) in the different treatments and in relation to genotypes and sex

Treatment groups	Sex	n	Class E LMC ≥55 %		Class U LMC 50-55 %		Class R LMC 45–50 %	
			[%]	n	[%]	n	[%]	n
2T110/R110(a)	Castrates	10	50,0	5	40,0	4	10,0	1
	Females	10	80,0	8	20,0	2	- -	-
2T110/R110(b)	Castrates	9	11,1	1	77,8	7	11,1	1
	Females	9	88,9	8	11,1	1	- -	-
3R110/R110(a)	Castrates	9	22,2	2	77,8	7	- -	-
	Females	9	88,9	8	11,1	1	- -	-
3R110/R110(b)	Castrates	8	25,0	2	75,0	6	- -	-
	Females	10	70,0	7	30,0	3	- -	-
4R100/J80(a)	Castrates	6	16,7	1	66,6	4	16,7	1
	Females	10	60,0	6	40,0	4	10,0	1
4R100/J80(c)	Castrates	9	44,4	4	33,4	3	22,2	2
	Females	9	77,8	7	22,2	2	- -	-
5S100/T100(a)	Castrates	7	28,6	2	71,4	5	- -	-
	Females	9	88,9	8	11,1	1	- -	-
5S100/T100(c)	Castrates	11	36,4	4	63,6	7	- -	-
	Females	4	100,0	4	- -	-	- -	-
6R100/J80(a)	Castrates	6	16,7	1	66,6	4	16,7	1
	Females	11	90,9	10	9,1	1	- -	-
6R100/J80(c)	Castrates	9	44,4	4	44,4	4	11,2	1
	Females	6	83,3	5	16,7	1	- -	-

Feeding crops: T = Turnip; R = Ryegrass; J = Jerusalem Artichoke; S = Stubble
Genotypes: (a) = (Ha x Pi) x (Du x GL); (b) = Pi x (LW x GL), (c) = Pi x (Du x GL)

Conclusions

The results show that it is possible to obtain acceptable daily live-weight gains and carcass yields in organic pig production under free range conditions. Due to differences between the treatment groups there is reason to assume relevant interactions between genotype and the available feed offered by concentrates and forage on the paddock. Despite the fact that only 80 % of concentrates during the finishing period were fed by additionally using Jerusalem Artichokes the pigs reached similar results in growth performance and carcass yield compared to pigs fed with 100 % concentrates. Thus, a certain amount of concentrates was substituted by offering this plant on the paddock. Further studies are needed to estimate the amount of "herbage on demand" and feed intake of crops by the pigs under outdoor conditions.

Summary

Aim of the project was to assess the effect of substitution of concentrates by home grown feedstuffs on pig performance, and variation of carcass quality in a free range organic system. In five treatments three different genotypes (Ha x Pi) x (Du x GL), Pi x (LW x GL) and Pi x (Du x GL) and 4 different crops as forage for the pigs were used: Turnip (**T**), Ryegrass (**R**), Jerusalem Artichoke (**J**) and barley stubble (**S**). The amount of supplemented concentrates differed in relation to the season and the crops available on the paddocks.

The results show that fattening pigs achieved an average daily live-weight gain (ADG) of 740 g. Differences in ADG between treatments were primarily due to the different genotypes.

When pigs were kept on the paddock with Jerusalem artichoke, they reached a similar and even higher ADG compared to other treatments although the amount of concentrate offered was clearly reduced. Obviously pigs were able to use nutrients offered by Jerusalem artichoke to a high degree.

Lean meat content (LMC) of the carcasses was about 55 % on average. There were no significant differences in LMC between genotypes, however, clear differences between treatments. In all treatments carcasses from female pigs attained a higher classification of the carcass than the castrates.

It can be concluded that under free range conditions fattening pigs can achieve acceptable ADG and carcass quality. Concentrates can be substituted to a certain degree by offering forage, esp. Jerusalem Artichoke on the paddock. However, further studies are needed to evaluate the amount of "herbage on demand" needed and feed intake of crops by pigs under free range conditions.

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Integration of organic pig production within crop rotation: Implications on nutrient losses

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Introduction

The acceptance of outdoor pig production to farmers, consumers and politicians is partly focused to environmental compatibility and sustainability (Krumm, 2002). The most critical aspects of outdoor pig production are soil compaction (Brandt et al., 1995a) and nutrient leaching (Worthington & Dranks, 1992, Worthington & Dranks, 1994, Stauffer et al., 1999) due to high nutrient input (Daub and Ross, 1996, Zihlmann & Weisskopf, 1997) and heterogeneity in soil nutrient distribution (Brandt et al., 1995b, Watson et al., 2003). Brandt et al. (1995b) and Ingold & Kunz (1997) demanded to integrate outdoor pig production into crop rotation to ensure nutrient output by the following crops instead of keeping the pigs on permanent paddocks.

The objective was to investigate, if optimizing the management of outdoor pig production under conditions of organic farming leads to a more sustainable production system. Several groups of fattening pigs were fattened outdoors, while balancing nutrient input and examine nutrient distribution. Several strategies of management should be tested to reduce nutrient input and homogenise nutrient distribution.

Material and methods

Location

The project of outdoor pig fattening was located at the organic research farm of the Faculty of Organic Agricultural Sciences at the University of Kassel. The research farm is located in the centre of Germany, 20 km north of Kassel (latitude N 44 32 03.304, longitude E 47 04 36.320), 150 to 300 m above sea level. Total farm size is 309 ha with 208 ha of arable land and 44 ha of pasture. The strived crop rotation consists of 6 fields: grass-clover, grass-clover (2nd year), winter wheat (catch crop as green manure), potatoes or carrots (catch crop as green manure), faba beans, and winter barley.

Two classes of soil prevail at Frankenhausen, those from loess with silty, loamy soils and those from claystone with clayey soils. Outdoor pigs were fattened on two paddocks described in detail by Brandt (2001). The loessial soil with the soil type Luvisol has a low potential for leaching of nitrate due to high effective plant available water capacity within the depth of rootening of 314 mm (150 cm for winter-wheat). The clayey soil was described as soil type Vertisol with an effective plant available water capacity within the depth of rootening of 94 mm due to low field capacity and rootening depth (100 cm for winter-wheat). Soil conditions were surveyed by Brandt et al. (2001) and summarised in Table 1.

The mean annual precipitation of the last 30 years and the experimental years 2002 and 2003 were 699 mm, 703 mm and 505 mm (Fig. 1). The weather of the experimental year was not typical for the conditions of the area of Frankenhausen and can be described as a very wet autumn and winter in 2002/03 and an extreme drought in spring and summer 2003.

Field experimental design

During the period from Oct. 2002 to Dec. 2003 24 groups (treatments), with 20 fattening pigs each, were kept outdoor at all weather conditions. The fattening period was separated in starting (30 to 70 kg live weight) and finishing period (70 to 120 kg live weight). Pigs were fed with specific concentrates as pellets with higher protein content in the starting period. Concentrate diet was based on a daily grain of 750 g due to indoor stock keeping (= 100%) (GfE, 1987). Concentrate diet varied during the project from 80% to 110%, depending on the supply of fresh green forage at the paddocks. Two treatments with different genotypes were fattened parallel at one time. Following crops were offered on paddocks: **T** turnip (*Brassica rapa rapifera*) sawn after winter barley, **R** ryegrass, **J** Jerusalem artichoke (*Helianthus tuberosus*), **P** harvested potatoes or **S** barley stubble. Treatments were described by their ID for example: 2T110(b); 2 = no. of treatment / T = turnip / 110% concentrate diet / (b) = genotype.

Sizes of paddocks were calculated to stocking rate, which was limited to 10 fattening pigs ha $^{-1}$ a^{-1} due to the regulations of Bioland (2003). These regulations allow an annual input of nitrogen of 112 kg ha^{-1} and an annual input of phosphorus of 43 kg ha^{-1}.Space allowance per fattening pig was calculated to 2,74 m^2.

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Table 1: Soil characteristic of experimental plots

Soil type	sand	silt	clay	pH ($CaCl_2$)	C_{org}	N_{total}	P (CAL)	K (CAL)
	[%]	[%]	[%]		[%]	[%]	[ppm]	[ppm]
Luvisol	2.6	80.1	17.3	6.8	1.22	0.14	61	141
Vertisol	4.8	66.3	28.9	6.9	1.57	0.16	109	174

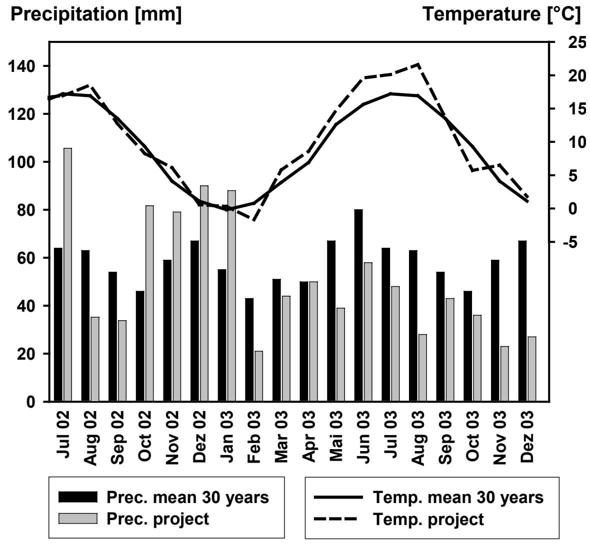

Figure 1: Weather data of the year of experiment and annual means

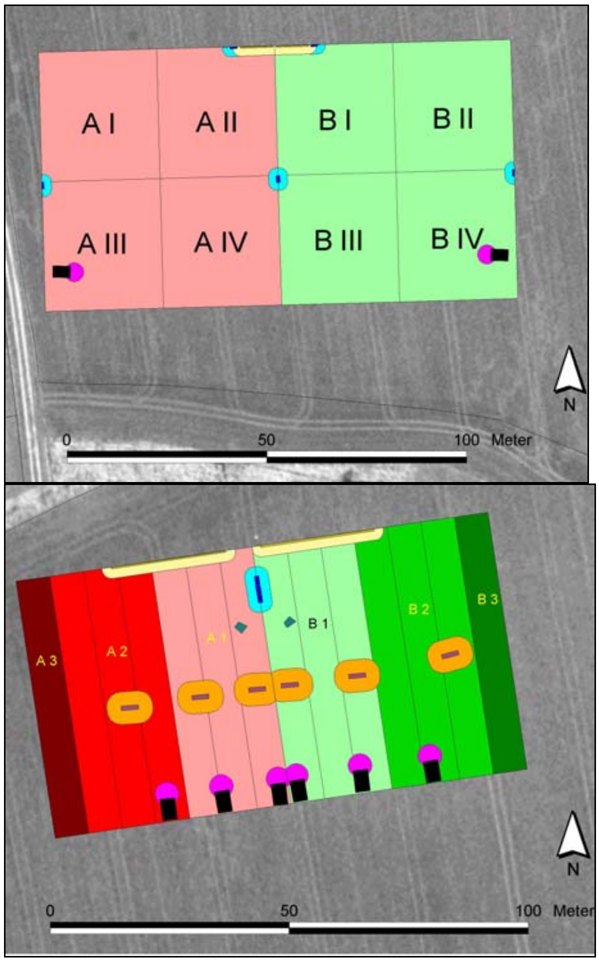

Figure 2: Design of paddocks with:
above: static installation units (treatment 2a and b) and
below: moved installation units (treatment 4a and b)

The size for a group of 20 fattening pigs for a fattening period of 9 weeks was calculated with 3452 m^2. Paddocks were designed in a Geo Information System (GIS), due to the geometries of the fields and the access to the paddocks. It was transferred with a Differential Global Positioning System (DGPS) to the field. The installation units (non insulated huts of 13.5 m^2 area, feeding and watering troughs, water tanks inside the huts in winter time, sun shelters and muddy pools in summer-time) were placed by the technicians, surveyed with DGPS and documented in GIS.

Installation units were arranged by two methods (Fig. 2): i) static installation units, where huts and troughs were not moved during the fattening period. Here the whole areas of the paddocks were given at the beginning of the fattening period at a whole; ii) moved installation units, where huts and troughs were moved every 3 weeks to increase nutrient accumulation. The paddocks were given in weekly intervals as strip grazing. Distances between installation units were maximized to increase pig activity.

Soil analysis

For the determination of inorganic nitrogen, the soil was cooled at 5°C and extracted with 0.01 Mol $CaCl_2$-solution in relation 1 : 4. Nitrate was measured due to Hoffmann (1991) and ammonia due to DIN38604 (1983). Nitrate was measured with a spectral photometer at 210 nm. Ammonia was determined as a complex with salycilat-citrat-solution with a spectral photometer at 655 nm.

Plant available phosphorus and potassium was extracted from air dried soil in a solution of calcium-acetate-lactate (CAL) in relation of 1:20. CAL-solution was buffered at pH of 4.1. After filtration, phosphorus was measured with a spectral photometer at 580 nm as a complex with molybdenum (Schüller, 1969). Potassium was measured in a flame photometer at 767 nm (Hoffmann, 1991).

Soil pH was assessed in a solution of soil and 0.01 Mol CaCl2 in relation of 1:2.5 after 1 h (Hoffmann, 1991)

Nutrient calculation

Nutrient input by concentrate was calculated for each treatment of pigs from the sum of concentrate that was fed and its nutrient concentration (Table 2).

$$\text{nutrient input [g] (concentrate)} = \text{concentrate [kg]} \times \text{nutrient content [g kg}^{-1}]$$

Nutrient output by the fattened pigs was calculated as product of the total gain of each treatment for the fattening period at one paddock and the nutrient content of pig carcass due to Kerschberger et al. (1997) (Table 2).

$$\text{nutrient output [g] (pigs)} = \text{gain [kg]} \times \text{nutrient content [g kg}^{-1}] \text{ (concentrate)}$$

Nutrient input of the paddock was defined as difference from nutrient input from concentrate and nutrient output by gain of pigs. Nutrient input to the paddock did not include field crops like grass or turnips.

$$\text{nutrient input [g] (paddock)} = \text{nutrient input[g] (concentrate)} - \text{nutrient output[g] (pigs)}$$

By transferring the nutrient input to the paddock to the nutrient input per pig and day it was possible to compare the results within the groups.

Results

Nutrient input

The nutrient input in term of nitrogen, phosphorus and potassium into the plant-soil system by excrements (pigs output) and losses of concentrate is given in tables 3 and 4. For assessing the nutrient inputs, means, minima and maxima were calculated separately for groups of starting and finishing periods. Finishing groups were also differentiated into ≤100 % and >100 % concentrate diet (100 % = daily gain of 750 g due to indoor stock keeping (GfE, 1987)).

Table 2: Nitrogen, phosphorus and potassium content of concentrates for starting and finishing period and of pig carcasses

I t e m	N [g kg^{-1}]	P [g kg^{-1}]	K [g kg^{-1}]
Concentrates			
Starting, treatment 2 to 6	21.5	6.0	8.5
Finishing, treatment 1	21.5	6.0	8.5
Finishing , treatment 2 to 6	19.7	6.0	8.5
Carcass			
German fertilizing regulations (BML, 1996)	25.6	5.1	0.2
Kerschberger et al. (1997)	27.2	6.0	0.2

Table 3: Nutrient input (per pig day) of nitrogen, phosphorus and potassium as a result of excrements and concentrate losses related to pig fattening period

Period	Diet*		N [kg^{-1}]	P [kg^{-1}]	K [kg^{-1}]
			Nutrient input per day		
Start		mean	23.4	7.7	15.6
		min	19.0	6.4	13.6
		max	28.9	9.2	17.8
Finish	>100%	mean	49.3	15.8	27.3
		min	42.6	14.8	26.0
		max	57.4	16.9	29.1
Finish	≤100%	mean	29.7	10.8	20.4
		min	23.4	8.9	17.4
		max	33.6	12.2	23.4
Regulation EEC 2092/91			33.3		
Regulations Bioland			30.7	11.8	
German fertilizing reg.			33.3		

* 100% = daily gain 750 g due to indoor keeping

Table 4: Input of nitrogen, phosphorus and potassium to paddock as a result of excrements and concentrate losses related to pig fattening period

Period	Diet*	Nutrient input per paddock**	N [kg^{-1}]	P [kg^{-1}]	K [kg^{-1}]
Start		mean	86	28	57
		min	69	23	49
		max	106	34	65
Finish	>100%	mean	180	58	100
		min	156	54	95
		max	209	62	106
Finish	≤100%	mean	109	40	74
		min	85	32	64
		max	123	45	85
Regulation EEC 2092/91			170		
Regulations Bioland			112	43	
German fertilizing reg.			170		

* 100% = daily gain 750 g due to indoor keeping

** standardized to 10 pigs ha^{-1} a^{-1}

During starting period, the mean daily nitrogen input per pig (Table 3) was 23.7 g, phosphorus input was 7.7 g and potassium input was 15.6 g. In relation to the regulations of (Bioland (2003) this were 76 % of the permitted nitrogen input (30.7 g pig^{-1} d^{-1}) and 65 % of the permitted phosphorus input (11.8 g pig^{-1} d^{-1}). In relation to the EEC-regulation (EEC, 2003) and the fertilizing regulation (BML, 1996), nitrogen input reached 70 % of the maximum permitted load (33.3 g pig^{-1} d^{-1}).

During the finishing period for concentrate diets ≤100 %, the daily nitrogen input per pig was 29.7 g, phosphorus input was 10.8 g per pig and day and potassium input 20.4 g per pig and day. In relation to the regulations to Bioland the means of nitrogen and phosphorus inputs per pig and day were close below the permitted inputs. The maximum values reached the permitted inputs of the EEC- and the German fertilizing regulation.

For concentrate diets >100 % for finishing period, nitrogen input per pig was 49.3 g, phosphorus input was 15.8 g per pig and day and potassium input 27.3 g per pig and day. The nitrogen and phosphorus inputs for concentrates diets >100 % were higher than the permitted in relation to all regulations.

More relevant for calculating the nutrient input to the following crops were the nutrient input in relation to the area, than to the daily input per pig. Nutrient inputs to the paddocks were calculated to the area which were standardized to 10 pigs ha^{-1} a^{-1} due to Bioland (2003) with an permitted input of 112 kg N ha^{-1} (Table 4).

Mean nutrient input to the area during the starting period for nitrogen, phosphorus and potassium were 86 kg ha^{-1}, 28 kg ha^{-1} and 57 kg ha^{-1}. The nutrient input for concentrate diets ≤100 %, related to the area, were 109 kg ha^{-1}, 40 kg ha^{-1} and 74 kg ha^{-1} and for concentrate diets >100 % 180 kg ha^{-1}, 58 kg ha^{-1} and 100 kg ha^{-1}.

Nutrient distribution

Nitrogen

The results of the distribution of nitrogen and ammonia concentrations are shown exemplary for two groups with static installation units (groups 2(a+b)), and two groups with moved installation units (groups 4(a+c)).

Static installation units

Groups 2(a) and 2(b) were kept on turnips during the starting period. The concentration of nitrate-N (Table 5) was at the beginning (02-12-2002) in 0-90 cm depth low with 5.3 ± 0.1 ppm and didn't change until the end of the fattening period (05-02-2003) either on the control areas, paddocks or installation units with 5.3 ± 2.7 ppm. Until the end of the leaching period (02-04-2003), when soil samples were taken to measure the nitrate-N concentration after seepage, the concentration in the control areas slightly increased to 10.1 ± 1.7 ppm, at the paddocks of 14.4 ± 0.4 ppm and at the feeding troughs of 12.2 ± 3.1 ppm with highest concentrations in the top soil (0-30 cm depth). The highest increase of nitrate-N concentrations happened during the leaching period in front of the huts with 34.2 ppm for group 2(a) and 44.2 ppm for group 2(c). Again the highest concentrations were found in the top soil (0-30 cm) with 21.7 to 25.3 ppm. In the depth from 30-60 cm the nitrate-N concentrations increased slightly with 8.4 ppm respective 14.1 ppm. The displacement of nitrate did not reach any deeper than 60 cm in the silty clayey soil with its high available field capacity.

Table 6 shows the changes in the concentrations of ammonia-N in the soil of treatment 2(a+b) during fattening period and leaching period. There was no ammonia-N in the soil found at the beginning and in the control area at the end of the fattening period. Low concentrations of ammonia-N were found in the paddocks of treatment 2(a+b) (5.1 ppm and 3.1 ppm) after the end of fattening period and no ammonia-N after the leaching period. Ammonia-N concentrations were higher around the feeding troughs with 20.0 ppm and 15.4 ppm at the end of the fattening period and compared to the end of the leaching period slightly lower with 8.5 ppm and 7.5 ppm. Ammonia-N concentrations were very high in front of the huts with 13.9 ppm and 23 ppm at the end of the fattening period. At the end of seepage, ammonia-N concentrations were 48.3 ppm and 105.7 ppm in front of huts, here ammonia-N was also found in the depth of 30-60 cm.

Table 5: Nitrate-N concentration [ppm] in soil during outdoor pig fattening in dependence of location of static installation units at start and end of fattening period and after leaching

Area	Time	Depth [cm]			
		0-30	30-60	60-90	0-90
Control	start	2.9	0.7	1.7	5.4
2(a)	end	1.9	1.1	0.5	3.5
	leach	5.0	2.1	1.3	8.4
Control	start	2.9	0.7	1.7	5.4
2(b)	end	2.6	1.9	1.3	5.8
	leach	6.1	3.5	2.2	11.8
Paddock	start	2.0	1.2	2.1	5.3
2(a)	end	2.7	1.7	1.0	5.3
	leach	8.7	3.8	2.4	14.8
Paddock	start	2.1	1.1	2.0	5.2
2(b)	end	3.1	1.8	1.1	6.0
	leach	8.1	3.5	2.3	13.9
Trough	end	0.8	1.7	0.5	3.0
2(a)	leach	3.4	2.4	1.3	7.1
Trough	end	2.5	2.2	0.9	5.6
2(b)	leach	7.1	3.6	2.6	13.3
Hut	end	2.7	1.5	0.8	4.9
2(a)	leach	21.7	8.4	4.2	34.2
Hut	end	3.6	2.9	1.5	8.0
2(b)	leach	25.2	14.1	4.8	44.2

Moved installation units

Treatments 4(a+c) were kept on Jerusalem artichoke during the finishing period. Feeding troughs and huts were moved two times during the fattening period, in intervals of three weeks. The paddocks were given weekly like strip grazing to access to the pigs (Fig. 2). Soil samples were taken at the start 1 of the fattening period on 15-07-2003, between 1 (on the already grazed paddock = start 2 for new ration of paddock) on 01-08-2003, between 2 (on the already grazed paddock = start 3 for new ration of paddock) on 25-08-2003 and at the end of the fattening period on 16-09-2003 (Table 7). Because of no leaching at summer time, no further samplings after the end of the fattening period were carried out.

Table 6: Ammonia-N concentration [ppm] in soil during outdoor pig production in relation to the location of static installation units at end of fattening period and after leaching

Area	Time	Depth [cm]			
		0-30	30-60	60-90	0-90
Control	end	0.0	0.0	0.0	0.0
2(a) (b)	leach	0.0	0.0	0.0	0.0
Paddock	end	5.1	0.0	0.0	5.1
2(a)	leach	0.1	0.0	0.0	0.1
Paddock	end	3.1	0.0	0.0	3.1
2(b)	leach	0.0	0.0	0.0	0.0
Trough	end	20.0	0.0	0.0	20.0
2(a)	leach	8.5	0.0	0.0	8.5
Trough	end	15.4	0.0	0.0	15.4
2(b)	leach	7.5	0.0	0.0	7.5
Hut	end	13.9	0.0	0.0	13.9
2(a)	leach	44.5	3.8	0.0	48.3
Hut	end	20.5	2.5	0.0	23.0
2(b)	leach	86.2	19.4	0.0	105.7

At the different sampling times of start (1 to 3), nitrate-N concentrations were low between 2.3 ppm and 5.2 ppm, due to the dry weather and the growing crop. On the paddocks the nitrate-N concentrations increased according to the grazing time at the paddocks with maximum concentration of 25.7 ppm for treatment 4(a) and 23.9 ppm for treatment 4(c). For the area of the paddock of treatment 4(a) with the longest access the concentrations of nitrate-N increased from 3.4 ppm at start 1 to 18.6 ppm at between 1 and 25.7 ppm at end 1. For treatment 4(c) the nitrate-N concentrations were respectively 3.1 ppm, 10.2 ppm and 23.9 ppm. The nitrate-N concentrations at the areas of feeding troughs reached from 8.6 ppm to maximum of 14.6 ppm. In front of the huts the nitrate-N concentrations were at the same level compared to the troughs except for one value of 31.5 ppm for treatment 4 (c). Nitrate-N concentrations in the soil depth of 30-60 cm were very low.

Nearly all ammonia-N concentration of the soil at the paddocks and at the installation units of groups 4(a+c) were at the same level of 2.7 ppm to 12.0 ppm (mean 7.7 ppm), except in front of the huts of group 4 (c) with a maximum of 44.8 ppm (Table 8). Ammonia-N was only found in soil depth of 0-30 cm. There was no ammonia-N found in the control area.

Table 7: Nitrate-N concentration [ppm] in the soil during outdoor pig production in dependence of location of moved installation units at start and end of the fattening period

Area	Time	Depth [cm]			
		0-30	30-60	60-90	0-60
Paddock 4 (a)	start 1	2.0	1.4	-/-	3.4
	start 2	2.9	1.6	-/-	4.5
	start 3	2.5	2.6	-/-	5.2
	betw. 1	11.0	7.6	-/-	18.6
	betw. 2	2.7	1.9	-/-	4.6
	end 1	18.3	7.3	-/-	25.7
	end 2	6.0	1.2	-/-	7.1
	end 3	4.9	1.5	-/-	6.4
Paddock 4 (c)	start 1	1.7	1.4	-/-	3.1
	start 2	2.2	1.1	-/-	3.2
	start 3	2.2	0.7	-/-	2.8
	betw. 1	6.4	3.8	-/-	10.2
	betw. 2	1.9	0.8	-/-	2.7
	end 1	20.2	3.7	-/-	23.9
	end 2	11.4	4.0	-/-	15.4
	end 3	2.8	1.0	-/-	3.8
Trough 4 (a)	start 1	1.8	1.2	-/-	3.0
	start 2	7.8	2.2	-/-	10.0
	end 1	10.7	2.5	-/-	13.1
	end 2	9.9	3.6	-/-	13.4
	end 3	11.4	2.9	-/-	14.3
Trough 4 (c)	start 1	1.8	1.0	-/-	2.7
	start 2	7.5	1.6	-/-	9.1
	end 1	8.2	3.3	-/-	11.5
	end 2	5.7	2.9	-/-	8.6
	end 3	10.6	2.2	-/-	12.8
Hut 4 (c)	start 1	2.8	0.9	-/-	3.7
	start 2	5.0	3.1	-/-	8.1
	end 1	11.2	1.9	-/-	13.1
	end 2	16.0	1.3	-/-	17.3
	end 3	6.5	1.9	-/-	8.4
Hut 4 (c)	start 1	1.4	0.8	-/-	2.2
	start 2	4.4	1.3	-/-	5.6
	end 1	29.5	2.0	-/-	31.5
	end 2	5.7	1.4	-/-	7.1
	end 3	5.7	0.5	-/-	6.2

Table 8: Ammonia-N concentration [ppm] in the soil during outdoor pig production in relation to the location of moved installation units at end of the fattening period

Area	Time	Depth [cm]	
		0-30	30-60
Control 4(a) (c)	end 2	0.0	0.0
Control 4(a) (c)	end 3	0.0	0.0
Paddock 4(a)	end 2	11.5	0.0
Paddock 4(a)	end 3	2.7	0.0
Paddock 4(c)	end 2	6.2	0.0
Paddock 4(c)	end 3	4.3	0.0
Hut 4(a)	end	8.8	0.0
Hut 4(b)	end	44.8	0.0
Sun shelter 4(a)	end	9.1	0.0
Sun shelter 4(b)	end	8.1	0.0
Muddy pool 4(a)	end	12.0	0.0
Muddy pool 4(b)	end	6.1	0.0

Phosphorus and potassium

To demonstrate the distribution of plant available phosphorus and potassium of the top soil (0-30cm) under optimised management, results of treatment 4(a+c) are shown in Table 9 as an example.

The available phosphorus content did not change in the control areas, paddocks or at the installation units during fattening period. Muddy pools were only sampled at the end of the fattening period. When ever installation units were moved, no increase of available phosphorus contents were measured in the top soil directly located to rest areas of the pigs or to troughs (Table 9).

During the fattening period the available potassium content increased on the paddocks, at the troughs and in front of the huts. At the muddy pools the potassium concentration was higher at the end of fattening period than at the control areas, where the potassium contents did not change during fattening period (Table 9). The areas around the sun shelters did not show increased potassium concentrations compared to the control areas.

Table 9: Plant available phosphorus and potassium concentration [ppm] in the top soils (0-30 cm) of outdoor pig production in relation to the location of moved installation units at start and end of the fattening period

Area	Time	Phosphorus [ppm]	Potassium [ppm]
Control 4(a)	start	72.4	133.9
Control 4(a)	end	71.7	139.4
Control 4(c)	start	69.1	137.5
Control 4(c)	end	71.7	139.4
Paddock 4(a)	start	64.4	131.5
Paddock 4(a)	end	64.3	157.6
Paddock 4(c)	start	62.7	140.9
Paddock 4(c)	end	64.4	154.1
Sun shelter 4(a)	start	60.8	-/-
Sun shelter 4(a)	end	63.0	134.0
Sun shelter 4(c)	start	68.8	-/-
Sun shelter 4(c)	end	63.0	148.1
Trough 4(a)	start	75.5	128.8
Trough 4(a)	end	69.4	161.3
Trough 4(c)	start	75.7	134.6
Trough 4(c)	end	82.1	183.3
Muddy pool 4(a)	end	65.2	150.5
Muddy pool 4(c)	end	66.4	160.0
Hut 4(a)	start	62.6	112.1
Hut 4(a)	end	66.8	152.3
Hut 4(c)	start	70.7	143.7
Hut 4(c)	end	66.6	184.6

Soil pH

Soil pH was measured in the top soils of the paddocks with static installation units. Examinations were focussed on areas of high inputs of urea, such as in front of huts and in areas with a potential of concentrate losses around troughs. As an example for all treatment with static installation units, Table 10 shows the results of treatment 3(a+b). In the control areas and at the paddocks no changes of the pH of the soil were determined. Slightly increases of 0.2 pH occurred around troughs and high increases of 0.65 pH were detected in front of the huts.

Discussion and conclusion

To reduce nutrient losses of nitrogen and phosphorus is one of the main goals in outdoor pig production in order to stay below the organic farming regulations and to stay below critical nutrient contents in order to exclude negative ecological impacts. Therefore concentrate diets should exceed the normal range. There is no need of increasing concentrate diet of 10 % to 20 % to periods of frost due to higher needs of energy. Available field fodder should be taken into account, so that the concentrate diet can be reduced up to 80 %. Stern & Andresen (2003) reported that feed intake of field fodder increased of 5 %, when concentrate diet was reduced by 20 %. The nitrogen and phosphorus balance of all fattening periods of this project (Table 4) showed, that ratios >100 % of the recommended diet exceeded the nitrogen and phosphorus input to the area tremendously. Very high nitrogen inputs of more than 200 kg ha^{-1} was caused by: i) high ratio of concentrate (110 %); ii) higher nitrogen content of concentrate compared to later finishing fattening groups; iii) small sized concentrate pellets, which led to higher concentrate losses.

Table 10: Soil pH in the top soils (0-30 cm) of outdoor pig production in relation to the location of static installation units at the start and end of the fattening period

Area	Soil pH	
	start	end
Control 3(a)	7.01	7.10
Control 3(b)	7.01	6.99
Paddock 3(a)	6.98	7.02
Paddock 3(b)	6.90	6.91
Trough 3(a)	-/-	7.23
Trough 3(b)	-/-	7.20
Hut 3(a)	-/-	7.68
Hut 3(b)	-/-	7.64

Observations of feed intake showed that smaller sized pellets easy sticked to the muddy feet and snout of the pigs. Pellets were carried out of the trough onto the soil. Bigger sized pellets led to decreased fodder losses in later phases of the project.

Fodder losses should be reduced to a minimum, for economical and ecological reasons. This can be realized by bigger sized pellets and by using feeding troughs in which concentrate stays dry and pigs can not step into to waste fodder. Fodder loss also leads to a high local input of nitrogen and phosphorus which was described by Daub & Ross (1996). The authors mentioned fodder losses as one reason for highly inhomogeneous distribution of nutrients on paddocks of outdoor pig farming.

Beside fodder losses the main cause for nitrogen and phosphorus concentrations in soils is due to pig's behaviour. Pigs keep their rest areas dry and clean from urine and excrements They depose urine mainly in the closer area of their rest areas (Ingold & Kunz, 1997). Deposition of excrements depends to a highly degree to the stay of the pigs (Lehmann & Seliger, 1995). Ingold & Kunz (1997) examined stay periods of pigs when kept outdoor. Brandt et al. (1995a), Lehmann & Seliger (1995) correlated this information to nitrogen and phosphorus distribution of the soil. The conclusion of all these studies is the positive correlation of the amount of nutrient input with the time of stay (except rest areas).

The ecological relevance of the nitrogen sources, the nitrogen forms (organic bound, nitrate and ammonia) and their distribution is quite different for specific management systems of outdoor pig production. Urine is concentrated in front of the huts and other rest areas in relation to the behaviour of pigs. Urea is transformed into ammonia and nitrate due to temperature and oxygen supply and therefore highly plant available. The risk of leaching depends on soils characteristics, climate and following crops. Nitrate leaching is high on coarse and shallow soils and with high rates of precipitation in winter time. In case of lack of oxygen, denitrification occurs. Due to increasing soil pH volatilisation occurs.

Faeces contain mainly organically bound, inorganic nitrogen. They are distributed on the paddock in relation to the frequency and the length of stay of the pigs. When providing paddocks in weekly intervals as strip grazing the attraction of the paddock is much higher and pigs are stimulated to distribute their faeces on the supplied area. This source of nitrogen is mineralised slowly and will be used by following crops. The risk for leaching is low.

Nitrogen input by losses of concentrate is located closely to the feeding troughs. Nitrogen is organically bound in the concentrate. There is a high risk of denitrification when troughs are not moved and the soil is compacted around the troughs.

In areas where pigs are rooting, mineralization of humus increases. These areas are small sized and irregular distributed on the field. The location of these spots is related to pig behaviour and depends on soil conditions, field forage (potatoes, Jerusalem artichokes) appearance of nests of mice and along fences. Depending on soil condition, crop rotation and climate the risk of nitrate leaching is moderate.

In field forage, like ryegrass, under seeds or turnips, nitrogen is organically bounded and is equally distributed on the paddock due to the homogeneity of the plant density. Spatial mineralization of the field forage on the field is different due to rooting, feeding by pigs (transformation of nitrogen) or soil tillage after pig fattening. As far as a positive nutrient input occurs by the concentrate diet, there will be no export of nutrients from the field forage. When concentration diets are reduced to a negative nutrient input by the concentrate ratios (extensive pig farming) the export of nitrogen from the field forage must be calculated for the following crops.

The potential of nitrogen leaching is one of the main arguments against outdoor pig production. Especially in water catchments areas this production form is criticised. However, the potential is primary due to the management of outdoor pig production. Nitrogen leaching risk is high as well in highly intensive farming systems (Williams et al., 2000), when stocking rates are too high as in production systems with intensive nutrient concentrations. Stauffer et al. (1999) found the leaching potential 20 times higher in front of the huts, than in the main pasture area.

Conclusion of this study highlights the fact provide potential to reduce the risk of nitrogen leaching drastically. Necessary for limiting the input of nutrients are i) adaptation of nitrogen content of the concentrate to the physiological age of the pigs, ii) limiting the amount of concentrate, iii) providing field fodder to reduce the ratio of concentrate, iv) avoiding fodder loss and v) taking nutrients out of the soil by integrating outdoor pig production into the crop rotation. Necessary for optimizing the distribution of nutrients are i) moving installation units in short intervals and ii) providing paddocks in weekly intervals as rationed grazing. Variable sizes for management are i) stocking rate and ii) length of stay. With these, the farmer has to adapt the nutrient input to the specific risk of leaching of nitrate and other nutrients to his soils and climate (Eriksen & Kristensen, 2001, Larsen & Kongstedt, 2001).

The soils and the general conditions of climate at the research farm in Frankenhausen lead to a low risk of nitrate leaching. Under these conditions it is possible to realise a well tolerable level of environmental impact with the maximum stocking rate of 10 pigs ha^{-1} a^{-1}.

The physical impact and its ecological effect to soils depends on soil texture, climate (like actual water content of the soil and frost periods), vegetation and pre compaction (Brandt et al., 1995b). This should be evaluated for each situation separately. Nevertheless, it is very important to give time to the soil to recover and meliorate. Durst & Willeke (1994) and Zihlmann & Weisskopf (1997) preferred sandy soils for outdoor pig farming to avoid damages to soil structure. This recommendation includes a high risk of nitrate leaching due to small available field capacity and demands an accurate calculation of nutrient input and their downward displacement.

Sizes of the areas in front of huts or around others installation units were calculated in GIS as: huts 15.3 m^2, feeding troughs 25.7 m^2, watering troughs 12.7 m^2 sun shelters 52.7 m^2 and muddy pools 3.1 m^2. Sizes of total paddocks were due to the length of the period of fattening (2.74 m^2 per pig and day) e.g. the size for a group of 20 fattening pigs for a fattening period of 9 weeks was calculated with 3452 m^2.

An example how pig production can be integrated into crop rotation in organic farming gives Fig. 3.

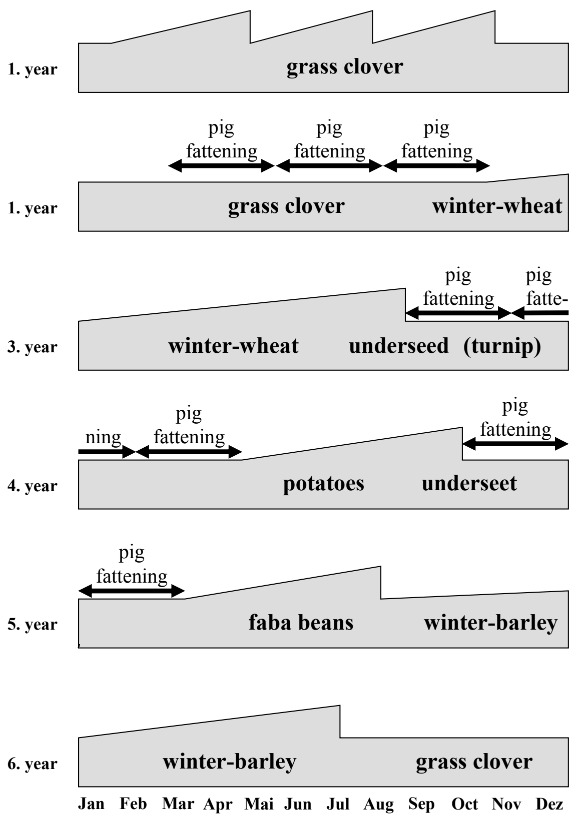

Figure 3: Possibilities for the integration of outdoor pig production into the crop rotation of an organic farm

When integrating outdoor pig production into the crop rotation, following aspect have to be taken into account: i) economically competition of outdoor pig production to other cash crops, ii) reducing nitrate leaching by following crops, and iii) conservation of soil structure by keeping pigs on growing cultures.

In autumn pigs can be kept after winter-wheat or after potatoes. Under seeds to winter-wheat has the advantage of higher attractiveness for the pigs, better distribution of nutrients, catching of nitrogen by the plants, soil protection towards compaction. Turnips can reduce fodder costs and, when pigs are kept after potatoes, it reduces growing potatoes in following crops and late blight infection. The pigs can be fattened until seeding or planting the following cash crops in spring time. Soil tillage should be adapted to soil and climatic condition to avoid mineralization.

During the main vegetation period the economically competition of pig production to cash crops is high. At this time the pigs can be fattened on paddocks with grass clover in the second year. The grass can either be harvested before installing the paddocks or it can applied to the pigs as fodder. The vegetation should not be destroyed by the pigs in order to catch nitrogen. Stocking rates and time of stay should therefore be adapted to the specific situation.

Summary

Within an interdisciplinary approach 24 groups of 20 pigs each were fattened outdoor to examine and calculate the nutrient inputs and their distribution in soils in relation to several management strategies. Management strategies varied in diets, field crops to pigs, static or moved installation units like huts, troughs, and sun shelters. Stocking rates were adapted to the regulations of the organic farming associations Bioland which limit the nutrient input to a maximum nitrogen load of 112 kg ha^{-1} a^{-1} respectively 10 fattening pig ha^{1} a^{-1}. The results were discussed with regard to the nutrient accumulation in soils and leaching of nitrate into groundwater. Recommendations in relation to management strategies and integration of outdoor pig fattening within crop rotation of an organic farming system were formulated. Nutrient accumulation and leaching can be kept on a well tolerated level by adapting nutrient inputs and optimising their distribution. Therefore the amount of concentrate has to be limited. Fodder loss should to be avoided and available field fodder has to be considered to the ratio of concentrate. The main conclusion of this approach: The results indicate that it is possible to integrate pig production within the crop rotation without the risk of high nutrient losses by moving huts and troughs in short intervals and rationed paddocks in weekly intervals which markedly homogenised the distribution of nutrients.

Acknowledgment

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Outdoor pig farming in the Netherlands

H. van der Mheen[1] and H. Vermeer[1]

Introduction

Pig farms in the Netherlands are generally large with respect to the number of animals kept at one farm, but small in terms of surface area. Most pig farms are specialized farms where pigs are kept in intensive systems. These farms have limited land available.

Outdoor farming of pigs is not common, and basically only organic producers and the so called "scharrel" producers allow their animals access to outdoor areas. Within these productions systems lactating sows, weaners and fattening pigs only have access to outdoor areas with concrete flooring. Only pregnant sows have access to pastures. The access to pasture is not defined in terms of minimum surface areas, duration of access nor frequency of access.

In order to get more insight in how farmers comply with the requirement of providing pregnant sows with access to pasture, we conducted surveys with questionnaires.

Survey results

We completed questionnaires at 26 organic and "scharrel" farms. Of these farms 13 farmers provided their sows with access to pastures. These 13 farms kept between 25 en 125 sows. Only during the gestation period the sows were allowed access to pastures. The surface area of the pastures varied between 480 m^2 and 3 hectares. The surface area per sow varied considerably between farms (Table 1).

Access to pastures

When sows have access to pastures the entrance to the indoor area is never closed. This means that the sows didn't spend all their time at pasture. Although access seemed in most cases unlimited, several farmers mentioned to take the weather conditions into account. On rainy days sows were not always allowed outside, other farmers also took the condition of the fields into consideration (Table 2).

Maintaining a good grass cover

Four farmers did not aim for a good grass cover, and considered it impossible. The other farmers wanted to maintain a grass cover but some argued that this was not possible (Table 3).

Eight farmers strived to maintain a good grass cover and used extra measures in order to achieve it. These measures varied and consisted of; providing the sows with of a swimming pool, keep rooting sows inside (often the younger sows), provide them with a rooting area, or regular change of fields.

Research items

Intensive use of pastures by sows may have a negative influence on the environment. By faeces and urine sows deposit minerals, which may exceed the capacity of the fields. Especially in the absence of a crop the mineral load quickly exceeds the requirements, resulting in leaching of minerals.

For that reason we designed two studies to analyze the effects of measures to minimize the risk of mineral leaching. The first trial studied the effect of a special rooting area to prevent pasture damage by rooting sows. The second trial studied the effect of an enriched indoor area on the time the sows spend at pasture and on the pasture damage.

Trial 1 – Provision of a special rooting area to prevent pasture damage

To assess the effects of a special rooting area on pasture damage by pregnant sows, 4 groups of 4 sows were subjected to 4 x 4 Latin square design experiment with one replication. Each group was given access to a 160 m^2 field for 4 hours per day, over a period of 5 consecutive days. Treatments consisted of different 4 m^2 rooting areas per field containing either ploughed dry sand (DrA), ploughed wet sand (WtA), dry sand with 400 g wheat and barley seeds (SeA) or no rooting area (NoA). Following each period new fields were fenced and groups were allocated to a new treatment. Pig behaviour was recorded at 5 minutes intervals, temperature was recorded daily and pasture damage was assessed following each 5 day period.

During the first 15 minutes on pasture sows spent 70% of their time grazing, this was gradually reduced to 20% during the last hour. Increasing temperature resulted in less grazing and more lying and rooting behaviour. Approximately 23% of total time was spent in the rooting area (if present), with no difference between treatments. Of all lying behaviour, 40% was performed in a rooting area. For WtA the use of rooting area was positively correlated with temperature ($P<0.05$). This relationship was not observed in other treatments.

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Table 1: Characteristics of pasture areas for sows

Farm	1	2	3	4	5	6	7	8	9	10	11	12	13
Soil type	peat	clay	sand	loam/ sand	clay	sand/ clay	sand	sand	clay	clay / peat	clay/ sand	sand	clay
type uitloop	grass	grass	grass	agric.	grass	Barren soil	Barren soil	grass	grass	Barren soil	grass	grass	grass
Surface area (m^2)	5000	15000	30000	15000	2000	3000	480	4000	18000	625	4500	2000	15000
Number of sows	96	90	150	225	55	45	48	20	40	20	85	75	50
m^2/sow	52	167	200	67	36	67	10	200	450	31	53	27	300

Table 2: Access to pastures and intention of use

Farm	1	2	3	4	5	6	7	8	9	10	11	12	13
Free access	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	some-times	Yes
From (month)	4	5	1	7	4	1	1	1	1	5	1	1	1
To (month inclusive)	9	10	12	2	8	12	12	12	12	10	12	12	12
Access during day	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	varying	Yes	Yes	Yes	Yes
Access during night	Yes	Yes	Yes*	Yes	Yes	Yes	Yes			Yes	Yes	Yes	Yes
Access days per year	180	210	365	240		365	365	330	365	180	365	365	365
Days really outside	180	210	270	180	180	360	?	330		180	365	365	365
Average number of hours/day outside	5	4	3	1	3	3	3	vary-ing	2	?	6	3-5	7

* in summer

Table 3: Measures to maintain a grass cover

Farm	1	2	3	4	5	6	7	8	9	10	11	12	13
Aim at a good grass cover	Yes	Yes	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	Yes
Possible to maintain grass cover	No	Yes	Yes	No	Yes	No		No		No	No	Yes	Yes
Part destroyed (%)	25-60	<10%	<10%		10-25	60-100		60-100	<10		25-60	60-100	25-60
Take into consideration													
Humidity of terrain	Yes	Yes			Yes			Yes	Yes	Yes		Yes	Yes
rain					Yes			Yes				Yes	
temperature												Yes	
frost													Yes
extra measures to maintain grass cover	Yes	Yes	Yes		Yes	No		Yes	Yes		No	Yes	Yes

Pasture damage was significantly influenced by treatment (15.3^a, 14.4^a, 6.8^b and 4.7^b m^2 for NoA, SeA, DrA and WeA respectively; different superscripts indicate significant differences P<0.05) It appeared that pasture rooting was used to create lying areas. SeA sows used the rooting area to find food, forcing pen mates to lie outside the rooting area. This may have resulted in a higher level of pasture damage for SeA compared to DrA and WtA.

Trial 2 – Effects of environmental enrichment and limiting access to pasture

Nose-ringing in pigs inhibits a range of functional activities, suggesting a degree of reduced welfare. Without nose-rings sows damage much of the pasture, with consequently increased nitrogen leaching. This study aims at reducing rooting damage by restricting daily access to pasture or by providing additional environmental enrichment. In a 2x2 factorial study four groups of 5 sows were offered access to pasture either restricted during 2 hours in the morning (R) or unlimited over 24 hours per day (U). In addition, the 60 m^2 concrete floor outside the pig house was either enriched with a rooting area and additional silage (E), or left barren (B). The study was replicated twice, and each replicate lasted 3 weeks. The effects of the treatments and their interaction were analysed with Anova. The total time at pasture was not affected by access time (7.3 and 9.6% for R and U). Access time did effect time at pasture during the two morning hours (48.7 and 17.9% for R and U, respectively; $P<0.05$). Environmental enrichment on the concrete floor tended to reduce time at pasture during the two morning hours (27.7 and 38.9% for E and B respectively; $P<0.10$). Mineral nitrogen content of the soil was not affected by treatments. Rooting damage was limited during the study, but there was a tendency that limiting access resulted in more rooting damage over the 3 week period (1.03 and 0.23 m^2 for R and U, respectively; $P=0.09$). We conclude that access to pastures fills a need for pregnant sows, as sows compensate for limited access by more intensive use. Pasture damage is not reduced by limiting access, but may be reduced by offering additional environmental enrichment.

Conclusions

We demonstrated ways of reducing pasture damage by rooting sows. A special area accommodated for much of the comfort rooting behavior of the sows and consequently reduced the damage. Enrichment of the indoors area reduced the time sows spend at pastures. Both measures may reduced the leaching of minerals. However the mineral loads at some farms were expected to be very high, due to small pastures and consequently high densities and no rotation of pastures. Under these circumstances the studies measures would not reduce the leaching of minerals to acceptable levels. Other measures will thus be needed.

Documentation of animal health in organic pig herds: A case study

M. Bonde[1], N. P. Baadsgaard[1] and J. T. Sørensen[1]

Introduction

Organic pig production is a small-scale production compared to organic milk production. Knowledge on animal health and welfare in existing systems is scarce. Due to high production costs the economic viability of organic pig production is depending to a high degree on the consumers willingness to pay premium prices compared to conventionally produced pork. Furthermore, good animal health is a prerequisite for a satisfactory economy in organic pig production.

Organic pig production differs from the conventional production in e.g. feeding, access to outdoor areas, weaning age and use of preventive medication. The animals benefit from a low animal density, and good possibilities for expressing normal behaviour such as locomotion, foraging, exploration and nest building. Therefore it is likely that the occurrence of health and welfare problems may be different in organic herds compared to conventional production systems.

Endoparasites must be considered one of the major constrains for welfare as well as economy in organic swine production (Nansen & Roepstorff, 1999). Two Danish survey studies have both shown high prevalences of helminth infestations in organic outdoor pig production (Roepstorff et al., 1992; Carstensen et al., 2002). Also Leeb and Baumgartner (2000) reported that endo- and ectoparasites was the main problem, while Vermeer et al. (2000) found that endoparasites as well as post weaning problems were health problems of main concern.

In a case study on four organic farms, Vaarst et al. (2000) concluded that lameness was a common clinical finding in sows, and respiratory diseases and parasites were problems in some fattening pig herds. Hansson et al. (1999) found significantly less chronic pleuritis and more leg problems in organic pigs than in non-organic pigs.

Roderick and Hovi (1999) found a low level of diseases in organic pig production in a postal questionnaire. Parasites were seen as the biggest problem, whereas diarrhoea and respiratory diseases were seen as minor problems.

Health and welfare problems in organic sow herds also have been the focus of a questionnaire study by Bonde & Sørensen (2003). Veterinarians and production advisers with experience in organic pig production reported that poor body condition and reproduction problems were frequently occurring in the sows. Crushing or trauma inflicted by the dam often caused injuries to suckling piglets, whereas insufficient supervision, care and disease treatment, disturbances and trauma from predators, and unsuccessful nursing were perceived as other causes of welfare problems. Diarrhoea was perceived as a major health problem in weaned pigs.

According to Baadsgaard (2001), it is necessary to use several information sources to get an overall picture of the health status in a pig herd. A description of the health state should contain information on clinical health, mortality, pathological findings at slaughter and medicine usage in the herd.

Clinical examinations cannot reveal all diseases in pigs. The examination provides an instantaneous assessment of any acute and chronic clinical disorders present in the herd. Additionally, the extent of disease and the effect on the general condition may be assessed through a clinical examination. However, pigs may have substantial pathological lesions in joints or lung tissue not visible clinically. Therefore, the clinical examination has to be combined with data from the pathological examination at slaughter.

The meat control data may be biased by large variation in recording intensity between different abattoirs (Willeberg et al, 1997). The abattoir records acute and chronic lesions present at the time of slaughter as a matter of standard procedure, whereas healed lesions from earlier infections wont be recorded. Furthermore, the clinical effect of the pathological lesions is not recognised. The extent of pathological lesions at time of slaughter depends on the course of the disease in the individual animal. Time of disease onset and changes in disease character from acute to chronic or healing processes have great influence on the findings at the abattoir.

Mortality data are relevant to include in an assessment of herd health state. Some diseases manifest themselves as sudden deaths without former clinical symptoms, and their prevalence cannot be assessed based on clinical examination or medicine usage. Euthanasia of chronically disabled animals depend of management in the individual herd, thus the mortality has to be related to the prevalence of animals with chronic diseases within the herd.

The on-farm medicine usage per se is not a valid measure for the herd health state as the threshold for medical therapy varies between herds (Baadsgaard, 2004). However, it provides valuable information on the health state if combined with systematic clinical examinations in the herd. A good health state would

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generally be characterized by a low prevalence of clinical or pathological symptoms and a modest medicine usage in the herd.

An analysis of the health state in organic pig production is needed. The purpose of this paper is to carry out a preliminary description of the health state in organic fattening pigs based on four cases. This preliminary investigation will be followed up by a comparative study of animal health in organic and conventional herds of fattening pigs.

Materials and methods

Data were collected in four organic pig herds, which are described with regard to herd size, production system and health management in Table 1.

The four herds were visited three times in July, October and December 2003. During these visits systematic clinical examinations of all weaned pigs present in the herds were carried out. The clinical protocol included body condition of the pig, skin lesions, lameness, CNS symptoms, gastro-intestinal as well as respiratory problems. All pigs were examined visually in the pens and clinical symptoms were recorded at pig level. The total number of pigs in the groups from weaning until 30 kg live weight and heavier than 30 kg was recorded, respectively. The herd prevalence of clinical disease has been calculated based on this.

The use of medicine in the herds has been estimated from data reported to the Danish central database Vetstat by veterinarians and pharmacies. The study focused on the amount of antibiotics and chemotherapeutics prescribed to the herds in 2003, while other drugs such as vaccines or anthelmintics were excluded from this analysis. The corresponding number of therapeutic doses has been calculated, i.e. the kg of pig that could be treated with the amount of medicine prescribed when following the standard dosage recommended by Vetstat. The medicine usage is subsequently related to the herd size, which have been estimated as the average number of weaned pigs (until 30 kg) and fattening pigs (heavier than 30 kg) present in each of the four herds at the three visits.

Pathological findings on slaughtered animals have been assessed through the abattoir statements to the four farmers including all fattening pigs supplied to the abattoir in the period February 12th – December 31st 2003 for herd 1 (731 pigs), July 4th – December 31st for herd 2 (1500 pigs) and January 1st – December 31st for herd 3 (1289 pigs) and herd 4 (785 pigs), respectively.

Herd 1, 2 and 3 have recorded the number of dead and euthanised pigs in a 19-week period in August to December 2003. The farmers were asked to categorise the dead pigs into three weight groups:

1. Weaning - 30 kg
2. 30-50 kg
3. Heavier than 50 kg

Table 1: System description for the 4 case herds

Item	Herd 1	Herd 2	Herd 3	Herd 4
Herd size	80 sows reduced to 60 sows in the period	200 sows	80 sows	110 sows
Produced slaughter pigs per year	800 pigs	3500 pigs	1450 pigs	1300 pigs
Declared health state	Mycopl+	PRRS+ Mycopl+, AP+	Mycopl+ AP 2+6	Not declared
Vaccination after weaning	No	Mycopl and AP at wean. + 3 weeks after wean	No	Mycopl at wean. Coli-serum at weaning
Production system weaned pigs	Deep litter pens (25 pigs) with outdoor run	Deep litter pens (50 pigs) with partly covered outdoor run	Pens with deep litter and slatted floor (80-90 pigs)	Pasture with huts (100 pigs)

In herd 4 the number of dead pigs (heavier than 30 kg) has been estimated through the bills received from the incinerating plant for collecting individual carcasses on-farm in a 22-week period August – December 2003. It was not possible to estimate the number of dead pigs lighter than 30 kg in this herd.

The mortality of weaned pigs (until 30 kg) and fattening pigs (heavier than 30 kg) was calculated as the number of dead pigs in the weight group related to the number of produced pigs in the period:

- Mortality < 30 kg: Dead animals lighter than 30 kg / (30 kg pigs sold (herd 1) + dead pigs heavier than 30 kg + slaughtered pigs)
- Mortality > 30 kg: Dead animals heavier than 30 kg / slaughtered pigs

Results

The total number of pigs examined clinically during three visits per herd was 584, 3016, 1516 and 1416 pigs in herd 1-4, respectively.

The examination showed that 8-18 % of the pigs in the four herds were displaying clinical symptoms as illustrated in Figure 1. 2-6 % of the pigs had more serious clinical symptoms defined as poor body condition and/or affected general condition combined with other clinical symptoms or the presence of extensive clinical symptoms even if not (yet) affecting the condition of the animal. The serious clinical symptoms normally should elicit some sort of action from the farmer such as medical intervention, isolation of the pig or euthanasia owing to incurable disease.

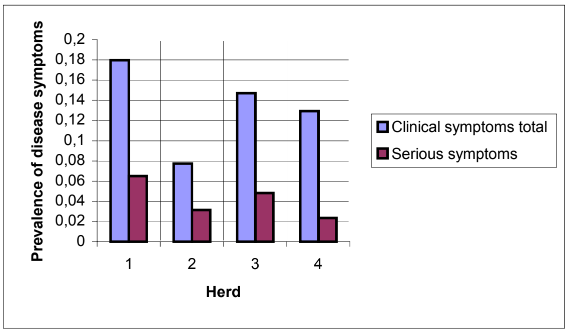

Fig. 1: Disease prevalence based on pooled results from 3 visits in 4 organic pig herds with clinical examination of pigs. The total prevalence of all clinical symptoms as well as serious symptoms is presented.

The prevalence of clinical findings classified according to main symptom is illustrated in Figure 2. The symptoms include poor body condition (thin pigs), affected general condition (depressed), skin lesions, lameness, diarrhoea and respiratory symptoms such as sneezing, coughing or dyspnoea. None of the disease symptoms occurred in more than 10 % of the pigs but the variation between herds was pronounced. The total disease prevalence was higher in herd 1, especially as regards thin or depressed pigs or pigs with diarrhoea. Skin lesions were more common in herd 3, caused by problems with ear lesions in one of the visits, while symptoms of lameness and respiratory symptoms occurred in all herds.

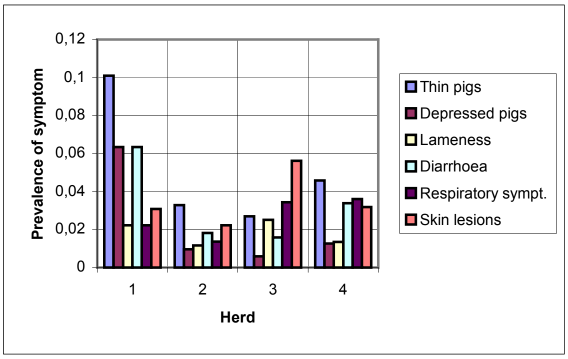

Fig. 2: Clinical symptoms based on pooled results from 3 visits in 4 organic pig herds with clinical examination of pigs. The symptoms are classified into poor body condition (thin pigs), affected general condition (depressed), lameness, diarrhoea, respiratory symptoms and skin lesions.

The prevalence of disease symptoms for each visit is illustrated in Figure 3 for weaned pigs (<30 kg) and fattening pigs (>30 kg), respectively. The variation in disease prevalence between visits was pronounced, especially for weaned pigs in herd 1 and 3. Generally, the disease prevalence was higher for weaned pigs than for fattening pigs. It should be noted that only one weaned pig (< 30 kg) was present in herd 1 at the visit in October.

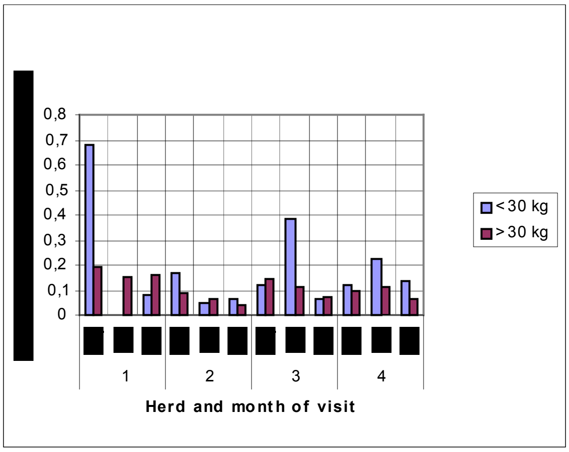

Fig. 3: The total prevalence of clinical symptoms at 3 visits in 4 organic pig herds, grouped for weaned pigs (< 30 kg) and fattening pigs (> 30 kg), respectively.

The ordination of antibiotics and chemotherapeutics in 2003 ranged from 5,000 therapeutic doses (medicine for treatment of 1 kg pig) in herd 4 to 150,000 doses in herd 2. The medicine usage in relation to herd size is illustrated in Figure 4. Herd 4 used a very small amount of medicine, predominantly to sows and suckling piglets. Herd 1, 2 and 3 treated 0,7- 0,9 kg fattening pig per pig in the herd per day. Additionally, herd 1 treated 0,8 kg weaned pig per pig in the herd per day.

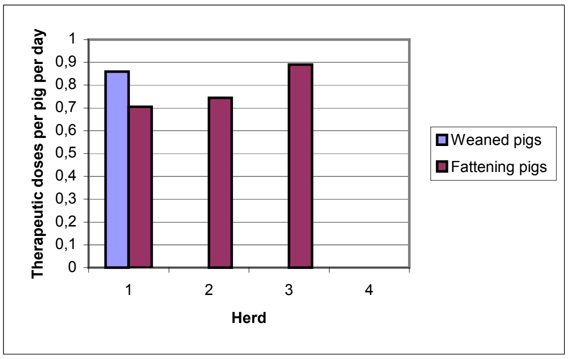

Fig. 4: Therapeutic doses of antibiotics and chemotherapeutics prescribed per pig per day in 4 organic pig herds in 2003. The medicine usage is grouped into weaned pigs and fattening pigs. Therapeutic doses correspond to kg animal treated with the standard dosage of the drug. The number of pigs is estimated as average herd size for 3 visits in each herd.

Pathological lesions at time of slaughter were observed in 10 – 17 % of the pigs slaughtered in 2003 from the four herds as illustrated in Figure 5. Skin lesions such as hernia, scars, abscesses, eczema, old fractures and tail wounds were the most frequent pathological diagnoses occurring in 4 – 8 % of the animals, liver spots were recorded in 3 – 8 % of the pigs while chronic arthritis was observed in less than 1 % of the pigs. Respiratory diseases, either chronic pneumonia or chronic pericarditis were recorded in 2 - 8 % of the pigs. Herd 2 showed more pigs with chronic pneumonia than the other herds (4 % of the pigs compared to less than 1,5 %). No pigs from any of the four herds got a remark for chronic pleuritis.

A specification of the observed skin lesions shown in Figure 6 emphasizes that abscesses were the main skin disorders encountered at slaughter, ranging from 1,4 % of the pigs in herd 4 to 4,3 % in herd 2. The primary locations of abscesses were neck and chest (35 % of the abscesses) and hindquarters (32 % of the abscesses). Old fractures were observed in 0,8 % of the pigs in all four herds, while tail wounds appeared in 0,1- 0,5 % of the animals.

The mortality of weaned and fattening pigs in the four herds is illustrated in Figure 7, showing variation in the mortality between herds. Herd 1 experienced a high mortality in fattening pigs, while herd 3 lost most pigs at an early stage after weaning. Herd 4 did not record the mortality among weaned piglets. The mortality of fattening pigs in herd 4 was low compared to the other herds, but the difference in recording method may lead to an underestimation of mortality in herd 4. A certain caution must therefore be exercised when comparing the mortality in herd 4 with herd 1-3.

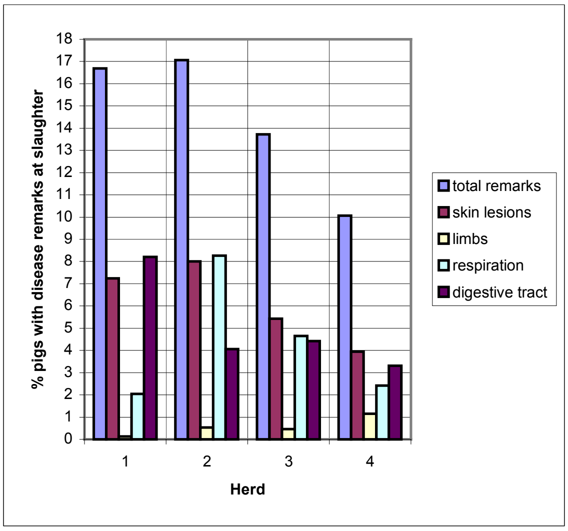

Fig. 5: Pathological findings at slaughter assessed from the abattoir statements to 4 organic pig herds in 2003. The total occurrence of remarks as well as remarks grouped into skin lesions (hernia, scars, abscesses, eczema, old fractures and tail wounds), limbs (chronic arthritis), respiration (chronic pleuritis, pericarditis and pneumonia) and digestive tract (liver spots, chronic peritonitis and enteritis).

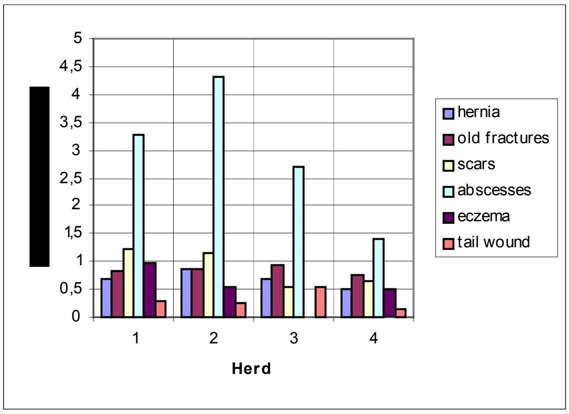

Fig. 6: Pathological findings at slaughter assessed from the abattoir statements to 4 organic pig herds in 2003, including hernia, scars, abscesses, eczema, old fractures and tail wounds.

Discussion

Due to previous studies, lameness was expected to be a problem in organic pig herds but only 1 – 2,5 % of the pigs from the four case herds were visibly lame in the clinical examination. Chronic arthritis were observed in less than 1 % of the pigs at slaughter.

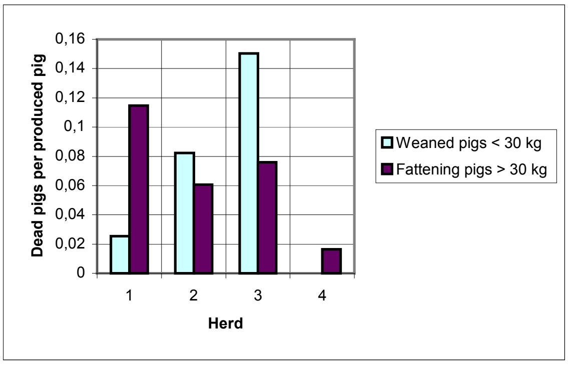

Fig. 7: Post weaning mortality in 4 organic pig herds in August - December 2003. The mortality is reported separately for weaned pigs and fattening pigs. Herd 4 used another recording strategy of dead pigs and did not record death of weaned pigs.

In 2003 an investigation of the prevalence of clinical diseases in conventional fattening pigs was carried out in 100 herds (Landsudvalget, 2003). The most frequent diagnosis was ear wounds observed in 4,26% of the pigs. Coughing was recorded in 2.14 %, and lameness in 2,05% of the pigs. Thus, the results from the four organic herds in the present study do not indicate any substantial differences in clinical health between organic and conventional pig herds.

It is remarkable that no pigs at all were diagnosed with chronic pleuritis at slaughter, whereas a number of pigs got remarks for chronic pericarditis. It is likely that some of these pigs have suffered from chronic pleuritis as well.

This study estimates the medicine usage at herd level applying one out of several possible methods. Therapeutic dose per pig in the herd per day was chosen as a parameter to relate the medicine consumption to herd size as well as observation period. Other accounts may report the number of standard pigs treated or the medicine usage per produced slaughter pig. The lack of a common calculation method makes it impossible to compare the medicine usage in the present study to current reports of the medicine usage in alternative production systems.

The importance of including several information sources in the evaluation of herd health was highlighted as an alternative to focusing solely on e.g. abattoir remarks recorded routinely at the veterinary meat control at slaughter.

For some purposes it would be informative to aggregate the information to get an overall documentation of animal health in the individual herd in a simple form. A way to do this is suggested in Table 2. This requires the definition of benchmarks for good and poor health described by the different measures such as clinical examination, medicine usage, pathological findings at slaughter and mortality, respectively. As an example the clinical health might be defined as good if the prevalence of serious clinical symptoms is below 3 % and likewise health at slaughter might be good if total remarks are less than 10 %. Further a mortality of less than 3 % might indicate good health and medicine usage below 1 kg therapeutic dose per pig per day also could indicate good health.

Table 2: Suggestion for an aggregated health status description illustrated by 4 organic pig herds. As a preliminary guideline the healthy herd is defined as having **low** prevalence of clinical symptoms (< 3%), **low** medicine usage (< 1 kg dose per pig per day), **low** number of remarks at slaughter (< 10% of the pigs) and **low** mortality (< 3%).

I t e m	Herd 1	Herd 2	Herd 3	Herd 4
Clinical symptoms	High	Low	High	Low
Medicine usage	Low	Low	Low	Low
Abattoir observations	High	High	High	Low
Mortality	High	High	High	Low
N "High"	3	2	3	0

Overall, the evaluation ranks herd 4 as having the best herd health in this investigation, followed by herd 2, herd 1 and herd 3. Herd 4 kept the fattening pigs on pasture, while herd 3 was granted an exeption from the rule requiring outdoor area for weaned pigs. Furthermore, the high group size and continuous management system may constitute possible risk factors for the health problems observed in this herd.

The clinical examination provides an instantaneous view of the herd health. However, some clinical symptoms may be difficult to notice at a visual examination of groups of pigs. Respiratory diseases are difficult to diagnose based solely on a clinical examination, and it is also difficult to estimate the exact number of pigs having diarrhoea. Compared to this poor body condition and lameness are easier to assess.

The amount of veterinary medicine used in the herd is an important part of the characterisation of herd health. The effect of veterinary treatment will be reflected in a reduced mortality, or reduced prevalence of clinical disease and remarks at slaughter. A healthy herd is characterised by simultaneously having low medicine usage, low disease prevalence and low mortality. Herds with high medicine usage and low disease prevalence and mortality are successfully controlling diseases by means of medicine. High medicine usage combined with high disease prevalence and mortality indicates no treatment effect of the medicine used to treat disease problems, and the combination of low medicine usage and high disease prevalence and mortality is characteristic of a herd experiencing health problems without even attempting to treat the problem.

Summary

In a case study four organic pig herds each fattening between 800 and 3500 pigs per year provided data from clinical examinations, pathological findings at slaughter, post weaning mortality and medicine usage in the herd.

Clinical symptoms were present in 8 – 18 % of the pigs, and 2 – 6 % of the pigs showed serious symptoms of disease. At slaughter 10 – 17 % of the pigs got remarks for pathological lesions, primarily liver spots, abscesses and chronic pericarditis. The post weaning mortality varied between herds, while the usage of medicine was rather low in the herds. The herd health status can be aggregated in many ways. A suggestion is made for the four herds. A good health status is achieved in herds combining a modest medicine usage with a low level of disease, measured by low prevalence of clinical symptoms, low number of remarks at slaughter and low mortality.

Acknowledgement

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