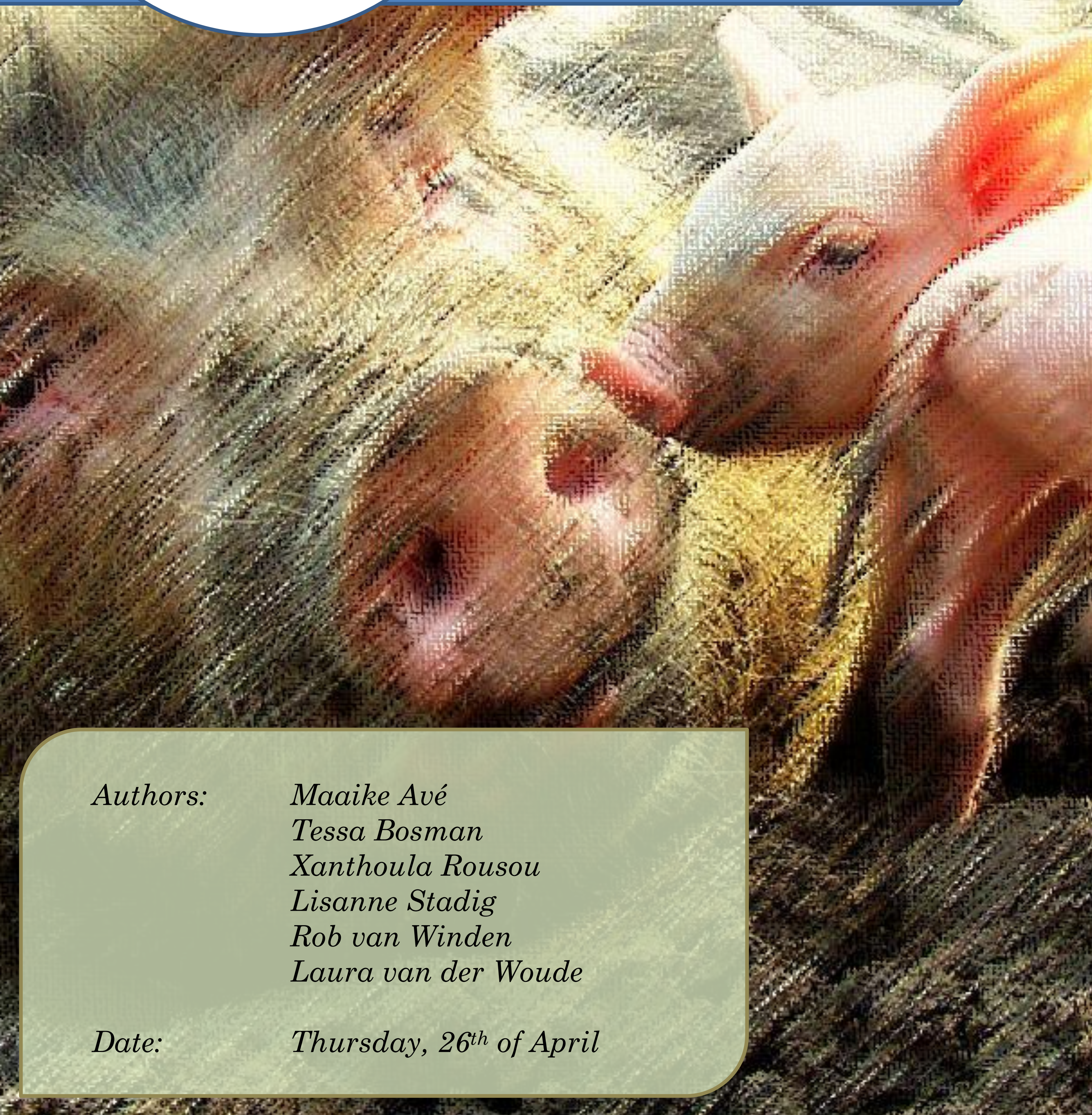
The effects of outdoor and indoor housing on pig health



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Project: How can outdoor animal husbandry contribute to quality of life? (933)

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Klarien Klingen and Anne-Marieke Smid

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Preface

This report is the result of the work of six students, who were given the opportunity by Stichting Boerengroep to work on a project about the relation between outdoor animal husbandry and the quality of life. We have chosen to focus on pigs, and to only look at health-related aspects of indoor and outdoor husbandry. There were multiple reasons for this; the duration of the project, the current pig housing system in The Netherlands, and our expertise. Due to the time constraints, we could not focus on all production animals *and* deliver a high quality product with sufficient depth. Currently, in The Netherlands, pigs are very often housed indoors and therefore it would be interesting to understand the reasons for this situation. Lastly, our own interests were mainly on animal health, more than on other sides of farming such as production and economics.

We have worked on this report and our presentations for eight weeks, and we are proud of the products that we have delivered. In order to deliver this report we have looked at the scientific side of the story, by conducting a literature review and interviewing experts, but also at the practical side by interviewing farmers. It was important to us to get insight in their opinions as well, since practice and theory can be very different. In our opinion we have delivered a clear overview of scientific and practical information, and in addition we provided recommendations on how to make outdoor pig husbandry possible.

The goal of this report is to inform and give recommendations about how to make outdoor pig husbandry feasible, in the light of pig health. It is intended for anyone with a background in animal husbandry, whether you are a professor, a farmer, or a student. It contains valuable knowledge and experiences on pig health related to outdoor husbandry.

Acknowledgments

We would like to thank all the people that cooperated to this report. First of all we want to thank the farmers; Andries van den Bogert, Peter van Leeuwen, Anita Marskamp, Henk Schellekens, Berdy Sloetjes, Erik Stegink, and Pieter Vlemminx for letting us interview them and showing us their farms. This has been very helpful in getting to know farmers' views, and getting an impression of different pig farming systems. Also we would like to thank the experts; Eddie Bokkers, Liesbeth Bolhuis, Mart de Jong, and Herman Vermeer for their interviews, as their expertise has been very useful to us. We would like to thank Eddie Bokkers in particular, since he was our content coach as well, and provided us with valuable feedback on our report during the process. Next to that, we would like to thank our process coach, Karlijn Nortier, for her guidance of our team in developing ourselves in the professional area. Finally, we would like to thank our commissioners Klarien Klingen and Anne Marieke Smid from Stichting Boerengroep, and Jaap Schouls from the Studiekring Biologische Landbouw, for this opportunity and for their support.

Summary

Due to the growing interest in both consumers and farmers in the quality of life of farm animals, there is a discussion on alternative ways of housing pigs, which promote animal welfare and health. The purpose of this study was to evaluate the effect of outdoor husbandry on pig health, compared to indoor housing. In order to do so, we conducted a literature research, interviews with experts on various scientific fields (behaviour, welfare, transmission of infectious diseases and production systems) and interviews with farmers (three organic, two free range, and two conventional).

From the literature study, where we focussed on various fields of health (digestion, respiration, locomotion, reproduction and skin) numerous differences were found in health between outdoor and indoor kept pigs. One of the main problems that was found in outdoor housing are parasitic infections: helminths and protozoa have both a higher prevalence rate outdoors, mostly caused by their survival in soil and needed intermediate hosts that live in pastures. However, most of these problems can easily be solved by an effective de-worming scheme. Pneumonia was also found to be more prevalent in organic pig farms. However, this seems to be caused more by the increase in dust in the barn through the providence of straw, than the effect of housing pigs outdoors. On the other hand, pleurisy scores lower in outdoor housed pigs because of the better air quality with less toxic gas concentrations. When looking at locomotion, soft solid floors with deep bedding have the lowest prevalence of foot and limb lesions, and osteochondrosis. Therefore, pastures and straw bedding would be beneficial for the pig. Reproductive performance has been found to be lower in outdoor housing, which is caused by a longer lactation period in organic farming as well as by seasonal infertility. This problem is perhaps the most difficult to overcome, however a possible solution is the use of a lactational estrus. There is a higher risk of an infection with toxoplamsa by contact with cats. Furthermore, tail biting and aggressive behaviour in general were less prevalent in outdoor systems because of more space and better foraging opportunities.

Some of these effects of outdoor housing are similar in pigs as in other production animals. The similarities and differences between pigs on one side, and dairy cattle and poultry on the other side, have been shortly reviewed in this report. For example, straw covered floors are also beneficial for the cow's foot health. In addition, outdoor cows and chickens have a higher likelihood of intestinal parasites. Like pigs, outdoor housed cows and pigs have seasonal influence on their reproductive performance. Also, the chicken equivalent to tail biting, feather peaking, is significantly less in outdoor farms. Even with this small sampling of data, there is an indication that outdoor farming also has health benefits for dairy cows and laying chickens.

When talking to the farmers, it showed that conventional farmers often perceive indoor housing as more healthy than outdoor housing. However, they are willing to switch to free range or organic, as long as there is enough demand for the meat, and environmental regulations are not too strict. The main reasons why free range and organic farmers chose for these housing systems were a more natural way of keeping animals, as well as the increasing demand for animal friendly meat. They did not seem to encounter major health problems on their farms, and had no problems with using only a small amount of antibiotics.

The interviewed experts named several benefits and potential problems of outdoor pig husbandry. Outdoor housing would lead to less behavioural problems such as tail biting, because there are more stimuli. Also it was said to be beneficial for respiratory problems, since the pigs have more access to fresh air, although draughts may be a problem. Pigs are well capable of attending to their own needs; reacting to changes in the weather by going indoors when it is cold, or wallow when it is warm. Parasites were perceived as difference between indoor and outdoor housing, although they can be kept under control by using anthelmintics. Another problem could be with disease transmission from farm to farm, because the pigs cannot be enclosed and isolated. The great distances between the farms however would make this less probable.

In conclusion, from literature it appears there are benefits as well as potential problems associated with the outdoor husbandry of pigs. However, there are also many ways to overcome these problems, and from this point of view it seems feasible to house the pigs outdoors. This is confirmed by the interviews with the experts; they also think it is feasible and beneficial to the animals. From the interviews with the farmers it appeared that they are often willing to house their pigs outdoors, however they have problems with an insufficient market demand and constricting environmental regulations. These issues need to be solved in order to make outdoor pig husbandry more prevalent.

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Introduction

When pig farmers shifted their animals indoors after the second world war, it was to increase production and reduce health problems, while having a low monetary input (Millet et al., 2005). However, there is a growing interest in both consumers and farmers in the quality of life of farm animals (Huik and Bock, 2007). Therefore, there is a growing interest in developing alternatives to the conventional indoor system (Millet et al., 2005). An alternative system is preferred where attention is paid to; animal welfare, good health with the emphasis on the prevention of diseases, and natural feed (Ruis, 2011). One of the current trends is the transition to outdoor pig production systems like organic and free range, which would be more adequate systems to fulfil the behavioural needs of the animal (Fraser et al., 2001).

From the 6,525 pig farms in The Netherlands (CBS, 2011), 99 are organic (Table 1) (Doorn, 2012) and six free range farms are registered (ProduCert).

Table 1: Overview of the organic pig farms in The Netherlands (Doorn, 2012).

	2000	2004	2011
No. of organic pig farms	77	119	99
No. of organic pigs	24,449	53,466	57,487
No. of pigs per farm	318	449	581
No. of finishing pigs	11,366	24,918	29,604

Organic pig meat is a growing market (Doorn, 2012). Although the number of organic pig farms decreased from 119 in 2004 to 99 in 2011, the number of organically kept pigs between 2004 and 2011 in The Netherlands has increased from 53,466 to 57,487 pigs. Besides, if the situation of 2011 is compared to 2000, where there were 77 organic pig farms and 24,449 pigs, this market has grown exceptionally. Furthermore, massive up scaling of the organic pig farms occurred where the number of pigs per farm increased from 318 in 2000 until 581 in 2011 (Doorn, 2012). The growing demand for high animal welfare products by the Dutch consumer seems to be the underlying cause, but also the lower antibiotics use in organic farming partly explains this recent growth of interest in organic products, as this lowers the development of resistant infectious agents (Bonde and Sørensen, 2004).

Outdoor housing systems, organic and free range, are developed as alternatives for the conventional farm, with the emphasis on good health and welfare of the pig. However, since pigs were bred for many years for high performance in indoor housing systems, it can be discussed if outdoor systems really improve the health of these modern pigs. Outdoors, pigs are exposed to a lot more infectious agents and extremer climates than their indoor relatives (Edwards, 2005). Can modern pigs cope with these challenges and is outdoor pig rearing an option with the production requirements, epidemiological problems and regulations of this society? In the current economic system, outdoor animal husbandry is therefore often seen as too cost inefficient and disadvantageous for animal health (Huik and Bock, 2007). In the last few years a number of studies have been performed to investigate animal health in outdoor systems and the differences compared to the indoor conventional system. However, an overview of the knowledge on this subject is lacking. Therefore, the aim of this project is to give an overview of the existing knowledge on pig health in outdoor and indoor farming.

This will be done through reviewing scientific literature and interviewing conventional, free range, and organic farmers, and different experts on this subject. This project is commissioned by Stichting Boerengroep, a non-governmental organisation who wishes to connect agricultural knowledge with the work in practise by exchanging information through symposia, workshops, and debates. Stichting Boerengroep organises a congress on outdoor animal husbandry. The results of this project will be presented at the congress and processed in a report and draft brochure to inform pig farmers of our findings.

When searching for literature, it has to be taken into account that conclusions that are derived from foreign literature can not immediately be translated to the Dutch situation. In many cases the housing systems, climate, feed and management are not comparable with the Dutch situation and guidelines for organic pig husbandry. For example, 'real' outdoor systems as used in England, were pigs are housed outdoor day and night with the providence of a shelter, are rarely used in The Netherlands and are also not expected to be used often in the future due to space constraints. Also, when comparing health parameters between conventional and organic farms, most often smaller numbers of organic farms are used compared to the conventional, which causes difficulties with the static support of the found differences (Eijck et al., 2003). In addition, it will be difficult to separate the effects of indoor/outdoor housing from other factors, since many outdoor housed pigs are organic, and therefore more differences than the type of housing occur; such as animal density, antibiotics use, and choices of feed.

To ensure consistence, only closed system farms for the interviews will be used, i.e. consisting of breeding sows and finishing pigs. Furthermore, the following terminology is used in the report to indicate the different classification of pigs (Table 2).

Table 2: Names and definition of different classifications of pigs (Com-EU-Communities, 2009).

Name	Definition
Pig	an animal of the porcine species, of any age, kept for breeding or finishing
Boar	a male pig after puberty, intended for breeding
Gilt	a female pig after puberty and before farrowing
Sow	a female pig after the first farrowing
Farrowing sow	a female pig between the perinatal period and the weaning of the piglets
Dry pregnant sow	a sow between weaning her piglets and the perinatal period
Piglet	a pig from birth to weaning
Weaner	a pig from weaning to the age of 10 weeks
Finishing pig	a pig from 10 weeks to slaughter or service

It is well known that there are downsides as well as upsides in relation to pig health when housing them outdoors. It has to be carefully assessed what the factors are that cause differences between indoor and outdoor housing in relation to pig health. From a short scan through available literature the major issues which occur in outdoor and indoor husbandry in relation to pig health can be assigned:

- Digestion (Barton Gade, 2008; Guy et al., 2002; Hovi et al., 2003; Jolie et al., 1998)
- Respiration (Barton Gade, 2008; Guy et al., 2002; Hovi et al., 2003; Leeb and Baumgartner, 2000)

- Reproduction (Akos and Bilkei, 2004)
- Skin lesions (including damaging behavioural problems) (Vaarst et al., 2000)
- Locomotion (Barton Gade, 2008; Guy et al., 2002; Hovi et al., 2003; Vaarst et al., 2000)

These most prevalent health problems will be used as a guideline in this report to identify the differences in health between outdoor and indoor kept pigs in The Netherlands. In this report, besides an overview of knowledge, also recommendations are given to solve or reduce the health problems stated. At the end of the report, parallels with health of dairy cattle and poultry in outdoor systems are given.

Background different pig husbandry systems

In order to understand the theory presented in the following literature chapters, some underlying knowledge is required. Basic definitions, current production methods and regulations are important to understand the other parts. This chapter shortly discusses the main issues with regard to regulation, husbandry system, feed and grassland and health for organic, free range and conventional pig farming.

Regulation

Organic

Organic agricultural production in The Netherlands is bound to rules, which are mainly stated in two European regulations (No. 834/2007 and No. 889/2008). According to the European Council regulation No 834/2007, organic production is:

> "*an overall system of farm management and food production that combines best environmental practices, a high level of biodiversity, the preservation of natural resources, the application of high animal welfare standards, ….*" (Com-EU-Communities, 2007)

The following objectives within organic production are important, according to the Commission of European Communities (2007):

A. Establishing a sustainable management system for agriculture that:
   1) Respects nature's systems and cycles and sustains and enhances the health of water, soil, plants and animals and the balance between them;
   2) Contributes to a high level of biological diversity;
   3) Makes responsible use of energy and the natural resources, such as water, soil, organic matter and air;
   4) Respects animal welfare standards and meets animals' species-specific behavioural needs.
B. Aiming at producing products of high quality.
C. Aiming at producing a wide variety agricultural products and foods that respond to consumers' demand for goods produced by the use of processes that do not harm the environment, human health, plant health or animal health and welfare.

The whole organic chain in The Netherlands is supervised by Skal by means of inspection, certification and, where necessary, sanctions, such as revocation of the certificate (Skal, 2012a). The foundation Skal was commissioned by the Dutch Ministry of Economic Affairs, Agriculture and Innovation. Skal provides all members in the chain with rules that are based on European laws which were mentioned before. The products that are produced under these certificates can be labelled with the EKO logo (Figure 1). The Skal rules provide requirements with regard to the husbandry system, feed, grassland and crops, origin of the animals, manure and the feed. Furthermore, rules are provided with regard to the transition of free range areas and the transition of farms.

Figure 1. The EKO logo, found on organic products certified by Skal.

Free range

Within The Netherlands free range pig husbandry is called “scharrel varkenshouderij”. Free range pig husbandry in The Netherlands started around 1985 and at that time it was mainly an animal welfare improving pig farming system when comparing it to the conventional pig husbandry.

Although free range pigs husbandry has to comply with the basic rules for pig husbandry mentioned in the conventional paragraph, this type of husbandry has to comply with additional specific rules. The rules for this type of animal husbandry are described in “Algemene voorwaarden IKB Scharrelvarkens 2003”, which are determined by the Productschap Vee en Vlees (PVV).

ProduCert and Deltacon are taking care of the certification and control upon these rules (Figure 2) (Productschappen-Vee-Vlees-en-Eieren, 2012c). Free range is a wide definition and for this report it should be considered that every free range system is different and that rules are differing between countries. In order to demarcate this definition, in this background chapter for the most relevant topics, the Dutch free range methodology will be explained.

Figure 2. The free range logo from ProduCert.

Conventional

Beside organic and free range, most of the pig farms in The Netherlands are conventional farms. The conventional pig farms in The Netherlands are controlled by regulations which are stated in several Dutch laws, which are often based on European regulations.:

- ✓ *“Varkensbesluit”* (general regulation with regard to pig farming)
- ✓ *“Ingrepenbesluit”* (laws about interventions at animals)
- ✓ *“Besluit Identificatie en Registratie van dieren”* (laws about identification and registration of animals)
- ✓ *“Verordening Varkensleveringen “ (*laws with regard to pig delivery)
- ✓ *“Regeling preventie, bestrijding en monitoring van besmettelijke dierziekten en zoönosen en TSE’s”* (laws with regard to prevention control and monitoring of infectious diseases, zoonoses and transmissible spongiform encephalopathies (TSEs))

More detailed regulation is presented in the following chapters, regarding regulations for the husbandry system, feed and grassland and the health of the animals. In order to comply with the regulations, farmers can for example join IKB Varken. IKB Varken is certification procedure that checks farms on animal feed, medicine use, use of forbidden substances, hygiene, food safety and transport. When complying to the rules of IKB Varken, the farm is on those fields complying to the Dutch regulations. This certification was developed in order to guarantee quality and origin of meat and the way of producing in all parts of the production chain (Productschappen-Vee-Vlees-en-Eieren, 2012a).

Husbandry system

Organic

A husbandry system consists of the whole environment that the animals are living in. The barn, pastures and outdoor areas within organic pig production need to be designed in such a way that the animals can behave as natural as possible, which is according to Skal. Therefore, a barn for an organic pig husbandry system should meet the following requirements (Skal, 2012b):

- ✓ The floors are flat and a part of the flooring should be closed.
- ✓ Sufficient daylight should come into the barn.
- ✓ Natural ventilation should be applied in the barn.
- ✓ At least half of the floor should be a closed floor.
- ✓ The pigs should have sufficient clean and dry lying areas which are provided with sufficient litter material.
- ✓ The pigs should be provided with an outdoor area, but pasturing is not obligatory.
- ✓ Sows should be kept in groups, except during the last phase of the gestation and during the lactation period.
- ✓ Pigs should be able to defecate and root within their pen.

Besides, it is very important in organic pig production that the animals have the possibility to go outdoors, unless weather, soil or health circumstances make it impossible. Furthermore, it should overgrazing should be prevented, as well as that it gets too muddy. Next to that the outdoor areas should provide the animals with sufficient shelter (Skal, 2012b).

The organic rules contain very specific requirements with regard to space for each type of pig for both the indoor and the outdoor area. The space requirements for several types of pigs can be found in Table 3. It is important to mention that the outdoor area that is mentioned is excluding pastures.

Table 3: Minimum space requirements for an organic pig barn and the outdoor area (excluding pasturing area) for different pig types (Com-EU-Communities, 2008; Skal, 2012b).

		Indoor area	**Outdoor area (excl. pasturage)**
		m^2/animal	m^2/animal
Piglets	> 40 days and < 30kg	0.6	0.4
Finishing pigs	< 50kg	0.8	0.6
	50-85 kg	1.1	0.8
	85-110 kg	1.3	1.0
Farrowing sows with piglets	< 40 days	7.5	2.5
Breeding sows		2.5	1.9
Breeding boars		6.0	8.0

Outdoor or pasture areas for pigs should meet the following requirements (Skal, 2012b):

- ✓ The outdoor areas are allowed to have a roof, which covers maximally 75% of the outdoor area.
- ✓ The outdoor area should at least have a depth of four meters from the back fence until the barn wall.
- ✓ The lower 50 cm of the back fence is allowed to be closed.
- ✓ The unpaved outdoor area should be organic (e.g. use of pesticides and artificial fertilizer are not allowed) and the transition period is one year.
- ✓ The outdoor areas are allowed to be paved, no transition period is required for this. Soil conditions of a paved outdoor area cannot be a motivation to keep the pigs indoors.

Within organic production, the total stocking density as such should not exceed the limit of 170 kg of nitrogen per year per hectare of agricultural land (Com-EU-Communities, 2008). This has implications for the number of animals that are allowed to be kept per hectare (Table 4).

Table 4: Maximum number of animals per hectare for different classes of species (Com-EU-Communities, 2007).

	No. of animals/ha
Piglets	74
Breeding sows	6.5
Finishing pigs	14
Other pigs	14

The minimum age of the piglets at weaning is 40 days (Com-EU-Communities, 2008), which is the longest compared to the free range and conventional regulations.

In principle all animals that are bought for an organic farm should have an organic origin. In case insufficient animals are available, the farm can apply for an exemption yearly. This exemption would allow the farm to buy a certain percentage of conventionally raised animals (Com-EU-Communities, 2008).

Free range

Free range pigs should be housed in groups, with the exceptions for boars, pregnant sows (maximum a week before giving birth), farrowing sows and possible sick animals. The animals should have the possibility to stand, lie down and perform natural behaviour. In each group pen, the animals should have a structural tool in order to scratch themselves. Fixation of free range pigs is only allowed during artificial insemination, during the first 96 hours after giving birth and during veterinary practices for which fixation is required. The barn should be designed in such a way that the animals can protect themselves against extreme weather circumstances. Besides, the barn climate should be adjusted to the requirements of the pigs.

In a free range pig barn, daylight should be able to come in and the area that transmits the daylight should at least be 1/30 of the floor area. Besides, sufficient artificial lighting should be available in order to perform inspections and veterinary practices.

The lying area for the free range pigs should consist of a closed floor with a permanent layer of straw. The use of other litter material is only allowed by a written permission by the PVV. The lying areas should be clean, dry and fresh litter should be provided daily.

With regard to the size of the indoor lying area, specific rules are designed (Table 5). Breeding sows for example should have 1 m^2/animal, however it is important to mention that each group should at least consist of five animals. Farrowing sows with piglets should for example have at least 6.5 m^2. From this area, 4 m^2 should be lying area and 3 m^2 should be accessible for the sow.

Table 5: Minimum space requirements for the indoor pens for different type of free range pigs (ProduCert, 2003).

	Indoor lying area
	m^2/animal
Breeding sows	1
Boars	4
Farrowing sows with piglets	6.5
Pregnant sows, piglets, finishing pigs and other pigs	0.5 m^2 / pen + 0.1 m^2 / pig + 0.1 m^2 / 20 kg of pig

The rule that is described in Table 5 for pregnant sows, piglets, finishing pigs and all other pigs is graphically displayed in Figure 3 for different pig weights and group sizes.

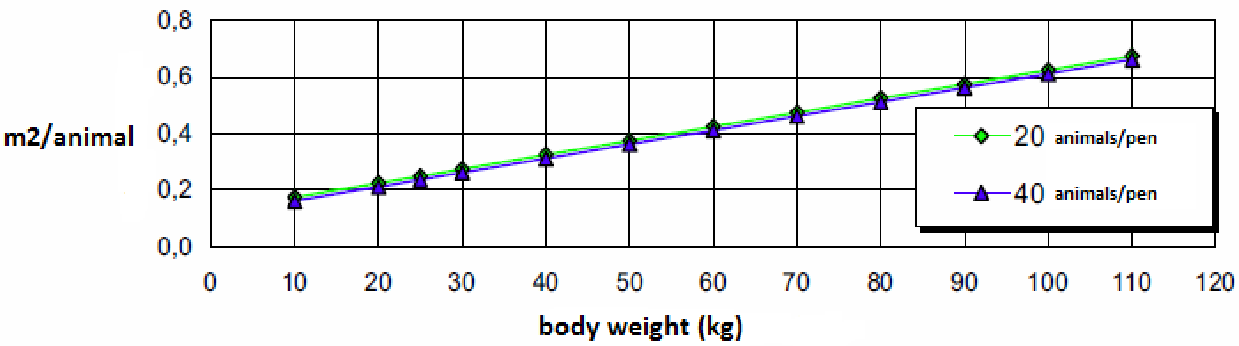

Figure 3. Space requirements for free range pigs considering the rule 0.5 / pen + 0.1 / animal + 0.1 / 20 kg animal (Spoolder et al., 2001).

Within the area that is designed for the pigs to defecate it is allowed to use slatted floors. The space in between the slats should not exceed 10 mm for animals between 12 and 25 kg. For pigs that are heavier, this should not exceed 20 mm. All free range pigs should have the availability of an outdoor free range area. These areas are allowed to be both paved and unpaved or a combination of both. The walls partitioning the free range area should not exceed 1.1 m, while for boars a maximum of 1.5 m is allowed. Farrowing sows with piglets, weaned piglets and possible sick animals do not necessarily have to have this. The surface area of these outdoor free range areas should not consist of more than 50% out of slatted floors, while for finishing pigs it is allowed to be 100%. The slats should have a minimal width of 70 mm (Spoolder et al., 2001). Table 6 displays the minimum space requirements for both paved and unpaved free range areas.

Table 6: Minimum space requirements for unpaved and paved free range areas for different types of pigs (ProduCert, 2003).

	Unpaved	**Paved**	**Combination**
	m^2/animal	m^2/animal	m^2/animal
Breeding sows	150	10	5 paved +100 unpaved
Boars	150	10	1.9 paved +100 unpaved
Farrowing sows	150	1	5 paved +100 unpaved
Finishing pigs	25	Equal to lying area	Paved: equal to lying area + 25 unpaved

Landless organic livestock production is forbidden in the European Union, unless the organic production holding establishes a written agreement with another holding, which complies with the organic production rules and which are with the intention of spreading surplus manure from organic production (Com-EU-Communities, 2007). From 2012 all the manure that is produced at the organic farm should be applied to the parcels belonging to that particular organic farm, or should be brought to other organic farms. In case the farm is highly intensive and exceeds the nitrogen norm of 170 kg N/ha, this farm should transport the surplus of manure to another organic farm.

Conventional

Finishing pigs, gilts and sows should be housed in separated groups. Once the groups of finishing pigs are formed, no changes to the group should be made. A group should be formed at least one week after the weaning period (Varkensbesluit, 2012).

In principle, it is forbidden to individually house sows or gilts. It is allowed to house a sow individually from one week before farrowing date until farrowing date and from weaning until four days after insemination. Furthermore, finishing pigs, gilts and sows are allowed to be separated from the group in case of veterinary treatments, feed intake or cleaning the barn (Varkensbesluit, 2012).

In the farrowing barn, the situation should be as such that the farrowing sow, which is housed together with the piglets, is able to move and turn. Furthermore the piglets should be protected from the sow by a certain protection mechanism. In a barn, in which the sow cannot move or turn, the piglets should be provided with sufficient space in order to suckle (Varkensbesluit, 2012).

Measures should be taken, as many as possible, in order to reduce aggression in groups. Straw or other materials should be provided to finishing pigs. When signs of severe fighting are showing, immediate investigation into the causes should take place (Varkensbesluit, 2012).

Table 7: Minimum indoor space requirements for pigs in conventional pig farming (Varkensbesluit, 2012).

		Indoor area
		m^2/animal
Gilts (after insemination) and sows without piglets		2.25
Finishing pigs	< 15 kg	0.2
	15-30 kg	0.4
	30-50 kg	0.6
	50-85 kg	0.8
	85-110 kg	1
	> 110 kg	1.3
Boars	< 12 months	4
	12-18 months	5
	> 18 months	6
	in case the area is being used for natural mating	10

In addition to the rules stated in Table 7, the areas can be either enlarged or reduced. In case the group of gilts or sows consists of less than six pigs, the area should be enlarged by 10%. In case the group of gilts or sows consists of more than 40 pigs, the area could be reduced by 10%. For finishing pigs with an average weight of more than 15 kg in a group of more than 40 animals, the area could be reduced by 10% (Varkensbesluit, 2012).

Weaning of piglets is not allowed before the piglets are 28 days old (Varkensbesluit, 2012). In case the welfare or the health of the sow or the piglets are being jeopardized it is allowed to wean the piglets earlier. Piglets can be weaned maximally seven days earlier, in case the piglets are being housed within a special facility (Varkensbesluit (2012):

- ✓ entirely emptied, thoroughly cleaned and disinfected before a new group comes in
- ✓ separated from the facility where sows are being kept in order to limit the transmission of diseases to the piglets

Climate systems vary a lot between farms. A research comparing conventional systems and organic with regard to barn climate is difficult to perform because within husbandry systems not one single climate system is typical for either organic or conventional husbandry (Eijck et al., 2003).

Feed and grassland

Organic

Organic animal feed should be produced organically and should not be produced with genetically modified crops. Besides, the feed should not contain antibiotics, medicines or growth stimulators. With regard to grassland and crops, this area should have had a transition period. For example for the unpaved outdoor area for pigs, this is one year, while for grassland this is two years. Furthermore, the starting material for these crops should be organic (Skal, 2012b).

The feed within organic pig farming differs from conventional farming in several ways. In a study from Eijk (2003) it was found that the proportion of crude fibre in the feed was higher compared to conventional pig husbandries. From 2011, it is obligatory in organic farming that all the feed has an organic origin. This could lead to health problems, such as weaning diarrhoea (Ruis et al., 2010). On the one hand this can be caused by the lacking of synthetic amino acids, which are not allowed in organic. On the other hand, the higher crude protein levels could cause health problems. At the moment research is being carried out in order to determine optimal organic diets including a regional origin of resources and a higher protein digestibility (Ruis et al., 2010).

In 1994, in the early days of organic farming, differences were found with regard to the quality of the organic feed by Thielen (1994). They researched 22 organic farms in Northern Germany and found that piglets are sometimes in a bad condition due to a too low protein content of the feed, a shortage on essential amino acids, insufficient minerals and a too low energy intake (Thielen, 1994).

Free range

Free range pigs should always have the possibility to eat undisturbed, having the possession of one feeding place per twelve animals of 35 cm wide (ProduCert, 2003). The feed needs to be retrieved from an approved supplier of free range pigs feed (Good Manufacturing Practice – Scharrel Diervoer recognition: GMP-SD). For all free range pigs, with the exemption of sows one week before farrowing, it is required that they have access to a large amount of roughage with a structure value of larger than 0.1. That makes it required to also feed roughage to lactating sows and piglets. Furthermore it is forbidden to add growth stimulators, medicines, antibiotics or chemotherapeutics to the drinking water (ProduCert, 2003).

Conventional

All pigs in the conventional pig husbandry should be fed minimally once a day. Pigs older than two weeks should permanently have access to fresh water. All sows should be provided with sufficient bulk- or rich of fibre and energy containing feed in order to satisfy their hunger and the need to chew (Varkensbesluit, 2012). Feed has a large influence on the animal health. Especially the general body resistance is highly correlated with the quality of the feed and the feed level (Eijck et al., 2003).

Health

Organic

The feeding, treating and housing should provide the animals with an optimal natural resistance against diseases. With regard to the treatment of diseases, homeopathic products, phytotherapeutic products and trace elements should be preferably used instead of antibiotics or chemically-synthesized allopathic veterinary treatments (Skal, 2012b). In case the use of these preferred measures appears to be not sufficient, antibiotics or chemically-synthesized allopathic veterinary treatments are allowed to be used under the responsibility of a veterinarian. When using these kind of medicines, the normal legal waiting period should be doubled. The use of hormones that induce parturition or stimulate the oestrus are forbidden (Skal, 2012b).

Vaccines, treatments for parasites and compulsory eradication schemes are allowed within organic pig production. Furthermore, it is allowed to give maximum three courses of treatments per year with chemically synthesised allopathic veterinary medicines or antibiotics. This is one course per year in case the productive lifecycle is less than one year. In case the animals receive more than this, the products may not be sold as organic products and the animals should undergo certain conversion periods (Com-EU-Communities, 2008).

Free range

Also in this system, hormones that induce parturition or stimulate the oestrus are forbidden (ProduCert, 2003). Inducing of parturition is only allowed by a written indication from a veterinarian. Tail docking and grinding of the canine teeth is forbidden, except with a written permission from a veterinarian in case piglets and sows are damaging each other (ProduCert, 2003).

Furthermore it is not allowed to provide the animals with medicines, antibiotics or chemotherapeutics via the animal feed or the drinking water or any another way. Only by written veterinarian permission, medicines, antibiotics or chemotherapeutics are allowed to be used, in case (ProduCert, 2003):

- ✓ a note has to be made in the logbook, signed by a veterinarian
- ✓ the antibiotics are not added to the feed

Conventional

In conventional pig farming preventative measures such as vaccination are being used in order to increase the specific resistance of the animals, but also allopathic medicines are often used to prevent a disease from spreading / becoming more severe (Eijck, 2003; Eijck et al., 2003). Besides, in conventional pig husbandry a lot of attention was paid to the improvement of housing, feed and management measures in the nineties. Animal health appeared to be mainly depending on farm management and less depending on the husbandry system (Eijck et al., 2003).

Antibiotics

Within the Dutch livestock production systems a parameter is being used in order to express the antibiotic use on the farm. This parameter is called daydose (in Dutch: dagdosering), which is a standard measure that displays the quantity of milligrams of a certain active substance in an antibiotic, which is needed to treat one kilo of animal for one day. Daydose is based on a registered dosage of a certain medicine for the most common disease for a certain animal species. Daydoses are determined for a ‘standard animal’, having a certain weight and within a specified age group and they can be summed up as a measure for the total exposure to antibiotics. In common the average daydose for a farm is being calculated per year and displayed with the abbreviation “dd/dj”, which is daydose per animal year. In The Netherlands, daydoses are determined by the pharmacy of the faculty Veterinary Medicine in Utrecht (Productschappen-Vee-Vlees-en-Eieren, 2012b; Spoolder et al., 2001).

The Dutch Ministry of Economic Affairs, Agriculture and Innovation and the group ‘Antibioticumresistentie Dierhouderij’ (Antibiotic resistance animal husbandry) are working towards a responsible, fully transparent and lower antibiotic use in the animal husbandry in The Netherlands. Therefore, quantitative antibiotic use data should be registered on farm level and target values are defined in order to grade the antibiotic use (SDa, 2011). Within the law there are not any norms with regard to antibiotic use, but the target values as stated below are indicative for usage on farms and the prescription of veterinarians. Table 8 shows benchmark indicators for 2009 and 2011 and critical values for individual farms in 2011. The benchmark indicators for 2009 are based on the average antibiotic use values from 2009. The critical values, where farmers get either an alert or further action is required are also shown in Table 8. For farms and veterinary practices with antibiotic use higher than the critical values, it is obligatory to take measures in order to improve the situation (SDa, 2011).

Table 8: Benchmark indicators and critical values for antibiotic use in 2011 (SDa, 2011).

	Benchmark indicators (dd/dj)		**Critical values individual farms 2011 (dd/dj)**	
	2009 (average value in that year)	2011	Alert	Action
Sows/Piglets	26	20	37	54
Finishing pigs	16	13	33	53

Literature review

Introduction

This literature review will focus on the differences in health between indoor and outdoor housed pigs. Health can be defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO, 1948). This chapter will focus on the systems that seem most affected by either indoor or outdoor housing, namely locomotion, digestion, respiration, skin lesions and reproduction. The following paragraphs will detail the effects of outdoor and indoor housing on the afore mentioned health aspects of the pig.

Locomotion

Introduction

In this chapter, attention will be given to the ability or not of pigs to walk in indoor and outdoor housing, in other words: the effect of housing on the prevalence of lameness. The term lameness encompasses any situation that results in a deviation from normal movement and posture (KilBride et al., 2009a). It is of major importance from a welfare perspective because it violates the freedom of 'relief from pain and discomfort'. In addition, the economic importance of lameness is huge, mainly because it is one of the major reasons for premature culling, with outdoor pig farming having a higher percentage (39%) compared with indoor (25%) (Akos and Bilkei, 2004).

The factors associated with lameness that are most frequently found in literature are foot and limb lesions due to injuries, osteochondrosis and infectious arthritis (Jensen and Toft, 2009). Therefore, in this section of the report, focus will be given to these problems.

Foot lesions

The hoof of the pig consists of the toe, sole and heel, which form the weight-bearing surface, and the wall (KilBride et al., 2009b). The white line separates the hoof wall horn from the weight-bearing surface (KilBride et al., 2009b). The lesions on the feet that are most commonly studied can be seen in Table 9. The major risk factor for foot lesions as well as limb lesions (bursitis, capped hock) is the type of floor that is used in order to accommodate each age group of pigs (e.g. finishing pigs, sows) (KilBride et al., 2009b; Mouttotou et al., 1997).Therefore, attention will be given to the impact of different floor types that are currently used in indoor and outdoor husbandry on foot and limb lesions. It must be highlighted that despite the fact that the indoor and outdoor housing systems used in other countries are different from those in The Netherlands (e.g. outdoors with huts in England), the type of floor can be comparable.

Table 9: Definition of foot lesions in finishing pigs given by Mouttotou et al. (1997).

Lesion	Definition (based on Mouttotou et al 1997)
Heel/sole bruising	Congestion and bruising of the solar corium presenting as a dark red pigmentation of the volar horn.
Heel/sole erosion	Loss of horny tissue from either the sole or the bulbar heel, in the form of irregular pit-like depressions or deeper grooves.
Heel flap	Located only on the heels and characterised by a partial peeling of the superficial layer of the heel horn with a deep groove visible underneath.
Overgrown hooves	Long hooves with elongated toes and a concave rather than a flat sole.
Toe erosion	Loss of horny tissue on the toe which appears as a dark area on the cranial aspect where the axial and volar surfaces of the toe meet.
Wall separation	The disintegration and penetration of the white line by debris with a visible gap between the wall and the sole.
White-line lesion	A black line in the sensitive laminae, separating the hard horn of the wall from the soft horn of the heel and/or sole. Small, superficial diagonal cracks along the white line of the abaxial surface of the hooves were also defined as white line lesions.

Effect of soil or solid concrete floors and bedding

Finishing pigs

It has been found that pigs housed on soft surfaces, such as deep bedding or soil, have higher percentages of toe erosions and wall separations than pigs housed on solid concrete floors (Gillman et al., 2009; Mouttotou et al., 1999; Scott et al., 2006). It seems that soft floors do not always permit the natural wear of the hoof wall, leading to overgrowth and possible erosions (Gillman et al., 2009). In case the floor surface such as soil or concrete with bedding is wet or covered with manure, the toe tissue becomes softer and erosions can occur more easily (Gilman et al 2009). However, it has also been found that the prevalence of sole erosion (1%) and bruising (5%) was less when pigs were housed on soil, compared with indoor flooring types (e.g. 22% and 56% of sole erosion and bruising respectively in slatted floors) (KilBride et al., 2009c) , possibly due to the fact that soft floors offer protection (Gillman et al., 2009). This has been confirmed by another study, where a lower prevalence of abnormal gait (indicator of foot and limb lesions) was found in pigs housed on concrete floors with deep bedding (5%) compared with concrete floors with sparse bedding (22.3%), partly slatted floors(16.9%), and fully slatted floors (34.3%) (KilBride et al., 2009a)

Piglets

In piglets of less than one week old, it has been found that foot and limb lesions in indoor housing were much more prevalent than in outdoor housing (60-90% vs. 9%) (KilBride et al., 2009c). In this study, the flooring in the outdoor system was soil, which was covered with deep bedding in the farrowing huts. The authors suggest that the soft surfaces protect the piglets from getting injured (KilBride et al., 2009b, c).

Sows

In sows it has been found that in general, the prevalence of abnormal gait is not different between indoor and outdoor housed animals (KilBride et al., 2009a). However, when comparing the outdoor sows with sows housed on slatted floors, the risk of developing an abnormal gait was significantly higher in the latter. The risk was similar for both outdoor housed sows and sows housed on solid concrete floors with deep bedding (KilBride et al., 2009a). This indicates that the type of flooring is probably more important in the development of lameness than indoor/outdoor housing, although the types of floors usually used outdoors seem to be more suitable.

Effect of slatted floors

Finishing pigs

When comparing finishing pigs on solid concrete floors with pigs housed on partially slatted floors, the latter were found to have significantly higher percentages of heel erosions (17.6%), white line lesions (59.8%) and wall separations (14.1%) (Mouttotou et al., 1999). Pigs housed on fully slatted floors also had higher percentages of sole erosions and heel flaps (Mouttotou et al., 1999). This is probably due to the hard surface of these floor types in combination with the slats, which adds more pressure on the hoof of the pig, resulting in injuries and in turn to lesions (KilBride et al., 2009c; Mouttotou et al., 1999). This is confirmed by another study, which found that finishing pigs housed on slatted floors had more heel and sole erosions, compared with pigs housed on floors with bedding (Scott et al., 2006). However, the same study also found that toe erosions were more prevalent in pigs housed on floors with bedding than in pigs housed on slatted floors (Scott et al., 2006).

Piglets

Piglets that are housed on partly or fully slatted floors were found to have a higher risk for sole erosion, sole bruising, swollen joints and swollen claws (KilBride et al., 2009b). Next to that, it was observed that coronary band injuries in piglets were frequent on slatted floors if there were sharp slat edges (KilBride et al., 2009b, c).

Sows

As in finishing pigs, also for sows the risk for sole erosions was found to be higher in sows housed on solid concrete floors with bedding than sows housed on slatted floors (Kilbride et al., 2010). On the other hand, these gestating sows also had lower risks for heel flaps and an abnormal posture on solid concrete floors (KilBride et al., 2010).

Conclusion

It appears that the type of flooring is probably more important in the development of foot lesions than indoor/outdoor housing, although the types of floors usually used outdoors seem to be more suitable. Soil or solid concrete with deep bedding of straw or wood shavings have the lowest prevalence of foot lesions and provide protection from heel/sole erosions and bruising. However, the prevalence and risk for toe erosions is higher, especially if the floor is wet and compiled with manure. Piglets kept on soil had no incidences of swollen joints and hoofs (KilBride et al., 2009c). Slatted floors had the highest prevalence and risk for foot lesions and abnormal gait. It seems that a soft surface such as soil or concrete with deep bedding, prevents most, but does not eliminate all foot lesions.

Limb lesions

There are several limb lesions that can occur in pigs, such as bursitis and capped hock. Bursitis is defined as a sac filled with fluid (Mouttotou et al., 1997), mostly located below the hock; it is rarely found in the front limbs (KilBride et al., 2008). Capped hock is a swelling or a sac filled with fluid in the subcutaneous connective tissue on the hock (KilBride et al., 2008). The severity of bursitis and capped hock are correlated with an increased risk of abnormal gait (KilBride et al., 2009a). It is suggested that bursitis and capped hock could become painful conditions for the animal, whereas the abnormal movement can either be the consequence of these, or the causal factor.

The prevalence of bursitis is found to be higher in pigs housed on fully or partly slatted floors, compared with pigs housed on solid concrete floors with deep straw bedding (Mouttotou et al., 1998). Also the bursitis is in general more severe in pigs housed on slatted floors than in pigs housed on floors with straw bedding (Scott et al., 2006). These findings have been reinforced by another study, where it appeared that prevalence of bursitis was much higher in pigs kept on slatted floors, than in pigs kept on soil with straw bedding (62.5% vs. 4.4%) (Gillman et al., 2008). It was also found that all other floor types (concrete with deep bedding, sparsely bedded concrete, party slatted and fully slatted) accounted for a higher risk of bursitis compared to the soil with straw bedding (Gillman et al., 2008). The pressure points forced on a pig’s leg when lying on a hard surface without bedding is much higher than when lying in soft surfaces with enough bedding. It must be also noted that slippery/wet floors were pointed out as additional risk factors for the presence of bursitis (Gillman et al., 2008). According to the authors, using soil as flooring for pigs instead of fully slatted floors, could lead to a reduction in bursitis prevalence of 45.7% in weaner pigs, 32.1% in grower pigs and 40.1% in finisher pigs.

Similar to bursitis, the prevalence of capped hock in finishing pigs is lowest in pigs housed on soil (4%), followed by pigs housed on solid concrete floors with deep bedding (9.7%). The other floor types (solid concrete with sparse or sparse/deep and partly or fully slatted) had much higher prevalence of capped hock (22.3%, 20.6%, 16.3% and 22.8% respectively) (KilBride et al., 2008). The risk for capped hock was higher in pigs housed on solid concrete floors with sparse bedding, on partly slatted floors or on fully slatted floors than in pigs housed on solid concrete with deep bedding (KilBride et al., 2008). It is indicated by these findings that the presence of deep bedding throughout the floor surface and not partly covering the surface, is a good preventative mechanism in reducing the risk of capped hocks.

Conclusion

It can be said, according to the afore mentioned studies, that the presence of capped hock and bursitis are minimized when pigs are housed outdoors on soil or indoors on solid concrete floors with deep bedding that was covering the whole floor surface and not partly (Gillman et al., 2008; KilBride et al., 2009c). It seems that partly or total slatted floors are a major risk for the occurrence of bursitis and capped hock.

Osteochondrosis

Osteochondrosis is defined as a focal disturbance of enchondral ossification (Ytrehus et al., 2007) and it affects the epiphyseal cartilage of young animals. It has been said that the susceptible age period where the cartilage is most sensitive to osteochondrosis could be from weaning at 56 days until 84 days of age (Grevenhof et al., 2012). Pigs are usually kept for meat production, and therefore need to reach a certain weight in a certain time period. To reach this, farmers prefer rapid growth, which can be achieved for e.g. by genetic selection or by feeding regimes. This growth rate forces extra pressure to the joints and predisposes for the occurrence of osteochondritic lesions (Grevenhof et al., 2012; Ytrehus et al., 2007).

Osteochondrosis has been found to be more prevalent in finishing pigs housed on partly slatted floors (50% solid / 50% slatted, 5 m^2) than in pigs housed on deep litter (solid concrete floor with 25-50 cm of wood shavings, 8.5 m^2). Next to that, the pigs that received ad libitum feed had a higher prevalence of osteochondrosis than pigs that were fed restrictedly (Grevenhof et al., 2011).The combination of deep litter housing plus more space presented the lowest prevalence osteochondrosis. It could be that the reduction in osteochondrosis in the pigs that were housed on deep litter is a result of a better bone development due to increased opportunity for physical activity provided by the extra space.

Conclusion

Osteochondrosis appears to be most prevalent in conventional housing, where the available space per pig is restricted and the floor type is partly slatted. The provision of more space and soft flooring can reduce the prevalence of osteochondrosis. This can be even more lowered if restricted feeding is applied. The combination of deep litter housing, sufficient space and restricted feeding could be a possible solution to reduce osteochondrosis occurrence (Grevenhof et al., 2011).

Infectious arthritis

Arthritis is an infection of the joints and is considered as one of the most frequent reasons for culling sows due to locomotion problems (Kirk et al., 2005). The most important factors causing arthritis in pigs are: *Mycoplasma hyosynoviae*, *Erysipelothrix rhusiopathiae*, *Haemophilus parasuis* (Glasser disease) and *Streptococcus suis* (reviewed by Jensen and Toft, 2009). These bacteria are zoonotic which highlights even more their importance. These will be discussed separately in the following sections, after which the differences in prevalence between different housing systems will be reviewed.

Mycoplasma hyosynoviae

M. hyosynoviae is a pig-specific bacterium that causes infectious arthritis in finishing pigs. It can be isolated from the tonsils of infected, but also from healthy animals (Taylor, 2006). It enters through the upper respiratory track to the blood stream and locates to the synovial membranes of joints (Taylor, 2006).

Erysipelothrix rhusiopathiae

E. rhusiopathiae is a Gram-positive bacterium with the characteristic clinical sign of rhomboid urticarial skin lesions. Sudden death is a common clinical sign in the acute phase of the disease, and the pigs that survive it develop arthritis and skin lesions (reviewed by Jensen and Toft, 2009). It causes acute or chronic arthritis, among other clinical manifestations, in pigs between three months and three years of age. It can be transmitted through the feed and water. It can survive in soil (reviewed by Jensen and Toft, 2009), which could indicate that pigs housed in systems that have an outdoor area with soil would be more susceptible.

Haemophilus parasuis (Glasser disease)

H. parasuis is a Gram-negative coccobacillus and the causative agent of Glasser disease. It causes polyarthritis, polyserositis, meningitis but also respiratory problems. In addition, it is suggested to be involved in the pathogenesis of PRRS (Porcine Respiratory and Reproduction Syndrome). *H. parasuis* usually affects pigs of four to eight weeks of age. *H. parasuis* most commonly colonises the upper respiratory tract of healthy pigs, but can also be found in the lower respiratory tract (Reiner et al., 2010). Pigs can be carriers of the bacterium without showing clinical signs of the disease (Reiner et al 2010). In Germany, *H. parasuis* DNA was isolated from the tonsils (69.1%) and the lungs (40.4%) of wild boar populations across the country, with an overall prevalence of 74.2% (Reiner et al., 2010). The latter indicates that since wild boars are a reservoir of the disease, the risk of transmission to outdoor pigs is increased compared to indoor pigs.

Streptococcus Suis

S. suis is a Gram-positive coccus that usually affects pigs of two to five weeks of age (reviewed by Jensen and Toft, 2009), but also at birth or immediately after (Taylor, 2006). It causes a multisystemic disease with most prevalent manifestations, meningitis and arthritis. When the bacterium is first encountered within a farm, the first sign is sudden death (Taylor, 2006). *S. suis* is usually transmitted through contact and less frequently through aerosol and ingestion (Taylor, 2006). Therefore, a risk factor could be a high stocking density in a pen, which implies that there is a higher risk in conventional indoor housing, since the number of pigs per pen is usually higher than in outdoor housing systems. It was mentioned by the organic farmers interviewed, that they had less problems with *S. suis* compared to when they had a conventional farm. However, no scientific information was found related to this subject.

Risk factors

According to a Swedish study performed in slaughterhouses, it was observed that joint diseases were significantly more prevalent on organic farms (2.1% for arthritis and 1.5% for arthrosis) than on conventional farms (1.3% for arthritis and 0.4% for arthrosis) (Hansson et al., 2000a). Scientific information concerning infectious arthritis in indoor and outdoor pig farms in The Netherlands is not available.

Physical injuries due to floor type are an important risk factor of arthritis (reviewed by Jensen and Toft, 2009). However, no correlation has been found between joint disease and floor type (Jørgensen, 2003). A low immune response is also a contributor to the development of infectious arthritis (reviewed by Jensen and Toft, 2009). Therefore any situation that affects the immune system, such as stress (e.g. weaning) makes the animals susceptible to infections.

Conclusion

Foot and limb lesions could be a predisposing factor for infectious arthritis. There is a theoretical risk of *E. rhusiopathiae* and *H. parasuis* arthritis in outdoor pig farms because of soil survival and wild animals that can act as a reservoir, respectively. *S. suis* is more of a risk in indoor pig farms because here the number of animals per pen is usually higher than in outdoor housing. There is no scientific information about the current situation in Dutch farms concerning these bacteria, or whether other causative agents of infectious arthritis are more prevalent.

Digestion

Introduction

Pigs in outdoor husbandry systems will encounter more external influences than animals in indoor systems, which might be difficult to control. These influences can either have beneficial, negative, or neutral effects on the animals. When housing animals outdoors, the risk for infections with internal parasites such as helminths (worms) is increased as compared to indoors (Borgsteede et al., 2011). This might be problematic for the pigs, however, most helminth infections give no symptoms in pigs. It is mainly a problem for the farmer, e.g. because of lower growth rates (Taylor, 2006). In addition it can be a problem for the consumers, since some helminth infections, such as *Trichinella* spp. infections, are zoonotic, although there is strict surveying at slaughter for this disease. The same goes for certain bacteria, which may also play a different role when pigs are housed outdoors than indoors. There is a possibility that pigs get infected with some bacteria through contact with wildlife, although, others seem to be less prevalent in outdoor housing. For the occurrence of viruses that affect the digestive system there seem to be little to none differences between indoor and outdoor housing, or at least they have not been studied, and therefore they will not be discussed here.

Intestinal Parasites

There are several intestinal parasites that occur in pigs, but they are not all influenced by either indoor or outdoor housing. The focus of this chapter will be on intestinal helminths, since there is a noteworthy difference in occurrence between indoor and outdoor housing systems. Next to that, coccidiosis and cryptosporidiosis will be discussed. Also, recommendations will be given to overcome possible problems with intestinal parasites associated with outdoor husbandry. The most important intestinal parasites in pigs in The Netherlands are displayed in Table 10.

Table 10: Life cycles and occurrence indoors and outdoors of intestinal helminths of pigs in The Netherlands.

Parasite	**Type**	**Life cycle**	**Prevalence higher in indoor or outdoor systems**	**Reference**
Ascaris suum	Helminth	Direct	Outdoor	(Eijck and Borgsteede, 2005; Nansen and Roepstorff, 1999; Roepstorff and Nansen, 1994)
Oesophagostomum spp.	Helminth	Direct	Equal	(Eijck and Borgsteede, 2005; Nansen and Roepstorff, 1999; Roepstorff and Nansen, 1994)
Trichuris suis	Helminth	Direct	Outdoor	(Eijck and Borgsteede, 2005; Nansen and Roepstorff, 1999; Roepstorff and Nansen, 1994)
Trichinella spiralis	Helminth	Indirect (several vertebrates can act as intermediate hosts)	Outdoor	(Nansen and Roepstorff, 1999; Pozio, 2005; RIVM, 2007; Roepstorff and Nansen, 1994)
Isospora suis	Coccidium	Direct	Equal	(Eijck and Borgsteede, 2005; Taylor, 2006)
***Eimeria* spp.**	Coccidium	Direct	Equal	(Eijck and Borgsteede, 2005; Taylor, 2006)
***Cryptosporidium* spp.**	Protozoan	Direct	Outdoor or equal	(Bilic and Bilkei, 2006; Eijck and Borgsteede, 2005; Ryan et al., 2003; Taylor, 2006)

Helminth infections

Infections with intestinal helminths rarely manifest themselves clinically in pigs (Roepstorff and Nansen, 1994; Taylor, 2006). However, subclinical infections (i.e. no symptoms of disease can be observed in the pig) can be of economic importance because they may lead to lower growth rates or poor meat quality (Taylor, 2006). The development, survival and transmission of helminths depend on a lot of factors, such as the presence of intermediate hosts, management practices and protective immunity (Roepstorff and Nansen, 1994). Table 10 contains the most common helminth species of pigs in The Netherlands. A direct life cycle means that the species can complete the entire cycle without the need for intermediate hosts. Species with indirect life cycles do need these hosts, such as earthworms or snails, to complete the cycle and be able to reproduce.

In temperate climate regions, in indoor systems the most common intestinal helminths are *Ascaris suum, Oesophagostomum* spp. and *Trichuris suis* (Nansen and Roepstorff, 1999). These are helminths with a direct life cycle, meaning that no intermediate hosts are needed to complete the entire cycle (Roepstorff and Nansen, 1994). For intensive indoor systems with good hygiene only *A. suum* seems to be of real importance. In outdoor systems, however, *Oesophagostomum* spp. and *Trichuris suis* are more prevalent. There are other helminths that are less common but can be found in outdoor systems, such as *Trichinella spiralis, Taenia solium, Fasciola hepatica and Dicrocoelium dendriticum* (Nansen and Roepstorff, 1999). These last four have indirect life cycles, which is the main reason why they only occur in outdoor pigs, since the chances of encountering the right intermediate hosts are higher here (Roepstorff and Nansen, 1994). However, they have not recently been found in The Netherlands (Eijck and Borgsteede, 2005), and will therefore not be discussed, except for *Trichinella* spp. because of its zoonotic importance (RIVM, 2007).

Ascaris suum

Ascariosis rarely causes clinical signs in pigs but is important because it causes condemnation of livers at slaughter due to white spots (Taylor, 2006). Pigs get infected by ingesting eggs, which have shown to be able to survive on pasture for up to nine years (Roepstorff et al., 2011). The prevalence of gastrointestinal parasites in pigs in The Netherlands has been examined, and a division was made between conventional (n=9), free-range (n=16) and organic (n=11) farms. The prevalence of *A. suum* was lower on conventional than on free range and organic farms (11.1% vs. 50% and 72.7%) (Eijck and Borgsteede, 2005). Of all age groups, mainly finishing pigs were infected with *A. suum* (Eijck and Borgsteede, 2005). This is quite high compared to studies done in other countries, such as Denmark, where the prevalence of *A. suum* on organic farms ranged from 4-33%, depending on the age group (Carstensen et al., 2002a). It needs to be noted though, that during the time of the Dutch study no anthelmintics (i.e. drugs that expel helminths from the body) were used (Eijck and Borgsteede, 2005), which can account for a higher prevalence. It does, however, show that pigs that are housed outdoor are at higher risk of becoming infected with *A. suum*, and therefore attention needs to be paid to prevention (see 'prevention and treatment of helminth infections').

Oesophagostomum spp.

Severe infections with *Oesophagostomum* spp. that cause diarrhoea are rare, but subclinical infections can cause damage such as lower weight gain in finishing pigs or lower milk production in sows. Pigs get infected by ingesting infective larvae, which are not resistant to drying or low temperatures (Taylor, 2006). There was no difference in the prevalence of

Oesophagostomum spp. between different farm types in The Netherlands (CF: 22.2%, FRF: 25.0%, OF: 27.2%). Of all age groups, *Oesophagostomum* spp. infections were most common in sows (Eijck and Borgsteede, 2005). In Denmark, higher prevalences in outdoor systems have been found, with 50% of organic sows being infected compared to 40% of conventional sows (reviewed by Nansen and Roepstorff, 1999). This is probably due to the fact that *Oesophagostomum* spp. is relatively sensitive for hygienic measures, such as the use of slatted floors and high pen cleaning rates (Roepstorff and Jorsal, 1990), which can be accomplished easier in indoor housing systems.

Trichuris suis

Also for this helminths species, infections in pigs are usually subclinical, and occasionally weight loss and diarrhoea may occur (Taylor, 2006). Pigs get infected by ingesting infective eggs, which are very resistant and can survive for up to eleven years outdoors. Because the eggs develop slowly, the chances are high that they will be removed indoors before they get infective, but outdoor they will have the time to develop and therefore the chances of infection are likely to be higher (Roepstorff and Murrell, 1997a). However, there was no significant difference in the prevalence of *T. suis* between the farm types in The Netherlands, although there seemed to be a trend for higher prevalence in outdoor systems (CF: 11.1%, FRF: 37.5%, OF: 36.4%) (Eijck and Borgsteede, 2005). *T. suis* infections were most common in sows, compared to other age groups (Eijck and Borgsteede, 2005).

Trichinella spp.

Trichinellosis does not cause any symptoms in pigs, but it is a zoonosis (RIVM, 2007). Humans usually get infected by ingesting infective larvae, through eating raw or poorly heated pork. Symptoms in humans range from nausea, fatigue, fever and stomach pains to dehydration, low blood pressure, heart and respiratory symptoms and meningitis (VWA, 2008). Pig carcasses are always tested for *Trichinella* spp. at the slaughter house. Tests at the slaughter house from 2000 to 2006 have shown that *Trichinella* spp. is virtually non-existent in The Netherlands in indoor-housed pigs. Only one carcass was tested morphologically positive, but that could not be confirmed by a DNA test (RIVM, 2007). In a study from the State Institute for Public Health and Environment (RIVM) and the Food and Consumer Product Safety Authority (VWA), organic (n=40), free-range (n=9) and conventional (n=24) pigs farms were serologically tested for *Trichinella* spp. *T. spiralis* seropositivity was not different between organic and conventional farms (0.24% vs. 0.12%) (RIVM, 2007).

A risk factor of housing pigs outdoors could be that they get infected with *Trichinella* spp. through contact with wildlife. From serological testing it appeared that *Trichinella* spp. was prevalent in wild boars in The Netherlands, with prevalences of 9.8% and 6.1% in 2003 and 2004, respectively. However, DNA tests on carcasses never revealed a positive outcome. Therefore the serological test was adapted, and in 2005 and 2006 only one wild boar has been tested serologically positive, although this could not be confirmed when testing the carcass (RIVM, 2007). Overall, *Trichinella* spp. may occur in wild boars, although in very low levels. Another possible source are foxes, in which the prevalence of *T. britovi* was 3.9% in 1998 (Van der Giessen et al., 1998). Pigs cannot get directly infected by wild boar or foxes, since they have to ingest meat containing infective larvae. This could be the case if they eat infected rodents, which in turn can feed on carcasses of infected boar or foxes (Roepstorff and Nansen, 1994). Therefore it is good to continue to monitor the occurrence of *Trichinella* spp., since there might be a slightly increased risk on outdoor farms.

Prevention and treatment of helminth infections

There are different solutions and preventive measures to reduce the occurrence of helminth infections in pigs. The most frequently used strategy is probably the use of anthelmintics. In The Netherlands however, pigs that are housed outdoors are mainly found on organic farms. One of the objectives of organic farming is to reduce the use of allopathic, i.e. conventional, medicine (Von Borell and Sørensen, 2004). It is allowed to use anthelmintics as a treatment on organic farms in The Netherlands. A danger of using anthelmintics is that the helminths can develop resistance to them (Wolstenholme et al., 2004). There are indications however, that the use of anthelmintics in outdoor systems may favour later and weaker development of drug resistance compared to conventional systems, because the refugium is larger and can persist longer than indoors (Nansen and Roepstorff, 1999). The refugium is a subpopulation of the helminths, e.g. the larvae on pasture, that are not susceptible to the effects of anthelmintics. Because they are not susceptible, the selection for resistance is slower than if all parasites that are present are treated (Wolstenholme et al., 2004). Another way to prevent helminths-infections on a pig farm, is to start off with helminth-free sows. However, organic farmers prefer to buy organic animals instead of indoor-raised animals, and these are usually pre-treated with anthelmintics (Carstensen et al., 2002a).

Other measures such as management strategies like pasture rotation or biological control can also be used to prevent infections (Nansen and Roepstorff, 1999). Pasture rotation in The Netherlands is difficult because of the often limited amount of space per farm looking at the number of pigs allowed per hectare and the average number of pigs per farm. Pasture infection can be reduced by having a high stocking density, so the earth becomes bare, which has a negative influence on the survival of the larvae (Taylor, 2006). This has also been found in a study where pastures were experimentally contaminated with *O. dentatum* and *H. rubidus,* by inoculating pigs with infective larvae. Continuous grazing showed to reduce the transmission of these parasite species, because of the reduction in vegetation on the pastures. This is however not a desired situation because the soil will be vulnerable to erosion, there will be run-off of animal waste, and ground water may be contaminated (Roepstorff and Murrell, 1997b). When the same experiment was done with *A. suum* and *T. suis,* their infective eggs seemed to be much more resistant to environmental influences than the infective larvae of *O. dentatum* and *H. rubidus.* Therefore it is more difficult to control these species in outdoor husbandry systems (Roepstorff and Murrell, 1997a).

Biological control, which is the use of natural enemies to control pests or diseases, has been investigated, e.g. it has been tried to reduce the number of *Oesophagostomum dentatum* and *Hyostrongylus rubidus* infections in pigs by using a fungus. Sows (n=30, Danish Landrace x Yorkshire) were experimentally infected with these helminths and kept on pasture. Subsequently, half of them were treated with the microfungus *Duddingtonia flagrans* for two months*,* which was mixed through their feed, while the other half was left untreated. It was found that the number of infectious larvae in vegetation on pasture were lower in the treated group. Also, at slaughter the treated pigs had a 86.6% lower *O. dentatum* count, and a 70.2% lower *Hyostrongylus rubidus* count (Nansen et al., 1996). However, helminths with resistant egg shells, such as *A. suum* and *T. suis* cannot be successfully attacked by *D. flagrans*, because that can only kill larvae that are free-living and mobile (Nansen and Roepstorff, 1999).

It has also been studied whether better hygiene would reduce the prevalence of *A. suum* infections, but no effects were found (Borgsteede et al., 2011). In indoor systems it appears to be easier to remove the eggs of *A. suum* from the pens by disinfection than outdoors. This can however be difficult in straw yards, which is reflected in the risk of infection being 5.4 times greater here than on concrete floors (Taylor, 2006).

In summary, it appears that mainly *A. suum* and *T. suis* are more prevalent in outdoor systems than in indoor systems. The prevalence of *Oesophagostomum* spp. was not influenced by either indoor or outdoor housing, but is probably more affected by other management factors. *Trichinella* spp. did not occur in The Netherlands recently, but the shift to outdoor husbandry may impose a slight risk for this parasite.

There are several ways of preventing the occurrence of helminth infections in pigs, of which the use of anthelmintics is probably still the most wide spread. The reason for this seems to be that this is until now the most effective and economic strategy. Pasture rotation is difficult because of a lack of space, and because the survival of some helminths on pasture is very long.

Coccidia

Coccidia are one-celled, intracellular parasites. The species that occur in pigs are *Isospora suis* (in piglets) and *Eimeria* spp. (in weaned pigs) (Taylor, 2006). The prevalence of coccidia infections in The Netherlands was higher on organic than on free range farms (90.9 vs. 43.8%) but not different from conventional farms (66.7%). Sows were the age group that was most often infected with coccidia. Mainly *I. suis* occurred in suckling piglets, and almost only *Eimeria spp.* in sows (Eijck and Borgsteede, 2005). The high prevalences on organic farms may have to do with the fact that high levels of hygiene are more difficult to reach here; hygiene is an important factor in the prevalence of coccidiosis (Taylor, 2006).

Piglets can get infected with *I. suis* by the faeces of other piglets, which have contaminated the pens. Clinical signs are usually seen between seven to ten days of age, because the parasite first has to go through a life cycle after it is ingested by the piglet. Signs include diarrhoea and weight loss, and severely affected piglets may die (Taylor, 2006; White, 2010). In indoor systems, the mortality can be reduced by providing electrolytes, but in outdoor systems mortality can be 20% (Taylor, 2006). However, in this context ‘outdoors’ probably means sows on pasture with farrowing huts, since the author is from the UK. In The Netherlands this system rarely occurs, and providing electrolytes is well possible in most Dutch outdoor systems. Preventive measures include high levels of hygiene, such as disinfection of the pens (Taylor, 2006), which may be more difficult in outdoor systems.

Pigs can get infected with *Eimeria* spp. by their mothers, from wild boar or when they are naively introduced to contaminated pens or yards. Infected pigs may suffer from emaciation and diarrhoea (Taylor, 2006). The prevalence of *Eimeria* spp. in The Netherlands is not totally clear. In studies in Poland and Germany prevalences of 12.5% and 8.6% have been found on conventional farms, respectively (Daugschies et al., 2004; Karamon et al., 2007). Although the prevalence of *Eimeria* spp. in non-captive animals in The Netherlands is unknown, it has been shown that *Eimeria* spp. oocysts were found in 58.5% of wild boars in Poland (Pilarczyk et al., 2004), *Eimeria* spp. or *Isospora* spp. oocysts in 4% of foxes in Iceland (Skirnisson et al., 1993), and *Eimeria* spp. oocysts in 19% of foxes in Sweden (Aguirre et al., 2000). These findings indicate that it might be possible that pigs with access to outdoor areas could get infected with coccidiosis by wild animals.

Overall, there does not seem to be a clear relationship between either indoor or outdoor housing and the occurrence of coccidiosis in pigs in The Netherlands. There are indications that the prevalence on outdoor farms may be higher, since levels of hygiene play a role and wildlife is also affected with different coccidia.

Cryptosporidium spp.

Cryptosporidium spp. is an protozoan, with which pigs can get infected if they ingest the oocysts. Cryptosporidiosis in young piglets can manifest itself through diarrhoea, in older pigs it can be subclinical or also be associated with diarrhoea (Taylor, 2006). Although no infections were found in a recent survey in pigs in The Netherlands (Eijck and Borgsteede, 2005), outdoor husbandry may be a risk factor. In Australia a higher prevalence of *Cryptosporidium* spp. in outdoor pigs was found, compared to indoor pigs (0.5% vs. 17.2%) (Ryan et al., 2003), and similarly in Croatia prevalence outdoors was higher than indoors (*Cryptosporidium* spp. + *Giardia* spp. outdoors 100% vs. indoors 38%) (Bilic and Bilkei, 2006). Of course the situations in these countries are difficult to compare with those in The Netherlands.

It is suggested that the high prevalence of *Cryptosporidium* spp. in outdoor pigs is mainly due to contamination of the environment; indoor pens with slatted floors are easier to clean than solid floors or pastures (Ryan et al., 2003). The problem thus is not so much in outdoor housing, but mainly in floor type, meaning that housing pigs indoors on solid floors or straw could also cause higher infection levels, and housing pigs outdoors on slatted floors could lead to a reduction. There may be a risk associated with outdoor housing, since wild animals can also be infected with *Cryptosporidium* spp. In Poland 14-17% of red deer, 7-9% of roe deer and 0-2% of wild boar were infected. Next to that, *Cryptosporidium* spp. oocysts were found in 0.6-19% of filth flies, and infection rates in birds ranged from 0-12.5% (reviewed by Bajer, 2008). It is however not clear what the importance of transmission via this route is.

Bacteria

There are numerous bacteria that can exert effects on the digestive system of pigs. They will not all be discussed here; the ones that are discussed in this chapter are the bacteria that are prevalent in pig farming, and/or can also have an influence on human health because they are zoonoses.

Campylobacter spp.

Campylobacteriosis is a disease that occurs in pigs; it can cause diarrhoea in piglets. Next to that it is also a zoonosis; consumers can get infected by eating contaminated pork (Jensen et al., 2006a). It has been shown that pigs on organic farms in Germany got infected with *Campylobacter coli* at an earlier age than pigs on conventional farms, although at the end of the fattening period no significant differences occurred anymore (average prevalence of 66.8%) (Alter et al., 2005). A Dutch study has found a prevalence of 55% on organic pig farms (n=31), which the authors argue is comparable to that on conventional farms (Hoogenboom et al., 2006). A study on *Campylobacter* spp. prevalence in conventional pigs in The Netherlands found this was 85% (Weljtens et al., 1993). More recent studies in France and Denmark found prevalences of 50-92% (Boes et al., 2005; Payot et al., 2004). So, research about whether the prevalence *Campylobacter* spp. in pigs is higher in indoor or outdoor systems is inconclusive.

The major cause of campylobacteriosis in humans is an infection with *C. jejuni.* It has been suggested that because of the prevalence of *C. jejuni* in wildlife, outdoor pigs could get infected with this more easily than indoor pigs (Jensen et al., 2006a). It has been shown that rats and crowbirds (e.g. jackdaws, magpies and crows) were infected with *C. jejuni* (Jensen et al., 2006a). However, the same research also showed that individual pigs hosted up to nine strains of *C. jejuni,* but their environment was usually contaminated with different strains. Only one strain was found to be identical for pigs, environment and birds. Another study also found no shared *Campylobacter* strains between rodents and pigs (Meerburg et al., 2006). This indicates that the outdoors pigs are not infected mainly by exposure to *C. jejuni* in the environment (Jensen et al., 2006a; Meerburg et al., 2006). On the other hand it has been suggested that outdoor housed animals are less susceptible to infections, because they usually have more space and access to roughage (Mikkelsen et al., 2004). This has however not been scientifically proven until now.

Salmonella spp.

Salmonellosis in pigs can occur in three forms. The septicaemic form will not be discussed here since it is not specific for the digestive system. The other two forms are the acute enteric and the chronic enteric forms. Pigs affected by the acute form may show diarrhoea, fever, weakness and nervous signs. In the chronic form the pigs are emaciated and have persistent diarrhoea (Taylor, 2006). Next to the devastating effects this disease can have on pigs, it is also a zoonosis; consumers can get infected by ingesting contaminated pork (Jensen et al., 2006b).

Research on differences in prevalence of *Salmonella* spp. between indoor and outdoor housed pigs is inconclusive. One study showed that in The Netherlands, free range finishing pigs had a higher seroprevalence of *Salmonella* spp. than conventional finishing pigs (25% vs. 11%) (Van der Wolf et al., 2001). However, the prevalence in organic finishing pigs (12.5%) did not differ significantly from that in conventional pigs (Van der Wolf et al., 2001). Also in sows the differences between conventional, free range and organic were not significant (10%, 11% and 5%, respectively) (Van der Wolf et al., 2001). The authors argue that the higher prevalence in finishing pigs on free range farms can be explained by the different floor types compared to conventional (solid floors with straw vs. (partially) slatted floors), resulting in increased pen contamination, by a longer lactation period, resulting in increased risks of vertical transmission from sows to piglets, or by the fact that free range pigs have more external influences, resulting in an increased risk of contamination from the environment. It has indeed been found that several wildlife species can be a source of *Salmonella* spp. infections. Rodents, birds and foxes have been shown to be infected with *Salmonella* spp., also with the same strains that occur in pigs (reviewed by Funk, 2004). It has been found that 5-10% of mice, 12% of cats and 8% of birds were infected (Meerburg and Kijlstra, 2007). Next to that, flies (prevalence 6% (Meerburg and Kijlstra, 2007)) and beetles can also act as vectors for *Salmonella* spp., although the risk that these animals impose for infecting pigs is still unclear (reviewed by Funk, 2004). However, these findings do not explain why the prevalence of the pigs on organic farms was the same as on conventional farms.

The exact prevalence of *Salmonella* spp. on pig farms however is unclear. Another study found a prevalence on organic farms of 27%, which the authors said was comparable with the ca. 30% on conventional farms (Hoogenboom et al., 2006), although another study revealed a prevalence of 47% on conventional pig farms (Swanenburg et al., 2001). Another outcome that was noticed was that when organic farms existed longer, the *Salmonella* spp. prevalence was lower than on farms that just started. It was argued this could be due to the fact that the longer existing organic farms fed more roughage and more diverse feed, which could influence the microflora of the intestines, leading to less colonisation of *Salmonella* spp. (Hoogenboom et al., 2006).

Another risk factor for *Salmonella* spp. infections in pigs is contamination by the environment. It has been found that *Salmonella enterica* from pig faeces persisted in soil for up to five weeks, which could pose a risk for the other pigs (Jensen et al., 2006b). This problem may be smaller in indoor housed pigs, especially when slatted floors are used, although also indoors eradication of *Salmonella* spp. is difficult (Taylor, 2006).

Overall, it is not totally clear whether *Salmonella* spp. infections in pigs occur more with indoor or outdoor housing. There seem to be risk factors related to outdoor housing, such as infections through contact with wildlife or contamination of the environment, but on the other hand other management factors that often go together with outdoor housing, such as feeding of roughage, can have positive effects on the occurrence of salmonellosis.

Lawsonia intracellularis

Lawsonia intracellularis can cause proliferative enteropathy in pigs; usually it affects recently weaned piglets, which show paleness, vomiting, anorexia and blood loss in the faeces. Morbidity and mortality can be up to 12% and 6%, respectively (Taylor, 2006). It seems that outdoor pigs have a lower infection prevalence of *L. cellularis* than indoor pigs, which has been found in several studies (Bona and Bilkei, 2003; Class and Bilkei, 2004; Hagen and Bilkei, 2003). One research found that the odds for finishing pigs to be seropositive were significantly lower for outdoor than for indoor pigs. The authors suggest a "lower stocking density, reduced stress and a more natural digestive flora from rooting in the soil" as possible reasons for this finding (Bronsvoort et al., 2001). In other studies, animals were serologically tested for *L. cellularis* at different ages, and the results are shown in Table 11. In all three studies the piglets of seropositive sows were followed over several weeks. It is clear that the outdoor pigs have a lower prevalence of *L. cellularis* than the indoor pigs. In one study it is suggested this is due to decreased reinfection rates, which are in turn due to dilution or denaturation of the organism (Class and Bilkei, 2004). It has indeed been found that *L. cellularis* can survive in extracellular conditions only for one to two weeks at 5-15°C (Collins et al., 2000).

Table 11: Percentages of L. cellularis seropositive pigs in indoor and outdoor housing.

		Age in weeks										
Reference	**Housing**	**2**	**6**	**7**	**10**	**12**	**14**	**17**	**18**	**22**	**26**	**27**
(Bona and Bilkei, 2003)	Indoor	-	-	-	71.1	-	71.1	-	52.1	47.8	21.7	-
	Outdoor	-	-	-	32.8	-	7.6	-	0	0	0	-
(Hagen and Bilkei, 2003)	Indoor	0	-	0	-	81.0	-	82.5	-	17.7	-	11.5
	Outdoor	0	-	0	-	51.0	-	31.3	-	7.4	-	0
(Class and Bilkei, 2004)	Indoor	0	0	-	74	-	68	-	23	15	11	-
	Outdoor	0	0	-	76	-	7	-	0	0	0	-

A risk factor for outdoor housing related to infections with *L. cellularis* could be contact with infected wildlife. A recent study has found a prevalence of 20.6% for *L. intracellularis* in wild boars in Germany (Reiner et al., 2011). Pigs get infected through the oral route (Taylor, 2006), but it is not clear whether the pathogens are exchanged between domestic outdoor pigs and wild boars (Reiner et al., 2011).

Respiration

Introduction

A serious problem that is found worldwide in the pig production sector are respiratory diseases (reviewed by Stärk, 2000). Respiratory diseases are mostly multifactorial problems due to both non-organic and organic causive agents. The economic impact of these diseases is considerable, which is mainly caused by reduced growth, reduced feed efficiency, and in some cases reduced fertility (Stärk, 2000).

Since intensive pig husbandry has turned indoors in the last twenty years, pigs reared in enclosed barns are continuously exposed to airborne contaminants like dust, gases, microtoxins and endotoxins, which can lead to multiple respiratory diseases and problems (Jolie et al., 1998). However, due to a number of reasons, keeping pigs outdoors does not seem to solve the problem, as it was found that the main diseases recorded for outdoor raised slaughter pigs were infections of the respiratory tract (reviewed by Cabaret, 2003). Also in The Netherlands it was found that respiratory problems are more present in organic than in conventionally raised pigs (Ruis, 2011).

The most relevant diseases that cause respiratory problems are pleuropneumonia, pneumonia, and pleurisy, which are caused by multiple agents. These diseases can lead to high morbidity, reduced growth, feed efficiency, fertility, and even mortality depending on the causive agents, which will have a considerable economic impact. In fact, respiratory diseases are among the most devastating diseases in intensive pig production (reviewed by Stärk, 2000). In this chapter an overview of the most prominent respiratory problems is given with the possible causes and the comparison of the prevalence between indoor and outdoor housing.

Pneumonia

Pneumonia is an inflammation of the lungs, which particularly affects the alveoli (small lung sacs were gas exchange takes place). It is usually accompanied by fever, coughing and fast breathing. Pneumonia is caused by an infection, which can be caused by a number of agents. These agents include viruses, bacteria, fungi, and parasites, but predisposing factors such as chemicals, dust, extreme temperatures and other irritants that may affect the respiratory tract also play a role (Lawhorn, 1998).

In The Netherlands, in the years 2001 and 2002, pneumonia was detected in 19.2% of the organic slaughter pigs, compared to 4.5% in conventionally raised pigs (Kijlstra and Eijck, 2006b). These animals seem to be mostly infected by *Mycoplasma hyopneumoniae* or *Actinobacillus pleuropneumoniae (APP),* both primary infection diseases for pneumonia, which means that no other infectious agents are necessary to make the animal ill (Stärk, 2000). These are further described below.

Mycoplasma hyopneumoniae

M. hyopneumoniae can be one of the causes of pneumonia and is present on almost all pig farms in The Netherlands. However, the severity of the symptoms varies highly per farm, from a dry cough to an increased mortality rate (Kijlstra and Eijck, 2006b). *M. hyopneumoniae* attacks the mucosa of the upper respiratory tract and weakens the lungs' normal defences; as a consequence other bacteria can strike, which can make the pneumonia more severe. The combination of a primary infection with *M. hyopneumoniae* followed by *Pasteurella multocida* is considered the most frequent form of pneumonia and is also called enzootic pneumonia (Lawhorn, 1998). The first infections with *M. hyopneumoniae* can already take place in the nursing barn. However, because the spreading of the disease is very slow, only later a chronic dry cough can be distinguished (Lawhorn, 1998).

The occurrence of a *M. hyopneumoniae* infection is highly dependent on barn climate and density. The presence of draught and fluctuating temperatures are factors that can enhance the chance of a *M. hyopneumoniae* infection (Stärk, 2000). Housing systems with access to outdoor areas have a more fluctuating climate and have usually more draught due to the outdoor entrances in the barn, which might explain the higher prevalence of pneumonia in organic pig herds.

Actinobacillus pleuropneumoniae (APP)

A. pleuropneumoniae can cause a severe or milder form of pneumonia dependent on the type, and usually occurs between the age of 8 and 26 weeks. This infection can be transmitted over short distances through respiratory secretions, by for example nose-to-nose contact. Symptoms include rapid breathing, bloody discharge from the nose and even sudden death (Lawhorn, 1998).

A. pleuropneumoniae infections are mainly caused by climatic stress through draught and fluctuating temperatures. It was proven that the immune response of pigs which are challenged with *A. pleuropneumoniae* is significantly influenced by fluctuating temperatures and draught (Stärk, 2000). This is, as explained earlier, more difficult to control in housings with outdoor access.

Lungworms

Lungworms can cause coughing and a mild pneumonia through the presence of worms and eggs in the bronchi and the migration of the larvae through the lungs, which causes irritation, hemorrhages and obstruction of airways by adults worms. The presence of lungworms make pigs also more susceptible for other bacteria such as *M. hyopneumoniae* (Lawhorn, 1998).

Lungworms that are present in pigs are *Metastrongyluselongatus, Metastrongylus pudendotectus,* and *Metastrongylus salmi,* which often co-exist. They have an indirect life cycle, where the earthworm is necessary as the intermediate host. The eggs of these lungworms have a thick resistant shell in which the embryos can develop. However, only when the eggs get swallowed by an earthworm they hatch and develop further. In this way the eggs in the soil as well as the infectious larvae in the earthworm can stay viable up to a couple of years (Nansen and Roepstorff, 1999).

Because of their necessary intermediate host, lungworm infections are largely restricted to outdoor pigs (Thamsborg et al., 1999). However in two comparing studies on parasitic infections in organic pig herds, infections with *Metastrongylus* spp. were not found among the pigs (Carstensen et al., 2002b; Carstensen et al., 2002a; Roepstorff and Nansen, 1994). The authors of these two studies argued that the main reasons for this finding were improved hygiene, better pasture rotation and better housing in general, compared to older studies to this subject (Lund and Algers, 2003).

In The Netherlands de-worming with anthelmintics is a normal procedure for conventional as well as organic farmers, so (lung)worm infections are normally no problem at these farms (personal communication with farmers). This seems to be a good solution to the problem of lungworms. However, it has to be taken into account that no residues may be present at slaughter and that resistance may develop in the worms for these anthelmintics, which requires a need to develop new possibilities to treat lungworm infections.

Pleurisy

Pleurisy is an inflammation of the pleural membrane (the lining of the pleural cavity which is surrounding the lungs), the serosal surfaces of the lung and chest cavity, which facilitate smooth inflation of the lung. The inflamed pleura layers rub against each other while breathing, which causes sharp chest pain. Symptoms can be coughing, sleepiness, fever and difficulty breathing (Jäger et al., 2012).

Significantly less chronic pleurisy was found in Swedish organic pigs compared to conventional (Hansson et al., 2000a; Hansson et al., 2000b). Hansson et al. (2000) found in a comparison of carcass quality in organic and conventional meat production in Sweden that in conventional reared pigs pleurisy was the most common pathological finding with 7.4% of the slaughtered pigs being infected. In organic carcasses only 1.8% were found to be infected, see Table 12.

Table 12: Lesions in 3,464 organic and 3,963,799 conventionally reared growing-finishing pigs slaughtered in 1997 in Sweden (Hansson et al., 2000).

	Organic (%)	Conventional (%)
Pneumonia	0.6	0.7
Pleurisy	1.8*	7.4

** Significant difference between organic and conventional (P<0.001)*

Pleurisy is mainly caused by dust, ammonia, and carbon dioxide in combination with infectious microbes. Ammonia can enhance the effect of pathogens to cause pleurisy, by its reduction of the ciliary activity in the respiratory tract, which enhances the attachment of pathogens. This explains the fact that pleurisy is less prevalent in organic herds, because of the day and night access to fresh air causing lower exposure to ammonia, dust and other toxic gases than in conventional housing (Stärk, 2000).

Air quality factors

Air contamination with ammonia, dust and hydrogen sulphide is a common problem in indoor housing, which can lead to inflicting toxic effects on the respiratory tract for workers as well as pigs.

Ammonia

Ammonia becomes irritating to mucous surfaces in the respiratory tract and eyes at 100-500 ppm. Coughing, severe irritation of the eyes and possible fatale endings occur at 2,000-3,000 ppm and it is rapidly fatal at 10,000 ppm (Kijlstra and Eijck, 2006b; Kim et al., 2005).

In enclosed pig barns ammonia is reported to cause convulsions, irregular breathing and a reduced appetite in pigs (Hansson et al., 2000a; Hansson et al., 2000b). It is also an important cofactor in the origination of atrophic rhinitis or enzootic bronchopneumonia (Seedorf and Hartung, 1999). Several behavioural studies have shown that pigs prefer fresh air sites, without ammonia (Cabaret, 2003; Carstensen et al., 2002b; Carstensen et al., 2002a). When pigs have access to an outdoor area with fresh air and natural ventilation of the barn, ammonia levels in the barn will be lower, which favours outdoor farming (Møller, 2000).

Hydrogen sulphide

Hydrogen sulphide originates from an anaerobic degradation of the manure and respiration of the pigs (Thamsborg et al., 1999). Hydrogen sulphide causes irritation to the eyes and respiratory tract at 50-100 ppm for one hour, it can be fatal at 150 ppm with an exposure of between 8-48 h and can cause rapid death at 700-2,000 ppm (Hansson et al., 2000a). In pigs it was reported to cause a loss of appetite and photophobia (fear of light) at 20 ppm, and diarrhoea and vomiting at 50-200 ppm (reviewed by Kim et al., 2005). In indoor housing with poor ventilation this can be a big problem. In pigs that have access to outdoor areas these problems are probably prevented by their day and night access to fresh air and natural ventilation of the barn.

Dust

Dust in pig barns is proven to cause severe respiratory health issues in several experiments (Møller, 2000; Nansen and Roepstorff, 1999; Pedersen et al., 2000). The composition of dust found in pig barns is a mixture of organic and inorganic particles and several gases absorbed in aerosol droplets (Pedersen et al., 2000). These particles originate from a variation of sources including dried faeces and urine, skin flakes, spores, pollens, grain mites, a range of microorganisms and their cell wall components and feed and bedding particles. The solid part of dust can act as a transporter of microbial components and products and gases, which will be inhaled deep into the lungs (reviewed by Kim et al., 2005; reviewed by Pedersen et al., 2000). These may induce respiratory disorders like bronchitis, rhinitis and pneumonia (Nansen and Roepstorff, 1999). This information corresponds to the fact that the amount of dust is correlated with as well ammonia, odour and airborne bacteria. Dust is also found to be significantly correlated with temperature and relative humidity (Table 13) (Kim et al., 2005).

Table 13: Correlation of airborne environment risk factors and temperature and relative humidity observed in the enclosed pig building (Kim et al., 2005).

Variable	Temperature	Relative humidity	Odour index level	NH3	H2S	Total dust	Total bacteria
Temperature	1.00						
Relative humidity	-0.24	1.00					
Odour index level	0.62*	-0.43	1.00				
NH_3	0.57*	-0.44	0.55*	1.00			
H_2S	0.36	-0.25	0.44	0.28	1.00		
Total dust	0.69**	-0.52*	0.62*	0.64*	0.36	1.00	
Total bacteria	0.61*	-0.30	0.42	0.43	0.31	0.57*	1.00

*Significant correlations indicated by *P<0.05; **P<0.01*

In a study of Møller (2000) it was concluded that pigs housed with natural ventilation and with access openings to outdoor areas had consequently lower concentration of dust, ammonia and carbon dioxide compared to enclosed pig housing systems. However, in organic farming providing straw to the animals is obligatory. Providing straw can lead to a higher level of dust and bio-aerosol levels in pig barns (Kijlstra and Eijck, 2006b). Also when straw bedding is used, the endotoxin levels in dust may double from 40 ng per mg dust to 80 ng per mg dust, leading to very high endotoxin levels (Kijlstra and Eijck, 2006b). Because the pig's lung is very sensitive to these endotoxins, the chance of respiratory problems occurring is very high (Kijlstra and Eijck, 2006b).

From this information it can be implicated that dust is a carrier of aerial risk factors. Where low air volume and high stocking density are risk factors for poor air quality, outdoor pigs will have lower levels of these factors that cause respiratory diseases (Stärk, 2000). However, the obligatory provision of straw bedding in organic pig farming might cause more dust to be present than in conventional barns. Therefore, dust might be one of the most prominent causes of respiratory problems in organic pig husbandry.

Draught

Draught is time-unpredictable and uncontrollable forced cold air in the barn that originated from insufficient isolation or air holes (Scheepens et al., 1991). Draught can contribute to the occurrence of respiratory diseases as pneumonia and pleurisy, as it decreases the immune responses of the pigs to their infectious agents (Stärk, 2000). Draught is more difficult to control in systems with outdoor access, due to the always accessible outdoor areas in the barn, which are difficult to insulate and can always be opened (personal communication with Ir. H.M. Vermeer). Therefore draught might be, together with dust, one of the prominent causes of respiratory problems in the organic pig production sector.

Reproduction

Introduction

Through the years the reproductive function of pigs has been extensively researched. These studies have shown that there are many different conditions and factors influencing the reproduction of sows. Therefore, it was expected that the fluctuations in environmental conditions in outdoor systems compared to the stability of indoor systems will have an influence on the reproduction performance of outdoor sow herds (Buckner et al., 1998; Larsen and Jørgensen, 2002). Research shows that this is true and also that it is very difficult to compare published reproductive data between indoor and outdoor systems. This because of different factors influencing the systems such as feeding, climate, environmental circumstances, pathogenic pressure, soil type, reproductive management and genetic differences (reviewed by Bilkei, 1995; reviewed by Wrathall, 1990). The possible effect of the outdoor systems on the reproduction in sow herds are mainly due to management. Research of Karg and Bilkei (2002) even mentioned that reproductive problems in an outdoor herd can be seen as a lack of initiative by the management to achieve production targets such as; high parity at culling, low mortality and culling rates, large numbers of piglets born, live born and weaned piglets with a low number of non-productive days (reviewed by Karg and Bilkei, 2002). In this chapter we discuss the effects found for fertility between indoor and outdoor housing, seasonal infertility, parasitic infections, shelter use and indicators for piglets survival.

Sows

Besides conventional farming systems in Europe, a new way of housing sows is outdoor husbandry. In outdoor husbandries all sows are housed outdoors and are loose during lactation (Akos and Bilkei, 2004). The research of Akos and Bilkei (2004)(2004) compared the reproductive performance of sows in Croatia who were kept outdoors with that of sows kept indoors. The purpose of this research was to describe and analyse the level of and the variation in reproduction results obtained in several outdoor production systems for which detailed information on management practices exists. In this study, twenty-one indoor and twelve outdoor herds with the same feeding, similar genetics and health status were evaluated. The results showed that sow which were kept indoors stayed significantly longer in the sow herd than outdoor sows which means that sows kept indoors have a significantly higher lifetime reproduction performance (Table 14). This can also be seen at the culling rates, where culling is significantly higher in outdoor husbandry for sows in anoestrus and locomotion problems (Akos and Bilkei, 2004). Therefore, sows kept indoors have a longer lifespan and are less like to be culled for locomotion problems and between periods of reproduction.

The reproduction of an outdoor sow is influenced by the; life expectancy, length of lactation, and the litter size. The total piglets born to indoor sow herds were higher than outdoor herds in; liveborn piglets and piglets weaned (Table 14). The large percentage of the lifetime non-productive days can be seen in the shorter herd life for outdoor sows (Akos and Bilkei, 2004; Cox and Bilkei, 2004). This increase in indoor sow reproduction rate can partly be explained through the longer lactation period required in the outdoor husbandry, piglets may not be weaned until 40 days of age (Com-EU-Communities, 2008) compared with 28 days (Varkensbesluit, 2012) in conventional which means that sows in outdoor herds have a potential lower number of produced litters per sow per year (Kongsted and Hermansen, 2009). Also, the number of piglets per litter is lower for organic farming systems (Baxter et al., 2009). Therefore, the overall reproduction rate in outdoor sows is less than indoor sows.

Table 14: Lifetime performance of indoor or outdoor kept sows in large Croatian pig production units (Akos and Bilkei, 2004).

	Outdoor	Indoor	*P*
Parity at removal	3.01±0.27	4.52±0.54	<0.01
Non-productive sow days (%)	34.9±5.0	12.9±1.4	<0.001
Average annual sow mortality rate (%)	5.8±1.1	8.9±2.1	<0.05
Lifetime cumulative counts of total pigs born	36.1±2.0	54.1±4.2	<0.01
Lifetime cumulative counts of born alive	33.2±1.1	49.3±3.3	<0.01
Lifetime cumulative counts of weaned	19.4±1.2	41.2±3.1	<0.001
Herd days	561±13	659±21	<0.01

Then the rates of mortality in in- and outdoor sows were compared, the literature has mixed results to which housing type has a higher mortality. The research of Akos and Bilkei (2004)(2004) shows that sows which are kept indoors compared with sows outdoors had significantly higher average annual mortality rate. On the other hand, a study in Hungary shows the opposite after an evaluation period of four years, significant lower average annual mortality rates for indoor herds than in outdoor herds (reviewed by Karg and Bilkei, 2002). However, for both studies the principal reasons for culling of sows in outdoor systems were anoestrus, locomotion problems, swine urogenital disease, periparturient disease (mastitis metritis agalactia (MMA), and heart failure. Of these principal reasons for culling, culling for the periparturient disease MMA and heart failures were higher in indoor systems.

An obvious reason for higher culling rates in outdoor compared with indoor is that observation and identification of the sows is more difficult and the delay in disease detection can result in the sows having a more severe form of the disease. The periparturient period of the reproductive cycle in outdoor farms is characterized by 40.1% of the sows deaths while in indoor farming the majority of mortality happened during lactation (40.2%) (Akos and Bilkei, 2004).

It should be noted that studies mentioned above are comparing completely different housing systems, and that the reproduction obtained in outdoor systems not necessarily different from reproduction results obtained under controlled conditions in indoor systems. In general the published data between indoor and outdoor systems is difficult to compare because of the different farming systems, different countries and different factors like unfavourable climate and environmental conditions for outdoor. Management is very important in outdoor farming to reduce the differences between indoor and outdoor housing.

Seasonal infertility

Seasonal infertility is a term which describes poor reproduction in the sow herd in different seasons and results from a combination of the effects of day length and high temperatures (Taylor, 2006). Both indoor and outdoor farmers have reported seasonal infertility and it may be specific to one farm whilst neighbouring herds remain unaffected (Thornton, 1988). Research shows that seasonal infertility occurs significantly more in outdoor farming systems than in indoor systems (Akos and Bilkei, 2004; reviewed by Karg and Bilkei, 2002).

The temperature experienced by the pigs is very important to the reproduction capacity of the herds. Research of Kongsted and Hermansen (2009) showed that sexual activity was low during winter because the pigs found it difficult to walk on the frozen, uneven surface. So avoiding these types of surfaces with very low temperatures is important when planning the boar introduction. Also, pre attach embryo survival is known to be reduced significantly when ambient temperatures and humidity are high and this can be caused by elevated body temperatures of the pregnant female (Taylor, 2006). This can result in death of the pre attached embryo (Taylor, 2006). Therefore seasonal infertility, or anoestrus (a period when cyclicity stops), probably evolved as a way of preventing females from conceiving during periods of the year when survival of the developing embryos and the newborn piglet would be low (Senger, 1997). Sows can become anoestrus (a period when cyclicity stops) for a period of 19 weeks (Taylor, 2006). So, the sows in outdoor systems are housed under different conditions compared to indoor sows which greatly affect the entire reproduction cycle (Akos and Bilkei, 2004)(Akos and Bilkei, 2004). When the longer lactation period required for organic is included in the calculation, this will result in a lower number of produced litters and lesser weaned piglets per sow per year (Kongsted and Hermansen, 2009).

To decrease the non-productive days in an outdoor sow herd, requires increasing sow productivity. One potential way to increase the productiviety is lactational estrus (Alonso-Spilsbury et al., 2004; Kongsted and Hermansen, 2009)(Alonsso-Spilsbury et al., 2004). Lactational estrus is inducing pregnancy during lactation which reduces the period between farrowings without decreasing the lactational period (Mota et al., 2002). Besides pregnancy during lactation, lactational estrus would allow delayed weaning of piglets beyond 40 or 49 days of age without jeopardizing sow productivity which comply with principles of organic farming (Kongsted and Hermansen, 2009). There is no reduction of the animals' prolificacy, nor litter performance, because piglets will continue suckling while the dam is pregnant (Mota et al., 2002). Lactational estrus would even have a positive impact on the health and productivity of piglets and reduces the risk of weaning diarrhea (Jensen and Stangel, 1992).

To increase the possibility to obtain a better timing of lactation estrus, data of organic sow herds were compared with existing data of conventional sow herds (Kongsted and Hermansen, 2009). For this research they used the same stimulating factors like group housing and boar introduction. The results showed that sows showed signs of lactational estrus between 34 and 52 days after farrowing and after introducing the boar 84% of the sows showed estrus within day four and ten (Kongsted and Hermansen, 2009). This is an improvement in timing of lactation estrus compared with previous reports (reviewed by Petchey and Jolly, 1979; reviewed by Rowlinson et al., 1975; reviewed by Rowlinson and Bryant, 1981). It will be a good method to increase the number of farrowing and production per sow per year in organic farming systems (Kirkwood and Thacker, 1998). However, to make it more practical for the producer, further research has to be done on the different factors that contribute to the induction of lactational estrus (Kongsted and Hermansen, 2009; Mota et al., 2002).

Parasitic infections

An parasitic infection in The Netherlands which has a major influence on fertility and reproduction is the protozoan parasite *Toxoplasma gondii*. Infection by the protozoan parasite *Toxoplasma gondii* is widespread in humans and many other species of warm-blooded animals. Infection with Toxoplasma gondii is usually unapparent, but may result in abortion, stillbirth and the production of weak piglets (Taylor, 2006).

Pigs can be infected by *Toxoplasma gondii* through ingestion of oocysts or tissue cysts in faeces of juvenile cats. *T. gondii* is namely a coccidian parasite of juvenile cats which produce its oocysts in feaces. Ingestion results in the release of sporozoites or bradyzoites in the stomach and these quickly reproduces in the intestinal epithelium as tachyzoites and can be found in the blood between 108-120 hours, spreading to all parts of the body including the foetus. Abortion may occur in sows infected between 42 and 50 days of gestation and results in mummified, stillborn, and birth of weak piglets who may develop diarrhoea and ataxia or incoordination (Taylor, 2006).

A study from RIVM and VWA (2007) with 40 organic, 9 free range and 24 intensive farms showed that the seroprevalence of antibodies specific for Toxoplasma gondii is higher in pigs housed in husbandries where there is contact with the environment compared with intensive indoor husbandries (Table 15).

Table 15: Effect of farm type on Toxoplasma seroprevalence of slaughter pigs (2001/2002 study) (RIVM, 2007).

Farm type	% Toxoplasma positive pigs	% Toxoplasma positive farms
Organic	1.2	18
Free range	4.7	59
Regular	0	0

Site surveys done to detect various possible risk factors for Toxoplasma infections on 36 of the participating farms showed that access of cats to the farm premises, the use of compost and goat whey, and inappropriate rodent control were identified as possible risk (Table 16) (Kijlstra and Eijck, 2006a; Kijlstra and Eijck, 2006b; RIVM, 2007).

Table 16: Odd ratio estimates for Toxoplasma seroprevalence on organic pig farms (RIVM, 2007).

Factor	Odds ratio	Significance
Feeding goat whey	6.67	<0.01
> 3 cats on the farm	2.07	0.15
Roughage not covered	13.45	<0.001
Contact cat feces possible	4.55	<0.01

Treatment and prevention is (technically) possible but not practised in pigs. Prevention can be done by keeping away cats from pigs, their pens and their feed, and control of pigs. Also vaccination of cats for Toxoplasma gondii can reduce infection in pigs but this is not feasible to do for farmers vaccinate every stray cat in the area.

Shelter use

Outdoor sows are housed in a wide range of different climatic conditions than compared with conventional housing systems. Therefore, it would be expected that these different climate conditions have an influence on the behaviour of pigs (Buckner et al., 1998). Given the pigs the possibility to choose between environments, pigs were able to discriminate between conditions leading to excess heat loss or production, and those which were thermoneutral (reviewed by Mount, 1968).

Outdoor husbandries in different countries and especially in The Netherlands pigs have access to adequate shelter (Skal, 2012a). Studies on shelter-seeking behaviour of groups of young pigs housed outdoors has shown that the pigs respond to changes in the climatic environment (Ingram and Legge, 1970). Ambient temperatures above 5 °C had a little effect and radiant temperatures had no effect on shelter-seeking behaviour. However on rainy days the pigs were observed to be outside their huts less than normal and windiest parts of the paddocks were avoid by the pigs (Buckner et al., 1998). Research of (Buckner et al., 1998) examined if sows pregnant, prefarrowing, postfarrowing and lactating showed different behaviours through the four seasons. Their research showed that prefarrowing sows spent a significantly larger part of their time outdoor sitting, lying or wallowing during spring and winter (Table 17). Prefarrowing sows spent more time resting and sleeping outdoors at night compared with other sows. This behaviour appears to be driven by the need to lose heat, and the reduction in their mobility due to their increased foetal load. Interestingly, the last weeks of pregnancy sows had an increase in heat production (reviewed by Verstegen et al., 1971).

Table 17: Proportion of observations spent engaged in various activities by sows when outdoors during daylight hours (Buckner et al., 1998)

Season	Stage of reproductive cycle			
	Pregnant	**Prefarrowing**	**Postfarrowing**	**Lactating**
Spring				
Standing/walking	0.104 (0.047–0.173)	0.097 (0.061–0.117)	0.036 (0.031–0.089)	0.093 (0.075–0.128)
Foraging	0.225 (0.120–0.359)	0.095 (0.053–0.160)	0.041 (0.040–0.100)	0.186 (0.093–0.314)
Feeding/drinking	0.041 (0.025–0.072)	0.060 (0.047–0.062)	0.045 (0.033–0.051)	0.057 (0.038–0.092)
Inactive	0.068 (0.002–0.227)	0.219 (0.153–0.330)	0.026 (0.015–0.075)	0.066 (0.012–0.250)
Summer				
Standing/walking	0.071 (0.035–0.150)	0.095 (0.086–0.165)	0.047 (0.036–0.080)	0.077 (0.055–0.131)
Foraging	0.256 (0.136–0.309)	0.153 (0.090–0.237)	0.054 (0.037–0.088)	0.163 (0.047–0.306)
Feeding/drinking	0.042 (0.002–0.058)	0.058 (0.031–0.072)	0.029 (0.022–0.048)	0.060 (0.020–0.085)
Inactive	0.049 (0.001–0.401)	0.098 (0.054–0.297)	0.039 (0.001–0.092)	0.071 (0.003–0.441)
Autumn				
Standing/walking	0.077 (0.050–0.196)	0.116 (0.044–0.124)	0.057 (0.056–0.0580	0.082 (0.038–0.127)
Foraging	0.280 (0.131–0.451)	0.182 (0.107–0.301)	0.052 (0.050–0.053)	0.159 (0.058–0.405)
Feeding/drinking	0.065 (0.035–0.108)	0.083 (0.052–0.112)	0.047 (0.037–0.056)	0.087 (0.064–0.121)
Inactive	0.015 (0.000–0.247)	0.050 (0.007–0.362)	0.003 (0.000–0.006)	0.017 (0.000–0.168)
Winter				
Standing/walking	0.116 (0.046–0.262)	0.134 (0.066–0.390)	0.042 (0.024–0.086)	0.103 (0.052–0.311)
Foraging	0.276 (0.132–0.522)	0.181 (0.130–0.366)	0.043 (0.010–0.116)	0.214 (0.099–0.393)
Feeding/drinking	0.050 (0.021–0.089)	0.090 (0.053–0.113)	0.041 (0.013–0.059)	0.064 (0.020–0.161)
Inactive	0.002 (0.000–0.080)	0.063 (0.014–0.250)	0.001 (0.000–0.030)	0.003 (0.000–0.034)

The sows in the other reproductive stages spent the majority of the time during darkness within their huts (Table 18). During pregnancy, sows spent the least part of their time in the summer in an inactive state in comparison to the other sows. In general outdoor sow behaviour is strongly related to the stages of reproductive cycle, while the climate had a considerably smaller effect (Buckner et al., 1998).

Table 18: The estimated proportion of the total 24-h day spent outdoor by sows based on the assumption that sows spent all time during darkness inside their huts (Buckner et al., 1998)

Season	Stage of reproductive cycle			
	Pregnant	Prefarrowing	Postfarrowing	Lactating
Spring	0.284 (0.153–0.387)	0.292 (0.194–0.362)	0.093 (0.071–0.190)	0.288 (0.125–0.459)
Summer	0.282 (0.209–0.510)	0.302 (0.224–0.424)	0.111 (0.077–0.177)	0.259 (0.084–0.509)
Autumn	0.229 (0.105–0.338)	0.244 (0.125–0.1371)	0.077 (0.070–0.084)	0.183 (0.081–0.353)
Winter	0.150 (0.102–0.349)	0.148 (0.096–0.411)	0.048 (0.033–0.076)	0.138 (0.069–0.317)

Piglets

Reasons for piglet mortality in indoor systems is studied many times, but little is known about piglet mortality in outdoor systems (Edwards et al., 1994). The average mortality rate is influenced by a number of factors, including the animals environment, health care, management of the farmer, nutrition and genetics of the sow and/or piglets (RSPCA, 2008).

For European pig producers which keep outdoor breeding sows, high levels of neonatal piglet mortality is an important problem (Edwards et al., 1994). Compared with indoor husbandries, pig mortality in outdoor is higher, especially in second litters were the piglets get crushed faster (Vieuille et al., 2003). The main reason for this is not known, but it seems that piglets from primiparous sows (sow pregnant for the first time) move quicker away from the sow when she changed her position and that primiparous sows reacted more to the squeals emitted by trapped piglets (Vieuille et al., 2003).

The weight of the piglets is also an important factor for being crushed. Large litters contain more piglets with a lower birth-weight (Edwards et al., 1994). Lower birth weight means smaller piglets have a higher risk of becoming hypothermic and lethargic (Edwards et al., 1994). Research of Baxter et al. (2008) supported this. He found that piglets that died pre-weaning had lower birth rectal temperatures so it can be suggests that susceptible piglets might have lower homoeothermic capabilities. Since these piglets have higher risk of becoming hypothermic, piglets need to warm themselves next to the mother which leads to the risk of being crushed.

Pre-weaning mortality is defined as the percentage of piglets that are born alive per litter that die prior to weaning (Senger, 1997). The major causes of preweaning mortality are perinatal mortality and gastrointestinal problems (Akos and Bilkei, 2004)(Akos and Bilkei, 2004).

A possible recommendation found in the literature is that providing optimum nutrition to the sow during gestation and lactation have a positive effect on the piglet birth weight and also survival. Also sufficient amount of straw available or the amount of grass on the paddock can improve the survival of the piglets neonatal (Berger F., 1997; Chambre d'Agriculture des Pays de La Loire, 1933). Also, farmers and legislation writers cannot compare the reproductive rate of the indoor and outdoor sows because of the different conditions experienced by the pigs. Therefore, the reproduction aspect of pig farming should not be a reason to decide for or against outdoor husbandry.

Skin/behavioural problems

Introduction

Skin lesions are defined as damage to the dermis of the pig. Most skin lesions occur when pigs are interacting with other pigs or their environment. Generally, they are a result of different redirected pig behaviours. This section will examine the skin lesions with regard to the physical health of the pigs between the general farming systems of indoor and outdoor pig husbandry. To provide a broad basis, this section will cover behavioural problems associated with skin lesions. The first section will consider injuries associated with oral behaviour; tail biting, aggressive biting, nosing and chewing behaviours. The second section will comprise of infectious disease based skin lesions. The third section will cover the problems with sunburn.

Oral behaviour

The pig's omnivore diet has resulted in sharp front teeth. It is the presence of these teeth in combination with abnormal feeding behaviours which cause most of the skin lesion seen in this section.

Tail biting

There has been extensive research on tail biting because of the enormous economic and welfare problems that arises with its occurrence. Tail biting has been documented since the pig moved indoors and farms intensified (Schrøder-Petersen and Simonsen, 2001). The monetary loss is due to the need to discard injured pigs on the farm and slaughter house (Moinars, 2003). Additionally, pigs experience both acute and chronic pain from having the tail bitten and the infections that follow, which greatly reduces their welfare.

Tail biting generally is reported to begin after weaning (Moinars, 2003). Tail biting behaviour is displayed in two different types, which are categorised by the frequency and viciousness of the biting. Acute biting (cannibalism) starts suddenly and death follows, which is difficult to stop (Schrøder-Petersen and Simonsen, 2001). On the other hand, chronic biting is documented by gradual build-up; first mouthing the tail, this will cause open wounds which get infected and spread to other parts of the body, or the tail is bitten till it is removed (Schrøder-Petersen and Simonsen, 2001). Even mild tail biting can lead to infections in lungs, muscles, or bones, all of which greatly reduces the welfare of the pig and the meat's value (Schrøder-Petersen and Simonsen, 2001). Interesting, tail biting is not seen in any of the wild relative of the pig family, *Suidae*, nor in feral pigs (Taylor et al., 2010). Tail biting is caused due to boredom and stressors which reroutes foraging behaviour and has a negative impact on other pigs (Sutherland and Tucker, 2011). Therefore, it seems that tail biting is a side effect of the breeding and housing conditions in the modern pig husbandry sector.

Since tail biting is a common problem, there have been many comparative studies to analyse the prevalence of tail biting in different environments. In these studies, there has been found a range of tail biting on the various farms of 0.1% - 72% (Sutherland and Tucker, 2011). Within indoor systems, slatted floor had a higher instance of tail biting than deep litter straw pens with concrete flooring and enrichment (Weerd, 2005). Furthermore, tail biting occurs more in conventional indoor farms than outdoor farms (Cagienard et al., 2005). The lower rate of tail biting in outdoors farms suggests that the condition on the outdoor farms alleviate the foraging needs of the pigs more than indoor farms.

The only study which found tail biting in outdoor farms was in Croatia. Before this study, there were no known published findings on tail-biting in outdoor production (Walker, 2006). This Croatian study was performed on five farms where the outdoor system consisted of; five paddocks for 25-30 finishing pigs of 200 m^2 with huts of 20 m^2 and straw bedding (Walker, 2006). The experiment was done in the winter months because it was then that tail biting was generally noted (Walker, 2006). The rate of biting was significant but tail biting varied significantly between the farms even though the five farms were identical (Walker, 2006). Since the farms had sufficient space and rooting opportunities, the authors hypothesised that genetics, lung illness, insufficient diet, or normal foraging could have initiated the tail biting behaviour (Walker, 2006).

There is no direct condition that has been found to be the source of tail biting. However, studies have pinpointed irritations in the environment have been found to increase tail biting, i.e. the presence of neon light (Chambers, 1999) or a lack of ventilation (Moinars, 2003). Moreover, other studies note that at high stock densities, there is an increased likelihood that pigs will come into contact with a tail and the bitten pig cannot escape, thus more tail biting occurs (Sutherland and Tucker, 2011). Additionally, if the animal is sick with a respiratory illness they have been found to tail bite more often (Moinars, 2003). Also, breeding to reduce the pig's back fat may be effecting the pigs behaviour. An extra millimetre of back fat was found to reduce the risk of tail biting by 1.5 times (Moinard et al., 2003).

It is believed that tail biting stems from the pigs trying to find outlet for the inclination to explore and forage (Sutherland and Tucker, 2011). This is due to the fact that intensive farming limits the ability for foraging and socially interact with other pigs in a natural way, via farrow pens or crates (Moinars, 2003). Despite the extensive research done, there is a gap of knowledge in the literature of the numbers of biters, generally the number of pigs that are bitten are recorded (Taylor et al., 2010). This lack of data on the exact number of biters makes it very difficult to design manipulation experiments on tail biting. However, the research does indicate that the following factors have an affect; lighting, lack of clean air, illness, number of pigs, and the limitation of space.

There are alternatives to the normal conventional farmingenvironment that reduce tail biting on intensive farms. There have been extensive studies on enrichment items to reduce tail biting, i.e. rubber hose or chains (Zonderland et al., 2008). Tail biting can be temporarily diverted by enrichment of novel items, unfortunately the tail biting resumes after the novelty of the items is reduced (Schrøder-Petersen and Simonsen, 2001; Sutherland and Tucker, 2011; Weerd, 2005; Zonderland et al., 2008). When pigs are given roughage, a mixture of barley and peas plants, they have significantly fewer lesion on their tail, ears, and body (Olsen, 2001). Redirected oral behaviour was reduced when roughage was used in their diet. However, Olsen (2001) stated that the use of roughage alone is not enough if the pigs are kept indoors with the foraging activities restricted. The other alternatives are to add straw or enrichment, or to separate the tail biter from the group; however these are not completely effective and it can be difficult to identify the biter (Sutherland and Tucker, 2011). Alternatives that temporally add to the environment do not enough diminish the restrictions of existing environment.

Tail docking is used as a preventative for tail biting (Sutherland and Tucker, 2011). Tail docking does reduce the behaviour, but does not stop the problem (Sutherland and Tucker, 2011). A side effect, is the procedure is painful to the pigs, i.e. more vocalization and stress movement than control pigs (Sutherland and Tucker, 2011). Even though tail docking is common it is still considered controversial, because of the perceived pain (Sutherland and Tucker, 2011). Tail docking is very common in Belgium, Denmark, France, Ireland, The Netherlands, Spain, and the United Kingdom. However, tail docking is not common everywhere, it is rare in Finland, Norway, Sweden, and Switzerland (Sutherland and Tucker, 2011). So, tail docking in generally considered to reduce the behaviour. However, since docking is a painful procedure which is not entirely effective at preventing tail biting and it is not even used in some countries, it is hard to advocate its continued use.

In conclusion, tail biting is a regrettable consequence of the pig denied foraging while exposed to stressors. While, it is still noted in outdoor farming, indoor farming without deep litter has consistently higher rates. It was noted by Schrøder-Petersen and Simonsem (2001) that tail biting could be utilized as an indicator for insufficient living conditions.

Aggression biting

Aggressive biting in pigs stems from the need to establish a hierarchy (Cagienard et al., 2005). The aggression is more common in farmed pigs compared to natural circumstances because of massive mixing compared to the individual introduction that occur in nature. Moreover, there is less space in conventional farms for the required submission movements during mixing (Turner et al., 2006).

There are two types of bites that occur during mixing, which can be distinguished by the area bitten on the pig. Biting lesions caused by reciprocal fighting between two rivals are generally found to the front of the pig; while biting resulting from bulling is seen in the posterior (Turner et al., 2006). Turner et al. (2006) established that the ratio of skin lesions on the head, neck, and shoulders is linked to the aggression per individual. Therefore, the aggression witnessed on farms is partly the housing system, but also due to the specific pig.

When examining the fighting in different indoor systems, there is a contradiction of results. One study states, indoor flooring types do not make a significant difference in the skin lesion or aggression when pigs are mixed (Weerd, 2005). While another study notes, that skin lesions in intensive indoor farms with slatted floors were higher than deep litter straw bedding with fewer animals per pen (Moinars, 2003). In outdoor pigs there was no difference between the last two flooring systems (Edwards, 2005).

On the other hand, there are several studies that agree that outdoor husbandry has less fighting than intensive indoor farms. When there is less room, there are more lesions on the ears and shoulders when mixing the pigs, because the submissive pigs cannot run away (Cagienard et al., 2005). Furthermore, confined piglets are more likely to act aggressively when mixing before the slaughter (Hötzel, 2004). The stress levels before slaughter were lower in outdoor farmed pigs which could been seen by fewer skin lesions and lower stress hormones levels from fighting than indoor pigs (Foury et al., 2011). Therefore, the amount of space available to the pigs during their life and transport influences the amount of fighting and welfare of the pigs.

In conclusion, confinement increases the intensity of aggressive biting because the submissive pigs cannot run away and therefore will have more extensive wounds. When pigs are kept in large deep litter pens or outdoor, there are fewer lesions than in conventional holding areas. Also, the exposure to an outdoor area during their life can reduce the stress of the pigs. Therefore, biting can reduce when the setting changes.

Nosing and chewing

Belly nosing and other agonist nosing behaviours are more prevalent with indoor piglets during weaning than outdoor piglets (Hötzel, 2004). The oral fixation such as, belly nosing, which is an action when the piglets attempts to suckle on other piglets when separated from their mother, is seen at high rate in confined piglets (Weary et al., 1999). In free range piglets who begin to root around week four, and there is no evidence of damaging oral behaviour to other animals even when observed to week seventeen (Petersen, 1994). The frequency of mother-offspring interaction is also important, a lower frequency of contact in the outdoor pigs stems from the choice of the sow to temporarily remove herself from the piglets, which motivates the piglets to forage and this can reduce later distress (Hötzel, 2004). Therefore, the management of the sows movement is very important to prevent belly nosing in piglets.

Other basic oral behaviours of indoor and outdoor pigs are similar, because they chew the available substrates; pigs in pasture chewed grass, pigs in mud or soil chewed the rocks or soil, and crated pigs chewed on the bars or the neighbouring pigs (Dailey and McGlone, 1997). Interestingly, outdoor pigs used the top of their snouts more than indoor pigs when foraging (Dailey and McGlone, 1997). This could indicate a higher oral fixation from indoor piglets. Furthermore, confined piglets occupy more of their time with oral-nasal behaviours then outdoor pigs (Hötzel, 2004). When they are adults there are more skin lesions on the snouts due to pigs attempting to dig into the hard floor (Cagienard et al., 2005). Since, the behavioural needs of the pig do not change when it is housed differently, housing that is less suited for these behaviours will result in more skin lesions.

Infectious disease based skin lesions

The two diseases, mange and neocrotic skin, have been associated with skin lesion have not been compared between the indoor and outdoor housing systems. However, these diseases effect the welfare of the pig and the price of the pig meat so they will be briefly mentioned.

Porcine necrotic ear syndrome, is formed when weaners and finishing pigs ear bite. After the slight trauma of the skin, the skin is infected via *staphylococci* which results in encrusted dying patches of skin cells on the ears (Mirt, 1999). The biting has been postulated to stem from poor conditions and/or want to suckle (Mirt, 1999). The same pattern of trauma and infection occurs with flank lesions (Mirt, 1999). Therefore, this disease stems from unwanted oral behaviour and subsequent infection. The infection can be cured with antibiotics, or the strain can be resistant, so multiple injections may be necessary (Taylor, 2006).

On the other hand, Sarcoptic mange is caused by *Sarcoptes scabiei* mites (Taylor, 2006). The irritation and rubbing behaviour caused by Sarcoptic mange results in lesions in the skin of the pig (Davies, 1995). With a higher severity of mange can be indicated by more lesions and a lower growth rate (Davies, 1995). Since, mange is spread via transmission of the *S.scabiei* mite, treatment is easier. The pigs can be either given an injection of ivermectin or doramectin (Taylor, 2006). Or the animals are separated from the herd.

Sunburn

Sunburn occurs in all animals that have skin unprotected by pigmentation or hair. Obviously, with the opportunity to go outdoors, there are more opportunities for sunburn problems in outdoor farms (Cagienard et al., 2005). However, there is a very simple solution. Pigs will wallow to prevent sunburn and overheating, with wallowing defined as any action where the pig ends up covered in mud (Bracke, 2011). This is not simple generalization, in a study done by Olsen (2011), the time spent in the wallow had a significant positive relation with an increase in temperature and sunshine recordings. In addition, it has been noted that pigs which can wallow have better health (Bracke, 2011). Consequently, given the opportunity, outdoor pigs with a wallow will have few sunburn problems.

Conclusion

Most of the literature found that pigs in an outdoor husbandry which provides opportunities to forage and display natural behaviour of dominance and submission have fewer skin lesions than conventionally raised pigs. In addition, the infection disease based skin lesions show no indication that there were investigation in the differences between housing types. However, if porcine necrotic ear syndrome is based solely on piglets nibbling each other, then there will be fewer cases in outdoor housing systems because this behaviour is significantly less in the outdoors housing. Lastly, sunburn has a higher possibility in outdoor systems, but management of the areas can rectify any health issues.

Parallels with dairy cattle and poultry

Introduction

In The Netherlands, there are 1.47 million dairy cows on more than 17,000 farms, with an average farm size of 80 cows (LTO-Nederland, 2012a). The majority of them (74%) are still pastured, not only in the organic but also in the conventional sector, although there is currently a shift towards indoor housing. The main reason farmers give for pasturing their cows is because of better cow health (48%), followed by better cow welfare (35%). The reference to better health generally refers to claw and leg health (Keuper et al., 2011).

There are 1,560 chicken farms with in total over 99 million chickens in The Netherlands, of which 34 million broilers and 65 million laying hens (LTO-Nederland, 2012b). In 2011, over 1.8 million chickens were kept organically, meaning they have access to outdoor areas (CBS, 2012), in addition there are free range chickens which can also go outdoors.

This chapter will discuss the parallels between the different animal species. The information on pigs that has been discussed so far will be the starting point, and from here it will be assessed whether similar problems also occur in dairy cattle and poultry. It is important to note that this chapter contains only general information on major problems, and is not a complete overview.

Locomotion

Dairy cattle

Interdigital dermatitis (ID), digital dermatitis (DD), and heel/sole erosion (H/SE) are persisting situations that cause pain and discomfort and are the most studied and prevalent in the dairy cow population in The Netherlands (Somers et al 2005, Frankena et al 2009). ID is an inflammation of the skin which is manifested by *Bacteroides nodosus* and perhaps in combination with *Fysobacterium necroforum*. Digital dermatitis is a more severe condition of still unidentified causes.

In the study of Somers et al. (2003) it was found that straw yards had the lowest prevalence of claw problems which was also confirmed by Frankena et al. (2009). When dutch dairy farms when contacted in three different studies, there is a higher risk for claw problems such as DD, ID, with solid concrete floors compared to slatted floors (Somers et al., 2003, 2005b, 2005a). In addition, the risk for claw diseases was low when a manure scraper was used on slatted floors. The latter type of flooring provides a better hygiene level which reduces the chances for infection. A wet slippery floor such as slatted floor with manure, increases the chances of injuries which predispose for claw infection, hence, dermatitis. Therefore, the use of a manure scraper which regularly removes manure is beneficial for claw health. Furthermore, access to pasture lowered the risk for digital dermatitis (Somers et al., 2005a). The prevalence of severe interdigital dermatitis was 23.4% at the end of the pasture period which was almost half compared with the prevalence found in the housing period (46.1%)(Somers et al., 2005b). However, in Holzhauer et al. (2006), which was also conducted in dutch dairy farms, concluded that more than 8h access to pasture increases the probability for digital dermatitis.

It can be concluded that wet floors and poor hygiene predispose for claw diseases (Frankena et al., 2009; Somers et al., 2003, 2005a). Therefore, dry floor surfaces as provided by straw-yard systems or slatted floors with a manure scraper or pasture are beneficial for claw health. In contrast to pigs, cows in solid concrete floors are in higher risk of claw problems. This partly due to the hardness of the surface on the claw, whereas for pigs, slatted floors where the risk factor.

Poultry

No scientific articles were found investigating locomotive problems in chicken in different housing systems (such as free-range, loose-housing). It was possible to find only one review which mentioned that there is an increased risk in laying hens housed in cages for injuries and fractures due to transport and handling compared to loose housed hens (reviewed by Kijlstra and Eijck, 2006).

Digestion

Dairy cattle

As in pigs, also in cattle housed outdoors, intestinal parasites may occur. A Dutch study showed that 88.5% of outdoor dairy cattle was infected with nematodes (roundworms). Helminths that occur most frequently in cattle in The Netherlands are *Ostertagia* spp., *Cooperia* spp., Haemonchus spp., *Oesophagostomum* spp., *Trichostrongylus* spp. (Borgsteede et al., 2000; Eysker et al., 2002). Cattle are usually only infected at low levels, which leads to low levels of pasture infectivity, although the levels are high enough to cause a reduction in milk yield (Eysker et al., 2002).

Poultry

Also in poultry housed outdoors there are more problems with helminths as compared to indoors. A Danish study found high prevalences of *Ascardia galli, Heterakis gallinarum,* and *Capillaria* spp. in free range and organic systems, while in indoor systems only low numbers of *A. galli*, *Raillietina cesticillus* and *Choanotaenia infundibulum* were found. However, also in deep litter systems prevalences of *A. galli*, *H. gallinarum* and *C. obsignata* were quite high, suggesting that mainly hygiene plays a role in the occurrence of helminths (Permin et al., 1999). Another risk may be infections with *Campylobacter jejuni;* a prevalence of 77-84% on organic farms in Switzerland has been found, compared to 4% in conventional systems (Hovi et al., 2005). However, in a Dutch study, no differences in the occurrence of *Campylobacter* spp. between conventional and organic farms was found (43% vs. 49%, respectively). The same was found for *Salmonella* spp. (8% vs. 4%, respectively) (reviewed by Rodenburg et al., 2004). There are however more risk factors for both bacteria on organic farms, such as open drinking water and contact with other animals (Rodenburg et al., 2004).

Respiration

Dairy cattle

The only study that found to document problems with respiration in cows had sample size with more than 500 cows. In the questionnaire of 40 dairy cattle farmers, with 20 farms of each organic and conventional farms, it was found that only 20% of the organic farmers reported occurrence of respiratory infections compared to 100% of the conventional farmers, see Table 1 (Pol and Ruegg, 2007). This outcome is not supported with more studies, but is it clear that organic farms have a better welfare regarding respiratory issues.

Poultry

In general, respirational health in poultry seem to be better in outdoor housing (Overbeke et al., 2006). However, there are certain risks that seem to increase when chickens have access to an outdoor area. One of these concerns is the risk to be infected with the influenza virus due to contact with wild birds and their faeces (Kijlstra and Eijck, 2006b). In 2003 this risk was confirmed by an outbreak of avian influenza on a free-range farm (Koch and Elbers, 2006). Therefore, the living conditions of the chickens does influence respiratory health chickens with; indoor farms negatively influence the air quality, and outdoor housing increases the possibility of disease.

Reproduction

Dairy cattle

As in pigs, temperatures can influence the fertility of dairy cows. Cows of the Holstein breed are less resistant to elevated temperatures and humidity than breeds originating from warmer climates (reviewed by Ferreira et al., 2010). Increased temperatures can compromise the development of the oocyte and early embryo, and lead to lower pregnancy rates (reviewed by Ferreira et al., 2010). Another study also found decreased conception rates with increasing temperatures (ranging from <20-35 °C) (García-Ispierto et al., 2007). Therefore it is necessary to provide enough shade when housing cattle outdoors, to ensure that the fertility is not affected by temperature.

Contrary to in pigs, *Toxoplasma gondii* does not cause abortions in cattle. However, there are other parasites that do, such as *Neospora caninum. N. caninum* is a major cause of abortions in cattle all around the world (Wiengcharoen et al., 2011). The seroprevalence in The Netherlands is 76% (Bartels et al., 2006). It has been found that the presence of dogs and cats are risk factors for the prevalence of *N. caninum* in cattle (Beck et al., 2010), which would increase the likelihood of outdoor housed cattle getting infected compared to indoor. However, there is no literature available on this.

Poultry

When housed indoors the laying hens will be less affected by heat stress. Egg production is reduced due to the heat stress during the summer (Mashaly, 2004). Therefore, outdoor production which lacks the ability to regulate the temperature will experience a lower egg production.

When a review compared quality of the eggs in the different housing systems where was mixed results, that it is difficult to say if there is indeed a difference ion egg quality (Holt et al., 2011). However, It is has also been found that battery farms in The Netherlands have a significantly higher amount of cracked and broken eggs than free range farms (reviewed by Mollenhorst and Boer, 2004).

Skin lesions

Dairy cattle

Mastitis is an infection of the udders which reduces the production of the milk and the overall health of the cow; it is generally caused by *Actinomyces pyogenes* and *Streptococcus dysgalactiae* (Marley et al., 2010). The organic farmer should have more difficulty in fighting mastitis because they are prohibited from using prophylactic antibiotics, and two thirds of conventional dairy farmers anti-biotic use is against mastitis (Wagenaar et al., 2011). However, when organic farms were checked for the prevalence of mastitis, the udder health was within normal ranges (Wagenaar et al., 2011).

As anti-biotic use needs to be reduced and eliminated, alternatives treatments are increasing tested. Two mastitis preventative practices are teat sealants and cows should be restricted from fields with flies (reviewed by Marley et al., 2010). In Wagenaar et al. (2011) a two-step oral homeopathic treatment was able to reduce the mastitis rate from 13 to 1.6% in 32 cows which was an improvement from the controls. In a Danish questionnaire study, organic farmers reported not wanting to return to anti-microbial treatments after they were phased out due to the treatments side effects and reduced demand for them (Vaarst et al., 2006). There were a number of 'life-style' changes that were quite effective; free access to outdoors, daily managing the bedding, selecting for mastitis resistant bulls, cleaning and drying the udders, plus many more tips (Vaarst et al., 2006). Therefore, mastitis is a continuous problem for all dairy farmers, but farmers are not compromised by switching to organic.

Poultry

Laying hens can have a severe welfare problem with the compulsion to feather peck their pen mates, which is akin to tail biting in pigs (Turner, 2011). There is an economic factor in feather pecking, because a chicken with reduced feather covering requires nearly 30% more feed to have sufficient energy (reviewed by Bilčík and Keeling, 2000). This important welfare problem stems from; selective breeding, conditions during rearing, and living environment (Rodenburg et al., 2008). Interestingly, when the chickens were monitored to identify the peckers the hens, 50% of the severe pecks had been delivered by fewer than 9% females (Keeling, 1994).

As with tail biting in pigs, feather pecking ranges from some chickens only gentle pecking to others continuing relentlessly till the other bird is dead (Rodenburg et al., 2008). There are two behaviours that are denied to chicken which could be redirected to feather pecking, foraging and dust bathing (Bilčík and Keeling, 2000). Since, the announcement that conventional cages are being ban in EU in 2012, there is has been a sudden increase of new designs for chicken housing (Shimmura et al., 2010). Feather pecking decreases when the hens have an outdoor run because of the ability to express natural behaviours (Shimmura et al., 2008). The new runs must be designed carefully because, groups with a 120 hens had significantly more pecking than hens kept in smaller groups ($P < 0.05$) (Bilčík and Keeling, 2000).

Currently, beck trimming is still used to reduce feather pecking (Brunberg et al., 2011). Another possible future solution is breeding to reduce feather pecking because feather pecking has been shown to be partly an unwanted by product of selective breeding (Turner, 2011). Furthermore, genetic testing may isolate gene trends that need to be avoided because there is a significant difference gene expression trends between peckers, victims, and control chickens (Brunberg et al., 2011). It is possible that a combined effort of the addition of outdoor runs and selective breeding will help remove the welfare and economic issues of feather pecking.

Conclusion

There are numerous similarities between indoor and outdoor farming between farms that house pig and farms that house cows and chickens. Straw covered floors are also beneficial for the cow's foot health. Like pigs, chicken which are housed outdoors have less injury during transportation. While outdoor cows and chickens have a higher likelihood of intestinal parasites than indoors, there is the same remedy as in pigs, anthelmintics. Cows have substantially reduced respiratory problems when housed outdoors as chickens and pigs do. *N. caninum* is an important threat to reproductive activity in cows, as is *T. gondii* in pigs, but there is insufficient research completed about the prevalence. For the reproduction, outdoor chickens will have lower egg production in the summer and might have better egg quality. The reduction of production due to heat stress also occurs in cows. Outdoor cows will not have increased problems with mastitis, even without antibiotics, which means that organic outdoor dairy farming is better for the resilience of the health of the cows. Also, the chicken equivalent to tail biting, feather peaking, is significantly less when outdoor farm have small groups than conventional farming. Even with this small sampling of data, there is an indication that outdoor farming also has health benefits for dairy cows and laying chickens.

Interviews experts

Introduction

There were two reasons why we wanted to interview experts. First, we wanted to gather information that was not present in journals. Second, the experts provided a broad overview that is difficult to find in the literature. We interviewed four experts; Eddie Bokker, Mart de Jong, Herman Vermeer, and Liesbeth Bolhuis. These experts respectively covered general knowledge of pigs, the influence of infectious diseases, pig welfare with production systems, and the behaviour of the pigs.

❖ Dr. Ir. Eddie Bokkers

Introduction

Dr. Ir. Eddie Bokkers is an assistant professor at the Animal Production Systems group of Wageningen University and Research centre. He has a background on pigs and pig husbandry, because he has worked on several pig farms, and during his study he wrote three theses about pigs, two of which were about extensive pig husbandry. Although he is not particularly specialised in pig health, he is aware of the general health problems that occur. The goal of the interview with him was to get a general overview of health-issues occurring on outdoor pig farms.

Free-range pigs

Next to conventional and organic pigs farms, there are also free-range farms, which are actually in between the other two. There used to be an official free-range quality mark for pork. The free-range pigs had more space, straw, and could go outdoors, so it was mainly focused on animal welfare. In comparison with organic the main difference was that organic is more concerned with the environment, so the feed also had to be organic. You could say that free-range was in between conventional and organic farming. In the 1980's free range farming increased over the years, but at one point organic became more popular and took over from free-range. Also around ten years ago Albert Heijn (retailer) wanted to sell more free-range meat so they contracted a lot of conventional pig farmers that then switched to free-range. However Albert Heijn could not sell enough meat, so the contracts with the free range farmers were terminated. At that point a lot of farmers already invested in new stables, so they went bankrupt. Now free-range seems to upcoming again, because there is free-range meat in the supermarkets.

Health aspects

The main problem with outdoor husbandry is still parasites, lungworms as well as intestinal worms. With indoor farmers this occurs as well, but to a lesser extent. Risk factors for outdoor farming could be that the animals are kept always on the same pasture, this can be prevented by changing the use of the pastures, but that is not feasible in this country. It might be that streptococcus, a bacteria that causes a lot of infections mainly in the joints of piglets, occurs less outdoors than indoors. It is difficult to say whether there are also less respiratory problems outdoors, since it is difficult to point out the exact cause of this; it could be the entire climate, the airflow, dust, rearing conditions, etc. It may be the case that there are less problems outdoors, but it is necessary to investigate the exact risk factors. Reproduction might be compromised because the animals have a more natural rhythm of the seasons, and usually they only giving birth in the spring. This can be resolved by giving them sufficient feed, and indoors by giving them more light and warmth.

The animals that are kept outdoors are generally healthier than the indoor animals, as long as they have shelter and a warm place to lie down. They get more exercise through being outdoors, and a better immune system. It is the same in humans, if you encounter viruses and bacteria you will have an active immune system, so you can get a bit ill now and then, but not seriously so. Especially the animals that are on a farm for a longer period, like the sows, should be housed in this way.

There are probably less behavioural problems outdoors, even when the animals have only a small outdoor space, because they get different kinds of stimuli. This also makes them easier to handle. When they are used to being outdoors the animals are in general much more interested and less scared, there are not any problems in getting them on transport to the slaughter house, as it is for conventional pigs. If animals are always indoors and the climate is always the same, it becomes boring because there are no stimuli. It is the same in humans; we like it when there is sun, but we appreciate it also because other days are colder.

On the other hand, many benefits of outdoor husbandry may be achieved with an optimal stable design. That means that you have to give the pigs good substrate to root in, and keep that interesting for them by refreshing the enrichment items to ensure that they keep finding things in it. Other things like light and fresh air are also achievable indoors, with good windows or open-fronted stables with covered lying areas. As long as they have a cool place when it is warm, and vice versa, pigs can take care of themselves very well. The problem with organic farms is that it is compulsory that the pigs have straw indoors, which is a good thing for numerous reasons, but if it gets too warm indoors the animals will start lying outdoors and defecating indoors. That is a problem for the farmer, because he has to clean all the pens.

Antibiotics have been used as a preventive for some time, even though they were produced as a curative. If it is used preventively, then it will suppress the infection pressure, so the animals grow faster. The rules concerning antibiotics in the organic sector are not optimal. They are inflexible, and sometimes antibiotics just need to used or animal welfare will be in danger. Ideally these rules would not be necessary anymore, and everyone would focus mostly on the prevention of diseases instead of cures. The problem with conventional farming is that it is cheaper to give antibiotics than to have animals a bit ill, what can cause a growth check, because then the pig needs more time to get to slaughter weight.

Practical aspects

Most farmers will be aware of the health issues on their farm, they keep up to date by reading professional journals and speaking with advisers. They want to have healthy animals, because unhealthy animals do not produce so they cannot use them.

One of the problems with outdoor husbandry is that people really like the sight of seeing animals outdoors, but when buying the meat it comes down to the price and they choose the conventional meat. That also has to do with the fact that people do not know where their food comes from anymore. They do not want to make the association that meat comes from animals, which is especially true for Dutch consumers, compared to other European countries. There will probably not be a great difference between the systems concerning the inconvenience for direct neighbours; if the manure is absorbed by the straw there will be less ammonia in the air, and less dust.

The future

Many farmers would like to downscale if they could make a living with less animals. In the end it has to do with income, which is a driving force for both conventional and organic farmers, but organic farmers get more money for their products because the consumer is willing to pay more. The situation in The Netherlands will not change in the coming years, because the pig husbandry is focused on the indoor systems. Also, there is just not enough land to give all these animals an outdoor area, or at least not an extensive outdoor area.

There is perspective in e.g. Wintergartens, where the animals have access to a covered outdoor area so they can get fresh air and light. However they are more expensive, and The Netherlands have to compete with other countries to sell the products. Maybe 50% of all pork meat is going abroad, and then the farmers have to compete with a lot of countries. Everything is about efficiency; the highest possible growth with the lowest possible amount of feed. Therefore the farmers cannot just simply decide to give their animals straw, unless they are compensated in their product price. In England they are a step further; Tesco (retailer) wants at least free-range meat, so that gave an impulse to create better circumstances for the animals.

Ultimately the conventional sector will disappear from The Netherlands because the land and the labour are too expensive. Hopefully there will remain farmers in this country because it is part of the landscape. What remains will be more focused on quality, for example by using special breeds that produce high-quality meat.

❖ Dr. Ir. Mart de Jong

Introduction

Dr. Ir, Mart de Jong is the Head Professor of Veterinary Epidemiology group in Wageningen University. His expertise lies in animal infectious and zoonotic diseases. He looks at how infectious diseases behave in farm animal populations and what are the risks for animals and humans. His experience allows him to have a general overview of outdoor pig husbandry.

Health aspects

A major problem in outdoor husbandry already identified are parasitic diseases, which are of major risk for public and animal health. *Trichinella* is a round worm which is still endemic in wild mammals and is a high risk for human health. Pig health can be managed with the use of antiparasitic drugs but without these drugs it is difficult to control the problem. In addition, humans have low tolerance for these parasites.

Outdoor housing could be beneficial for minimizing the occurrence of respiratory diseases since air circulation is better and animal intensity is lower in outdoor compared with indoor husbandry. However pigs are sensitive to air currents, which might counteract the benefits of being outdoors if no precaution measures are not taken.

Transmission of infectious diseases

At the moment, in The Netherlands there is the same amount of pigs but fewer farms. Therefore the distance between farms is bigger which makes the farm to farm transmission less of a problem than before. Farm to farm air transmission of some endemic diseases such as swine influenza, Porcine reproductive and respiratory syndrome virus (PRRSV), could occur more easily in outdoor housing than indoor. Hence, there is a higher probability of a major outbreak of e.g. swine fever, foot and mouth disease could start from outdoor farms. The measures that could be taken, in case of an epidemic, there must be available indoor housing so that animals can be relocated indoors for a prolonged period if necessary.

MRSA livestock strain is currently a concern in the pig sector for conventional indoor and as the method of transmission is not known, there will probably would be the same level of concern in the outdoor housing farms. MRSA's rate of transmission does not depend on the use of antibiotics. Of course, there could be new resistant strains could be produced by using antibiotics, but stopping the use of antibiotics would not affect the disease's transmission.

Hepatitis E virus (HEV) is zoonotic and is already present in indoor pigs. Incidents have been recorded of human infection from wild boar. Most Dutch people which contract HEV, receive it from contact with pig farms. Outdoor housing of pigs is not a major health risk in regards to people living in the surrounding area but it is a major public health issue in regards to the consumer e.g. the parasitic burden. Furthermore, people working in the farm are another susceptible group both in indoor and outdoor housing. Probably, it is less of a risk in the case of outdoor housing due to the lower animal density and better air circulation. Finally, if outdoor husbandry is a wishful situation from a welfare and societal point of view, then the possible public health risks should be dealt with the methods that are currently available.

Swine influenza

Swine influenza could become a future threat for outdoor swine husbandry. Pigs are more susceptible to avian influenza than other animal species and could be serving as the intermediate host resulting in introduction of new strains in the human population. Poultry were infected with influenza through contact with wild birds and pigs were infected through poultry. However, it can be that a direct transmission between wild birds and pigs is possible but this is still theoretical. The theoretical transmission from birds could indicate a major concern if it is true for outdoor housing. This is also mentioned by the GD (Gezondheidsdienst voor Dieren).

Virus types that affect pigs are the same as in humans but adjusted to pigs. Influenza Virus transmission from pigs to humans is rare, but it could be a potential threat in the future. At this moment the farmers are free to choose whether they vaccinate for influenza in fattening pigs. In the avian influenza outbreak, there were some pigs infected and therefore, it is sometimes said that pigs should not be on the same farm as poultry.

Wild boar as paradigm

Scientific information on wild boar in relation to animal and public health could be indicators of what could be the future situation of outdoor housing since not enough scientific knowledge is available about the effects of outdoor housing on health. However, wild boar and conventional breeds are genetically apart, therefore these information can be extrapolated only to a certain extend. In Germany they are now facing problems with a swine fever endemic in wild boar population and it can be a good indicator of what could happen in outdoor pig husbandry in case of outbreak and how to deal with it. In addition, contact between wild boar and outdoor pigs is more plausible than with pigs kept indoors, you would therefore, expect outdoor pigs to have a higher risk of infection.

Conclusion

Outdoor pig husbandry is a novel concept for pig sector and there is not enough experience in order to have a clear view of the health problems that could occur. If outdoor husbandry is a potential situation from a welfare and societal point of view, then the possible public health risks should be dealt with the methods that are currently available.

❖ Dr. Ir. Liesbeth Bolhuis

Introduction

Dr. Ir. Liesbeth Bolhuis is an Assistant Professor in the department of Adaptation Physiology, Wageningen University. Her focus is on the behaviour and welfare of pigs. She completed her pH.d on the behaviour and stress in pigs rearing and housing conditions.

Damaging oral behaviour

The occurrence of tail biting and other agonist behaviours are often due to the surroundings and social make-up. In nature, these behaviours do not readily happen because the pigs are able to run away and they are not inhibited from foraging. The risk factors of tail biting are; a lack of rooting material, gender, few feeding areas, or limited food and chewing capacity. The numbers in tail biting in the difference housing systems are misleading, because 99% on the tail in conventional farmers are docked and the organic farms are prohibited to do so. The undocked tail in organic farm offers pigs a greater enticement to play than conventional farms. To reduce tail biting, the environment needs to provide sufficient foraging opportunities. Large concrete pens can be greatly enhanced with deep litter straw that has food hidden in it and is regularly replenished. This condition creates an enormous improvement in the behaviour. Outdoor patios with deep litter have the advantage of daylight and weather variability that would be missing indoors. Therefore, damaging oral behaviour can be reduced by changing the environment.

The choice between indoor and outdoor housing

When choosing whether pigs should be indoors or outdoors, it is essential that management of the farm is considered. Simply placing the pigs outdoors without adequate shade or a wallow would reduce the pig's welfare. An example, there was a pig farm that allowed the pig loose in the forest, where they were able to forage. But, the pigs still had problems with tail biting and fights. In the end, it was due to the fact that the feeding area permitted one pig at a time to eat. Once that was changed, the harmful behaviour diminished. This small detail reduce the welfare of the entire farm. If the farms are properly managed, than pig would be happy to live outdoors.

❖ Ir. Herman Vermeer

Introduction

Ir. Herman Vermeer is an Animal Scientist specialized in behaviour, welfare and production systems. Animal welfare is his main focus. Some examples of project that he has worked on are: Preventive strategies and alternative treatments against roundworm in organic pig production systems, Environmental enrichment of organic pigs and Effect of outdoor access during lactation period on piglet health after weaning.

Health aspect

The main issue in organic farming are lung problems which are slightly more prevalent in outdoor pigs, due to draught caused by not well insulated openings in the pig house to the outdoor areas. Draught in the resting area can cause lung problems. A solution to this problem would be to close the openings really well or provide an indoor lying area with flaps before it.

The current used genotypes do not really have problems with the outdoor area. They are clever enough to make a choice to go outdoors or, when it is windy or cold, return to the indoor area. An exception is sunburn. Pigs that lie in the sun can easily burn as they are white skinned and no mud pool is provided to wallow. A layer of mud will act as protection from the sun.

Tail biting should be less in outdoors pigs since they have more room for rooting and exploring as well as space to get away from other pigs. If you have tail biting in organic farms, often something is wrong either with the ventilation or there is a lack of feeding places and /or lying areas.

If you look at lameness, there is no difference between indoor and outdoor. The claw of the pig is made for soft wet surfaces. So, wet/soft pastures outdoors are no problem at all. However, the combination of a wet floor and injuries is an important risk factor for coronet infections.

Parasitic infections are also a disadvantage of outdoor farming. Ascaris suum is a good example (white spots on the liver). However, it is controlled in the majority of farms with the use of anthelminthics that effectively treat the animals against parasites. Piglets that are several days after birth kept outdoors with some soil will develop a better gut flora by bacteria and microorganisms from the soil. In the past farmers also gave some combust or soil to the piglets for this reason. A project is running and will be finished in 2013/14.

Environmental aspect

The price per hectare in The Netherlands is very high and when pigs are rooting around the soil is hardly producing or growing anything. By the lack of plants and grass leakage of minerals is increased. A good way to overcome this is the rotation scheme which English outdoor pig farmers often work with.

Wild animals. Is it a risk?

In Northern Germany the wild boar population is a carrier of the swine fever virus. Therefore, German farmers often had double fences to protect the pigs on the outdoor areas. Another point is the risk for Toxoplasma if pigs come in contact with cat feces or with mice and rats. Hence, that risk is higher in outdoor pig housing than indoor. It is still allowed to kill rodents with poison, however we are trying to find alternative ways in fighting rodents and also flies. In theory flies can transmit diseases, however, it is more of a welfare point of view when the number of flies per animal is high. Outdoor pig farms attract flies because of open entrances and the straw in which the fly will lay eggs. Therefore, hygiene in the pen is really important.

Practical aspects

Farmers are really willing to do something about the health problems present in their farms. Reducing antibiotic use in conventional farms is currently a major topic of discussion. Organic pig farmers want to be one step ahead from conventional, so they are stimulated to further lower the antibiotic use. However, you cannot reduce antibiotics without improving the health of the pigs. Therefore you must make adaptations. Some farmers are strongly motivated others are less motivated. The better price and the possibility to stay relatively small was a very big motivation (and most of them like the way of pig farming much more). The more stable price is caused by the contract with a fixed price for a year and is more or less based on the cost price, a very good system. The highest costs in organic farming are caused by the feed price, which doubles the price of the meat.

Best Housing system

Design to the needs of the pig. Climate and temperature must be at a good level, a simple roof to protect them from rain and try to keep emissions as low as possible (so indoor). This is tried in the comfort class pig house in Raalte. Which was a tent-like construction, consisting of a plastic roof with a lot of light coming through it and creeps to sleep in. The building was relatively cheap and had two to three times more space than conventional indoor housing. So the building (=wind/rain protection) can be cheap and only the nest/lying area (=micro climate in creep) should be of high quality (more expensive).

Aspects that need more research

The environmental point is the most important. So far, in organic farming, there are no limitations for ammonia emissions, while in conventional farming, they have to invest a lot of money in ways to reduce ammonia emissions. There is no stimulus in doing something about it, which is in contrast to the environmental friendly image of the sector. The environmental pressure might be a very weak point of organic farming at the moment. Is not health, is not production, is about environment. Especially on the long term, there should be some measures taken. Perhaps, only to show that they are active or that they are concerned about the environmental pressure.

Conclusion of the expert interviews

There is a range of positive aspects and potential vulnerabilities with outdoor husbandry. Interestingly, public pressure to reduce antibiotics may come as an incentive for farmers to turn to the alternative housing methods, because they offer a way to have healthier pigs without using antibiotics as a preventive.

Outdoor pigs would have a stronger immune system, and due to the changing environment would be less bored which increases overall health. Boredom is an important health risk because it results in a higher chance of tail biting and other painful oral behaviours. Housing the pigs outdoor is beneficial for respiratory problems, because the fresh air reduces particulates and fumes that irritate the lungs. Since pigs are attentive to the weather, they will return indoors or wallow in mud to regulate their body temperature. A possible health problem with pigs kept outdoors, is that they have a higher chance to come into contact with wild animals which can be infected with the intestinal parasite, *Trichinella*. However, as long as the pigs are dewormed, there is no risk for humans consuming the meat. Lastly, people in the surrounding area should not have any problems with the pig odour or the threat of disease. Therefore, outdoor housing does not pose any inconvenience to the neighbours and it reduces the health risk of boredom and associated oral problems, and respiration. Next to that there are no negative impacts of the parasites.

It is possible to house the pigs indoors and reduce damaging oral behaviour. However, indoor farms would require lots of room, windows, and the ability to root to be considered similar to outdoor farms. Agonistic oral behaviours are greatly reduced by a complex environment with sufficient room for the pigs to hide when there is aggression. Whether the pigs are indoor in a deep litter area with buried food, or outdoors, there must be intense management to ensure that their natural behaviour is not inhibited because that is where the problems begin.

Still, there are some challenges with the outdoor husbandry. Foremost, outdoor farms without enclosures pose a higher risk to disease transmission because the pigs cannot be quickly quarantined. This is a main concern for potential scenarios with swine influenza. Secondly, housing which does not stop draughts will increase the likelihood of the pig having lung illnesses. In addition, there may not be enough space in The Netherlands to have rotation of the pig plots, which is recommended to reduce parasites and nutrient leakage. As long as there are areas where the pigs can be herded in, no draughts, and ways to make the needed land available, these problems should not stop outdoor husbandry of pigs.

Interviews farmers

Introduction

Next to information from literature and the opinion of experts from different fields related to pig health, the goal was to get an idea of the viewpoints of farmers, related to outdoor pig housing. Since time was limited, and literature was also seen as an important section, it was decided to limit the number of farm visits. The objective was to get an impression of the ideas of conventional, free range and organic pig farmers. In total two conventional, two free range, and three organic pig farmers were interviewed. The subjects discussed ranged from health problems, challenges of outdoor husbandry, arguments to choose a certain housing system, and the future as perceived by these farmers. This chapter contains summaries of all of these interviews, with at the end a conclusion giving the most important information.

❖ Pieter Vlemminx (conventional)

Introduction

Pieter Vlemminx is a conventional pig farmer from Oirschot. On his farm he has 300 sows and 2,000 growing finishing pigs. He finishes all the piglets himself, but he buys breeding gilts because the farm is not big enough for an own breeding program. The sows are of the Topigs 20 breed and for the finishing pigs a Tempo boar is used. All the pigs on his farm have been housed indoors from 1976 onwards.

Choice for conventional farming

In the past, the pigs on this farm have been housed outdoors. This required a lot of labour because nothing was automated yet. When the farm expanded, it was decided to house the animals indoors. The animals now have the space that is required for the one star quality label of the Dutch ‘Dierenbescherming’. The sows have even more space than required by this label, namely 3.5 m^2 per animal. Also they are provided with straw, which is not compulsory. This is sometimes difficult because the animals sleep where they eat, which is on the solid floors and therefore they start to defecate especially in the straw.

The Netherlands have a lot of environmental regulations preventing farmers to house their pigs outdoors. The limiting regulations are for example related to ammonia emissions and manure quantities. These regulations allow you to only have a certain amount of animals per hectare if you have them outdoors on a field. Outdoor housing with concrete floors is not real outdoor housing; that is just indoor housing without a roof. Housing the animals outdoors also gives much energy waste, because you have to keep it warm indoors, but it is difficult to insulate when the animals can freely walk in and out. If you have a farm of this size and you

would want to switch to organic, you could only keep about one fourth of the animals. We could do that, but if people are not willing to buy the meat for a higher price, we cannot. That is the thing: people want a lot, but they do not want to pay for it. That is why so much is subsidized and that is dangerous of course. Organic farmers are very motivated, they are environment-friendly, they want to do good, but they can only exist through subsidies and working very hard. A lot is also indirectly subsidized; for example organic farmers can rent land for a lower price from ‘Natuurmomumenten’, while if they had to buy it that would have never been possible.

Health

There are not a lot of health issues on the farm. The pigs are provided with a good housing and a good climate, which is checked regularly. Blood is drawn from 35 animals per group every year in order to check for diseases, and with those results it is decided which vaccinations will be used in the next period. This is done to prevent getting diseases on the farm and to use as little antibiotics as possible. For the growing finishing pigs 4.5 daydose is used and for the sows this is around eighteen. The replacement rate of the sows per year is around 43%. All the animals are dewormed according to a standard scheme. The goal is to become free of worms, and in relation to ten years ago worm infections have already decreased a lot. The percentage of condemned livers is now only 1%.

When the animals were only just housed indoors, straw was used in the farrowing crates. But because the floor was solid this was a huge source of infection, so the piglets of one or two days old always had diarrhoea. Also the ventilation was not so good and there were problems with intestinal parasites. In some litters, half of the piglets died. At the moment, this is much more optimized; there is floor heating so the piglets are comfortable, the hygiene is better, etc. The mortality rate of the piglets is 12%, which mainly has to do with the fact that the sows are bred in order to have a high number of piglets; the average is now fourteen piglets, which results in weaker piglets.

Problems with tail biting occur, especially when the tails are left too long, and in the groups that are closest to the windows, so the ones that get most light. It has been tried to leave the tails longer, but once they start tail biting you cannot use the pigs anymore, because they will not be accepted at the slaughterhouse. That costs too much money, and next to that the animals suffer from it.

Outdoor pigs seem to be more afraid than indoor pigs. When the pigs were still outdoors on this farm, they once broke out because they got scared by a truck. They see and hear more, so they are more skittish. The pigs that are housed indoors are calmer and are used to the fact that you walk in and out. The transporters of the pigs also tell that the outdoor pigs are

much more difficult to transport because they are wilder and more used to running than indoor pigs.

Overall, pigs that are housed outdoors are less healthy and also they are more aggressive, especially sows when they are in heat. Also there are problems with foxes and crows, which cause troubles if you have piglets walking outdoors. Furthermore, there are more problems with food safety, because there are more external influences that cannot be controlled.

The future

Looking at the number of people on this planet that need to be fed now and in the future, this can never be accomplished by organic farming. The entire world embraces the Dutch intensive agriculture system, because it is seen as the ideal. But as long as people attach sentimental value to organic farming and are willing to pay for it, organic farms will keep existing.

Many years ago, all farmers were organic, however many problems were encountered with that system, and the husbandry systems have been optimized and up scaled to what they are now. Now people want to go back to the ‘old days’, but without having the negative effects. First more research has to be done about how we can go back in a good way; economically feasible, without subsidies because the consumers should pay for it, and without the health problems, because the health of humans and animals are most important. Then this farm could be organic, if it is possible to make a living out of it.

❖ Erik Stegink (conventional and organic)

Introduction

Erik Stegink is a conventional pig farmer, who was looking for innovative ideas in the pig farming sector. This year he opened his Piggy Palace; an outdoor area which houses 50 piglets. If there is a market for the meat from the Piggy Palace piglets, he is willing to expand this concept. Next to these piglets he has 1,600 conventional piglets, 500 sows, and 4,500 finishing pigs, divided over several locations.

The Piggy Palace

It was a goal of a group of six farmers to come up with innovative ideas for pig farming, which were specific for each farm. For this farm it resulted in the Piggy Palace. This is an outdoor area that houses 50 piglets; they are outdoors day and night, are provided with shelter in the form of a straw hut built of hay bales, get feed in the automatic feeding systems, and have a mud pool. When the piglets reach 25 kilograms they will be moved to a larger pasture until slaughter. Each year will consist of two rounds of piglets that move into the Piggy Palace. These piglets are different from the conventional piglets on this farm; they are Topigs 50 x Tempo (normally a Piétrain boar is used), they have not been vaccinated, their tails are not docked and their teeth are not cut.

The meat of the Piggy Palace piglets will get the farm's own PiPaPork (Piggy Palace Pork) quality label. They will be slaughtered and sold by a small butcher. The farm is not certified by Skal, because that would cost too much money for only 50 piglets. And if it is possible to sell the meat this way, there is no reason to join Skal. There are no official permissions for the start of the concept; meetings were conducted but everything took so much energy, time and money that it was decided to just start. That is in the nature of an entrepreneur; you want to do something and sometimes you have to take risks.

The goal of the Piggy Palace is to serve to a niche market. It is not the intention to convert the whole farm to this system, because the market is not big enough. Also the barns of the conventional pigs are still new; they were built in 2009, so it is not feasible to convert them. However, if there is enough demand for the PiPaPork, the farm has around fifteen hectares available for expansion, and there are more possibilities in Brabant. The reason for starting with this concept was mainly to make money and to attend to the demand of the consumers, not because of ideological reasons.

The question is whether the meat from the Piggy Palace pigs will be of a different quality than the conventional meat. To test this, June 30th the first piglets will be slaughtered and the RIKILT will do tests on the meat.

Health

In the conventional pigs there are several health problems. These are the common problems you can find on many farms: streptococci, intestinal infections and joint infections for the piglets, and subfertility, lameness and influenza for the sows. It is expected that the piglets in the Piggy Palace will get more health problems, especially coughing and influenza because of the fluctuations in temperature. That is easily manageable indoors, but outdoors it is more difficult. They are of a stronger breed, but is still a try-out. Indoor housing is in general better for pig health, but outdoor housing is better for their welfare; then the advantages weigh up to the lower health status.

The piglets in the Piggy Palace are not vaccinated and no antibiotics have been used. They will be dewormed however; the conventional pigs are dewormed twice, but these will be dewormed three times in their lives. The percentage of condemned livers of the conventional pigs on this farm is 3%, but the percentage of the outdoor pigs might be as high as 100%, because the liver fluke is everywhere in the pastures.

The tails of the piglets are not docked, but there are no big problems expected because they will have enough distraction such as rooting, wallowing and foraging. There is also several indoor groups of piglets that still have their tails, as part of a German research. They get some paper every day, and also extra toys. Until now there are no problems with tail biting in these groups, but they are the same age as the Piggy Palace piglets (six to seven weeks), and problems with tail biting usually start at a later age. Straw is not provided to the indoor housed pigs, because that would interfere with the manure drainage system.

The future

As long as the consumers want to pay more for outdoor housing the future looks bright for that, but if they choose for the cheapest meat it will stop. There is of course a shift towards outdoor housing, to which is also anticipated at this farm. The farm will however also stay conventional, because a lot of investments have been done, and it is not likely that conventional pig farming will disappear.




❖ Henk Schellekens (free range)

Introduction

Henk Schellekens started in 1998 a free range farm in Dreumel. Nowadays the farm of Henk and his wife consist of 1,500 meat pigs (Large White x Piétrain) and 200 Large White sows. Mrs. Schellekens has stopped her work as pharmacy assistant to take care of the sows and piglets. Henk takes care of the meat pigs and is also the manager of Bon Vivant. Bon Vivant is the only certified seller of Dutch free range meat of which Henk owns 50% of the market share. On the farm the meat pigs are able to go outdoors on an indoor range and the sows have a run outdoors on concrete plates.

Choice for free range farming

Originally Henk Schellekens comes from Boxtel, Brabant. His parents had a conventional pig farm at the edge of the village. Henk wanted to take over the farm, but unfortunately that was not possible. Eventually their farm ended up in Dreumel. They started with dairy cows and sows, later added with meat pigs. In 1995 they planned to enlarged the farm from 80 sows to 200 sows in a closed system. This was however blocked. The only option to enlarge to 200 sows was to switch to free range. So in 1998 they started with a free range farm.

In The Netherlands there are eight free range farms and the farm of Henk Schellekens consist potentially of half the number of free range pigs in The Netherlands. On the one hand a strong position, on the other hand a very weak one: if one company has 50% market share this means that the market is very small.

The greatest advantage free range has with respect to organic according to Henk is that rules can be changed. If a farmer find a shortcoming and all free range farmers agree that this can be improved, the rules can be changed. Furthermore, the veterinarian has the competence to overrule the regulations, if that improves the welfare or health of the animals.

Health

There are a few health issues on the farm of Henk. The biggest problems are coughing, coronet inflammation, sunburn, the Glasser's disease, Swine Erysipelas and tail biting.

Coughing occurs when the pigs forget to get back indoor when it becomes cold, especially in spring and autumn when the days are warm and the night are cold. The philosophy on this farm is however, that a bit coughing is normal, like in humans and therefore they do not use antibiotics.




When the pigs are outdoors they are also more susceptible for sunburn. In order to counteract the burnings Henk had bred with the Terra 50 line of Topigs. These were black pigs which will not very quickly burn from the sun. However, these pigs produced more body fat, which the butchers would not buy. Therefore,Henk now uses white pigs again and still has the problem of sunburns.

Previously when the pigs were housed indoors, Henk had to cull only one or two pigs because of coronet inflammation, nowadays he has to cull five to ten pigs per year. The reason for this is that the pigs can now go outdoors and get more wet legs in combination with a higher incidence of injuries because of the larger space. Especially in autumn and winter the pigs get faster infected. Another problem is Swine Erysipelas. Last year it occurred on the farm. After that, the pigs were inoculated twice, but still the problem is not solved.

On the farm, a remarkable problem is Glasser’s disease which normally only occurs at SPF farms due to low resistance. Which is very strange as you do not expect a low resistance on free range farms. The problem is probably originated out of the low antibiotic use at their farm and high hygienic. Glasser’s can be treated with antibiotics.

Tail biting is a behavioural problem that occurs quite often on the farm. Mainly around August and September it occurs a lot. To prevent tail biting in the stables there are chains, teething balls, straw, hay racks and stir bags where the pigs can play with. Once the tail is damaged and bleeding, it goes from bad to worse. The pigs get very aggressive by the sight of blood. Besides the distractions in the stables Henk also cut their teeth, does a rubber band around the tail so that it stops bleeding and has more than 50 pigs in one group. In this way ranking is no longer present and the pigs do not fight for this. In the last years the problem of tail biting is decreased but still a present problem.

Future

For the future Henk sees some new challenges. For instance the use of grid floors, because it is easier to keep your farm hygienic and will in this way probably reduce the chance of infections and diseases. For the future of the pig sector, Henk thinks that the way of conventional farming will disappear in The Netherlands and thinks and hopes that free range farming will become a standard way of housing pigs.

❖ Country Smile – Anita Marskamp (free range)

Introduction

Anita Marskamp has a small farm which is called Countrysmile. With six finishing pigs on 250 m^2 it is a small farm that sells meat to nearby customers. The farm owners also eat the meat themselves as that was actually originally the idea. The farm started at the end of 2010, nearly 1.5 years ago. The pigs on this farm are a crossbreed of the 'Bonte Bentheimer' which are bought from a nearby free range pig breeding farm. The main philosophy on this farm is to start thinking from the needs of the pig. Respect for the animal comes at first place, from conception until packing the meat.

Choice for free range farming

The choice for this way of farming originates from the fact that the farm owners do not like the way pigs are being kept in conventional farms. When Anita was still young she could not change much about that, but now, many years later there was an opportunity to make a change. Organic meat is considered as too expensive and there was some land available so that created possibilities to start a little farm.

This farm is not certified by Skal nor by ProduCert. Initially the goal was to join the Skal certification. However the most important reason not to join one of these was the high price that needed to be paid for such a certification. It is very unpleasant that a large farm with for example 1,000 pigs is paying the same amount of money as a small farm. Actually that appeared to be the right choice. Now there are not restrictions too specific rules, which gives more freedom. The farm is very transparent for everyone; everyone can see what is happening. It would simply make the meat much more expensive if a certain certification would have been joined, and the meat should be affordable for every person.

Health

This farm does not encounter any health problems at all. Antibiotics are never used, only in really exceptional cases. All pigs are dewormed twice during their stay on this farm. As long as the animals are provided with a decent environment they will be healthy.

Future

The intention of this farm is not to grow in size at all. However it would be very appreciated if others are picking up this idea and start such a farm themselves. On this farm, maximally fifteen pigs can be kept, as that is what the barn is designed for. Large scale farms are not the way to go. Pig farmers should focus more on the future and take their responsibility with regard to the environment and the animals. People should eat a lot less meat. Then we would need only half of the livestock population that we have now. Large scale farms should be stopped right now and they will eventually.

❖ Andries van den Bogert (organic)

Introduction

Andries van den Bogert is the owner of a closed system, organic pig farm in Hedel. He started as a conventional farmer, but due to low market prices for pork and permits to grow, he decided to switch to organic farming in 2003. Currently the farm consists of 125 Topigs 20 (crossbred Landrace x Yorkshire) sows, 300 weaned piglets and around 900 finishing pigs crossed with a Piétrain boar.

Health

There are almost no health problems on the farm since the transition from conventional to organic. This was different on the conventional farm, where streptococci were a big problem among weaned piglets. To solve this problem the piglets were vaccinated. After the transition to organic this was no longer needed. At the moment only the sows are vaccinated against *Erysipelothrix rhusiopathiae* infection, and the piglets are vaccinated once against mycoplasma in the suckling period.

To prevent infections with parasites, sows are dewormed every three months, piglets till 50 kilos are dewormed two times and finishing pigs from 50-120 kg are not being dewormed anymore. Because of this deworming scheme there are no problems with parasites on the farm, but this would probably be different when this preventive use was not allowed.

On the old conventional farm, lung problems were present, but they were always immediately treated with antibiotics. Nowadays, it might happen that a pig has a slight influenza infection, but through mixing a few aspirin through the feed they will be up and running in a few days. However, these kinds of health problems are very difficult to compare with the conventional situation. In those days the climate was totally computer-programmed. When a door was accidently left open, immediately there were health problems such as coughing. Now the animals can go outdoors, they have much better resistance to diseases and you can see that in their health.

In the beginning of the transition from conventional to organic there were some troubles with mastitis and coronet inflammation, probably because of colder air flow and more wet floors, but all these problems have been solved now.

The biggest health problem that is experienced at the moment on the farm is tail biting and tail infections in a group of finishing pigs, probably caused by mycotoxin (a fungus) in the feed or bedding. This problem appears most often in piglets under 25 kg. Because of the mycotoxin, the end of the tail dies. When other piglets see and smell blood on the tail, tail biting is an immediate consequence. To fight the fungus an organic mycotoxin-binder is




added to the feed, which seems to help.

Tail biting is usually a problem with particular groups, which also have other problems like respiratory symptoms and lower general resistance to diseases. Probably this problem can also originate from problems the pigs experienced at an early age in the nursing stable, such as extreme colds during the winter. Therefore, besides mycotoxin binders, also the ventilation was adjusted. Furthermore, the groups that show tail biting are treated once with antibiotics in the beginning, to prevent tail infections. After they go to the finishing pigs-stable, no antibiotic treatment is provided anymore.

In summary, the biggest health problems that are present on the farm are: returnees for sows, joint infections for piglets and tail biting for finishing pigs. However, these are all no major problems and most of the time occur only occasionally. Overall the experience is that the pigs have more resistance and less sickness when they are housed outdoors.

Antibiotics

In 2010 three day doses were needed for the sows and 0.8 for the finishing pigs. In 2011 this was halved to 1.6 daily doses for the sows. This triggered a plan to start up a low-antibiotics food chain, although antibiotics-free is not possible because of animal welfare. The farm is also MRSA free, which might be due to the low antibiotics use.

Behaviour

Since the pigs were housed outdoors they are much calmer, compared to pigs that spend their lives indoors, which are a lot more fearful.

Production

Since switching to organic the piglets stay with the mother for at least six weeks. Because of this the uterus gets more time to restore after birth, which resulted in a growth of 1.5 piglet per litter, with a mean of fifteen piglets per litter. This is also a problem on the other hand, because it means that often there are weak piglets, or that the sows do not have enough milk. Compared to conventional farming, finishing pigs need a little bit more time (one week) and feed to get to their slaughter weight, because they get more exercise and are exposed to varying temperatures.




Peter van Leeuwen (organic)

The farm

Peter van Leeuwen is an organic pig farmer since fourteen years, after he made a switch from free range. The closed system farm contains 200 Topigs 40-like sows and around 1,400 finisher pigs (crossed with a Piétrain boar), with plans to extend to 260 sows. The sows are selected for usability, quickly coming into heat, vitality, economic piglet production and good meat piglets (Topigs). Half of his piglets are sold, and the other half is finished on the farm. The Piétrain is used for its lean meat, however a stronger breed would be preferred, for example York pigs. The meat goes to De Groene Weg, who distribute it further in The Netherlands but also abroad.

The reason to start with a free-range pig farm instead of a conventional farm is the desire to keep the animals in a way their needs could be fulfilled as much as possible. This was also a reason to later switch to organic (to take this a step further), but also the higher demand for organic meat played a role in this decision. On the current farm the pigs can always go outdoors, during the entire year and also day and night. Next to that, the pregnant sows have access to a pasture when the weather is good, usually starting around April 1st. In the farrowing stables, the indoor area is made somewhat lower than outdoors, so that the smallest piglets are unable to go outdoors to prevent them from freezing, since they are not yet capable of keeping themselves warm.

Health aspects

The health of the pigs is comparable to that of pigs on a conventional farm. It is important to have the pigs outdoors already when they are very young. In the past animals were sometimes bought from conventional farms, but it was difficult to fit them in because they were not used to going outdoors.

At the moment, one of the main problems is pleurisy, an inflammation of the lining of the lungs and chest. The incidence of pleurisy on the farm is not bad compared to other organic farms, but it needs to be reduced, both for the animal welfare as for the economical aspect. Therefore, pigs are now vaccinated against *Actinobacillus pleuropneumoniae (APP)*, one of the causes of pleurisy. The sows are also vaccinated against red fever (*Erysipelothrix rhusiopathiae*).

Antibiotics are almost not used; below one “daydose” (kilograms of treated animals divided by the average present kilograms of animals) per animal. Occassionaly there is a sow with a endometritis or mastitis, a lame piglet, or a weaned piglet that needs to be treated. For the finisher pigs antibiotic use it is even less, around 1 on 500, mainly for lameness.




Internal parasites are not a real problem because a preventive strategy is used, less than 2% of the livers are condemned at slaughtering. The sows stay on the farm on average for five or six litters. Around 35-40% of the sows is being replaced every year. In the past there were some problems with reproduction, because it was more difficult to get the animals pregnant in the fall, when the days are getting shorter. This has been solved by giving them more light and warmth indoors.

The main cause of piglet mortality is the increased number of piglets per litter, caused by the longer lactation period in organic pig husbandry, which enables their uterus to restore better after labour. This leads to piglets with a lower birth weight, combined with not enough milk, which leads to mortality.

Tail biting and other behavioural problems do sometimes occur, but usually have a multifactorial cause. Causes can be: too many animals in the pen, too little distraction, suboptimal climate, etc. Once the tail is damaged and bleeding, it goes from bad to worse. Also, the health status has improved in the last two years, and with that the incidence of tail biting has decreased. Problems with sunburn are only minor; every year pigs get burned once, and learn from it. Also, stables are mostly build with the outdoor areas facing north, so there is less wind and sun.

With some health-issues organic animals are scoring better than conventional, e.g. on liver score and lungs, and also the growth check at weaning is much less, because the piglets stay with the sows longer. On this farm there are almost never problems with streptococcus or diarrhoea. The pigs may be stronger, and not stressed so quickly. Also their behaviour is very different; they are much easier to handle because they are less nervous.

It would be interesting if more research would be done on e.g. MRSA, although that almost does not occur in organic farming because of the low antibiotics use. In relation to outdoor husbandry, parasites can be suppressed, and the same goes for vermin. Flies are a problem, research has been done on using natural enemies, but that did not work because it was too cold for them outdoors.

Practical aspects

It is more work to have an organic farm, because the space per animal is larger, and because straw is used you need more time to clean the pens. It is about double the work of a conventional farm.

If more animals would be allowed to have access to a pasture, there would be a problem with the land. You can only have around seventeen finisher pigs per hectare, and the land is too expensive for this. Also The Netherlands are top of the bill looking at the environment, and

you have to cherish that. Neighbours never complain about the animals that are outdoors.

The future

Organic farming will remain a niche market, however it is growing and other concepts such as free-range are also growing. Hopefully organic will remain the most important segment. The concept has to keep improving, to make sure that organic farms keep ahead of the rest.

❖ Farm 't Helder – Fam. Sloetjes (organic)

Introduction

't Helder farm is an organic farm that is run by the Sloetjes family in Winterswijk. The farm has around 100 sows and 500 finishing pigs. The farm changed from conventional to organic in 1998. The farm is a so called closed system and therefore they finish all the piglets themselves. 't Helder farm has its own breed, which is 't Heldervarken, which was created after years of breeding.

Choice for organic farming

At the time this farm converted from conventional to organic, the farm changed in such a way that the pigs could move around on closed floors and not on slatted floors. Before they became organic, they housed all the sows in crates. After the outbreak of swine fever, there was a market potential for organic meat, so they decided to become organic. A big challenge was that there was no other farm which they could learn from.

In 2009 the meat distributor of 't Helder farm, De Groene Weg, said that they had too much organic pig farmers and they had to stop trading with some organic farmers. De Groene Weg said that in 2013 there needed to be a new type of barn for housing pigs outdoors. If such a modernized barn was not built at that time, the farm would have to stop. In 2009 a new barn was built and the design originated from the German Nürtingen University. When designing and building the barn, it was kept in mind that it should be like the pigs preferred it. Pigs should have sufficient space and should be able to have fun. In 1998 there were some systems that kept finishing pigs in so-called ethoboxes. These are boxes provided with flaps so that the pigs can walk in and out, while the warmth stays inside the box. In 2008 a comparable box was designed for sows with piglets. This system was found very suitable for this farm and it was especially liked that the boxes are similar to the natural environment of the pigs. The ethoboxes are comparable with the bushes in the forest, where pigs can lie down warm underneath and have their nose in the fresh air. The farm is set up according to the Skal regulations and the pigs are provided with slightly more space than required.

Health

There are no big health issues on this farm. The only problems are coughing and leg injuries. When the pigs stay outdoors for the whole day during spring and autumn days, they even will sleep outdoors. Sometimes it occurs that the pigs get a cold because of the draught. The pigs just forget to get back indoors when it becomes cold. In order to address this problem homeopathic medicines are being used. Besides, the philosophy on this farm is that coughing is natural, as people also do it. The leg injuries arise when pigs are running too fast




especially when there are more pigs per m^2. The animals then have less space and run into things more often. Therefore the farmers do not want the pens to be too fully occupied. Within large intensive farms, diseases are spreading within herds much easier. A farm should never be too full, it was experienced the same here on this farm.

Another issue is the feed quality. For example organic feed which does not have a correct nutritional value can be very bad for the animals. Once, this farm got feed that had 20% too little protein content, which caused problems with the animals.

When the sows enter the farrowing sow barn they are cleaned in order to have a good start. Furthermore all the pigs are dewormed, so there are almost no white spots on the livers. This farm does not have problems with parasites at all. After the farrowing sow barn is being cleaned, the straw and manure from the ethoboxes is distributed in the pasture where the sows are kept. This is done from the philosophy that this gives the sows extra resistance as this happens in nature as well.

The farm has a growth of 340-370 gram per day for young piglets until they are moved to the finishing group. On average each sow has 11.2 piglets per litter, which is below average, as in conventional the average litter size is between twelve and thirteen. The sows on the farm give 2.1 births per year and the lifetime of a sow is five to six years. Mortality on this farm is 2%.

The future

The government should give more support to farmers that are changing from conventional to organic. It takes two years to convert but this costs a lot of money and that makes it very difficult for those farmers. Biodiversity has been seen to improve a lot since the transition twelve years ago. The ability of nature to restore itself and keep alive is very strong.

The market for organic pig meat is growing, but not very fast. It also depends on the type of government at the certain time. There was a time the government said they would like to have more organic farmers. At the moment the government considers organic farming as less important, so many farmers decided to convert their farm back to conventional.

Conclusion

After speaking with these seven farmers, there are some interesting conclusions that can be drawn from their interviews. There are some things that conventional, free range, and organic farmers have in common, but in other aspects they have quite opposite opinions. Of course these farmers cannot represent all pig farmers in The Netherlands, but their opinions can be an indication of what the most relevant benefits and challenges related to outdoor pig husbandry are.

It was interesting that both conventional farmers said that in general indoor housed pigs are healthier than outdoor housed pigs. The reason mentioned for this is that indoors all housing conditions, such as climate, can be managed very well. In outdoor farms there are more external influences, which cannot all be controlled. Also, in outdoor farms there are more dangers for young piglets, such as predation by foxes and crows. On the other hand, one of the conventional farmers (the one that started the Piggy Palace) did think that outdoor housing would be more beneficial to pig welfare than indoor housing, so that the potential health problems would be outweighed by these benefits.

Free range and organic farmers however did not seem to encounter major health problems in their pigs. The problems that they mentioned are comparable to those that occur in conventional pig farming. Also, they use far less antibiotics than conventional pig farmers. The use is of course limited by regulations, but they could all stay beneath this norm easily, and were even trying to reduce the use of antibiotics even further. The organic farmers did not seem to have problems with intestinal parasites. They all use anthelmintics, which results in a low percentage of liver condemnation at slaughter.

The main reasons why farmers chose to switch to free range or organic systems were that these systems comprised a more natural way of keeping animals, so that the animals' needs can be better fulfilled. Another important reason was that the demand for animal friendly meat was growing, so there was an opportunity to make a good living out of it. Without the demand for free range and organic meat it would not have been possible for the farmers to make the transition, because the costs of these systems are much higher than for the conventional pig farming system.

All farmers agree on that free range and organic farming will stay a niche market in The Netherlands. There is simply not enough space to feed all people with organic farming. The demand for free range and organic meat is growing, however this is a slow process. Organic farmers would like to make improvements in their farming systems, to keep ahead of the other systems. For example they would prefer to use stronger breeds, but this is now constricted by their meat distributor De Groene Weg. Also they would like to increase animal welfare even more, e.g. by providing more space or straw. However, this is difficult mainly because of economic reasons.

Both conventional farmers were willing to convert to free range or organic, or to expand their current organic system, as long as there is a market for it and a good living can be made out of it. It has to be taken into account though, that there is the possibility that problems will reoccur that were prevalent ca. 50 years ago, when all the animals were still housed outdoors. This could mean more problems with animal health and food safety. However, as long as there is a market for the free range and organic meat, these farmers were willing to make the transition.

Recommendations and conclusion

Introduction

Now that there is an overview of the effects of outdoor housing on pig health, there are some recommendations to be made. The recommendations will be given per system (locomotion, digestion, respiration, reproduction and skin); they will point out how some challenges of outdoor housing can be overcome, and what needs to be kept in mind to prevent or solve possible problems that occur. These solutions are derived from literature, as well as from the interviews with experts. Finally some recommendations to overcome the farmers' major challenges for going outdoors will be given, because they face more challenges besides health when housing their pigs outdoors.

Locomotion

Foot and limb lesions are mainly caused by physical injuries. Especially in combination with a wet slurry floor, there is a high risk for infections (personal communication with Ir. H.M. Vermeer). It is imperative that the floor is cleaned regularly and properly, so that it is not wet or compiled with manure. The major factor that influences the occurrence of foot and limb lesion is the type of floor. Foot and limb lesions are less of a problem if you have a soft surface for pigs to walk on, such as soil and solid concrete with deep bedding (KilBride et al., 2009c; Mouttotou et al., 1999). However, toe erosions are more prevalent on soft surfaces (Scott et al., 2006). In general, if the floor surface is soft, not abusive and with no sharp edges or slats that can injure the pigs, prevalence of leg problems will be low.

In the case of osteochondrosis, neither the farmers nor the experts have referred to it as prevalent or as a current problem in both outdoor and indoor pig farming. A good solution could be what Grevenhof et al. (2011) recommend; more space, soft surface and perhaps combined with restricted feeding.

Infectious arthritis is mostly caused by *M. hyosynoviae*, *E. rhusiopathiae*, *H. parasuis* and *S. suis*. It was mentioned by an organic farmer that *S. suis* is less prevalent now that it is an organic farm, compared to when the pigs where housed indoors. In addition, most of the farmers mention joint infections to be prevalent in their farm. However, no scientific information could be found on the situation in The Netherlands. This goes not only for *S. suis* but also for infectious arthritis in general.

It can be concluded that a housing system that provides more space, soft and dry floor surfaces that are cleaned regularly, would lead to a lower prevalence of locomotion problems in pigs. Currently, the outdoor housing systems are more close to these recommendations than indoor housing systems.

Digestion

The main problems when housing pigs outdoors are infections with intestinal parasites (Borgsteede et al., 2011). These can cause clinical symptoms, which reduce pig welfare, but often infections are subclinical, leading to impaired growth and condemnations at slaughter (Roepstorff and Nansen, 1994; Taylor, 2006). Although these are serious problems, they can be kept under control by good management. None of the interviewed farmers named intestinal parasites as a major problem on their farm. Since management strategies such as pasture rotation, biological control or starting off a farm with helminth-free sows are often not feasible because of lack of land, lack of knowledge, or preferences for outdoor raised animals (Carstensen et al., 2002a), the way to go appears to be the one that most farmers already use, namely the use of anthelmintics. The drawback of this strategy is the possible development of resistance to these drugs (Wolstenholme et al., 2004). Even though this may develop slower in outdoor systems (Wolstenholme et al., 2004), it is important to keep researching new anthelmintics and alternative strategies to prevent and treat helminth infections in pigs.

Also it is needed to control vermin and contact with possible wildlife in outdoor housed pigs, since they can play a role in transmitting parasites and bacteria (e.g. Aguirre et al., 2000; Bajer, 2008; Funk, 2004). Finally, other management factors often associated with outdoor housing, such as the provision of roughage, provision of creep feed and a longer lactation period, are likely to improve the intestinal flora of the pigs (Mikkelsen et al., 2004). This would lead to lower disease prevalence, which is also reflected in some of the interviews with the farmers, in which they say diarrhoea is less prevalent than on conventional farms.

Overall, looking at the aspects of digestion that are influenced by outdoor housing, it can be said that outdoor housing does not pose a major risk for intestinal health, as long as the proper management strategies are used (e.g. use of anthelmintics, provision of roughage, vermin control). If all these are fulfilled, there is not a clear reason related to the digestive system, why pigs should not be housed outdoors.

Respiration

Recommendations to prevent or lower respiratory problems in the pig sector are mostly referred to air quality and indoor climate control (Nansen and Roepstorff, 1999; Seedorf and Hartung, 1999; Stärk, 2000). Because organic pig farms are required to provide straw, dust and endotoxin concentrations are on average higher in organic pig farms, which can partly explain higher pneumonia in this sector (Kijlstra and Eijck, 2006b). Better ventilation of the barns can cause most of the dust to be transported out of the barn. Also spraying water or oil in spaces with large concentrations of dust can help to precipitate the dust or prevent it to mount (Ruis, 2011). From the organic farmers that were visited dust was indeed one of the problems that caused more coughing in the stable. One of the organic farmers was thinking of using a spraying system in the nursing stable were dust was very high, which caused some coughing problems. Poor air quality in indoor systems with large amount of ammonia and hydrogen sulphide can be solved by better ventilation of the barn or switching to an outdoor system were fresh air is day and night available (Møller, 2000).

Draught is another predisposal factor for respiratory problems as pneumonia and pleurisy (Stärk, 2000). Because most outdoor systems in The Netherlands have a day and night enterable outdoor area, draught and fluctuating temperatures are a bigger problem than with conventional farming (personal communication with Ir. H.M. Vermeer). This might explain that pneumonia is more common in organic herds. Also when interviewing organic and free range farmers, coughing caused by draught was mentioned several times. At one farm pleurisy was mentioned to be a problem. Therefore, the animals were now vaccinated, but looking at the occurrence and prevention of draught would also be an option to reduce the problems at this farm. To prevent draught in (partly) outdoor systems, opening to outdoor areas can be provided with plastic flaps or another material that cover the opening. Especially the resting area, where pigs spent 80% of the time, needs to be free of draught and fluctuating temperatures (personal communication with Ir. H.M. Vermeer). Also placing walls in the indoor area may prevent draught in the whole barn (Ruis, 2011). To prevent further spreading of infections to other animals, mixing of animals has to be minimized, as it enhances the transmission of infectious agents (Ruis, 2011).

In conclusion, the respirational problems in (partly) outdoor systems can for the major part be prevented be a better control of dust and draught in the barn. This was also confirmed by the organic and free range farmers that we visited. Fortunately, several opinions exist to lower these factors in the barn.

Reproduction

Through the years a lot of research has been done on reproduction in pigs. These researches show that there are many different conditions and factors influencing the reproduction of sows. Reproductive problems in outdoor farming are mainly due to management (Karg and Bilkei, 2002). One principal reasons for culling in outdoor systems is low fertility of the sows because of anoestrus (Akos and Bilkei, 2004)(Akos and Bilkei, 2004). Anoestrus or seasonal infertility is a term which describes poor reproduction in the sow herd in different seasons and results from a combination of the effects of day length and high temperatures (Taylor, 2006). One interviewed organic farmer also mentioned that in the fall he had problems with getting the sows pregnant. Although this is a problem for outdoor farming, reproduction can be increased through lactational estrus (Kongsted and Hermansen, 2009). Lactational estrus means inducing pregnancy during lactation and in this way reducing the period between two farrowings without decreasing the lactational period (Kongsted and Hermansen, 2009; Mota et al., 2002).

Literature shows that the parasitic infection *Toxoplasma gondii* in The Netherlands has influence on fertility and reproduction. The infection can cause abortion, stillbirth and the production of weak piglets (Taylor, 2006). Although it is mentioned in literature, the interviewed farmers were not affected by this problem. To be sure to not get exposed with this infection it is recommended to prevent the access of cats on the farm, since they are a possible way of transmission (RIVM, 2007).

Although it is not mentioned as a problem by the interviewed farmers, pig mortality in outdoor husbandries is higher compared with indoor (Berger F., 1997; Vieuille et al., 2003). Some indicators for piglet survival in outdoor husbandries are piglet weight and litter size. Large litters contain more piglets with a lower birth-weight (Edwards et al., 1994). Lower birth weight means smaller piglets with a higher surface area to volume ratios and a higher risk for the piglets to become hypothermic and lethargic (Edwards et al., 1994). Because of the higher risk of becoming hypothermic, piglets need to warm themselves next to the mother which leads to the risk of being crushed. This is a problem that was acknowledged by the organic farmers.

Overall, looking at the aspects of reproduction that are influenced by outdoor farming, it can be said that it is difficult to compare indoor with outdoor because of the different factors that influence the systems. It can be said that seasonal infertility or anoestrus is a bigger problem for outdoor farming and that a lot of reproductive problems can be prevented by a good management system. In general it can also been said that optimal nutrition for the sow during gestation and lactation can have a positive effect on the piglet birth weight and also survival.

Skin

Skin lesions that are affected by the housing systems are damaging oral behaviours and sunburn. Damaging oral behaviours like tail biting, acts of aggression, and belly nosing are abnormal for natural pigs (Taylor et al., 2010). It is very difficult to pinpoint the origin of these behaviours, but studies have shown that the following factors can increase these destructive behaviours: a lack of stimulus, confinement, slatted flooring, illnesses, genetics, a lack of ventilation, and redirected foraging or weaning behaviour (Cagienard et al., 2005; Hötzel, 2004; Moinars, 2003; Petersen, 1994; Sutherland and Tucker, 2011; Walker, 2006). On the other hand, sunburn has a very direct cause, too much time spent in the sun (Cagienard et al., 2005). Pigs are very astute to the changes in the weather and given a wallow or shade will prevent getting sunburned (Bracke, 2011; Olsen, 2001). The farmers do notice that the pigs get sunburned once early in the year, then they do not repeat the mistake.

There are many ways to enrich the pig's environment which has been found to reduce the damaging oral behaviour and thusly they are used in intensive farms today, however none of them are a hundred percent effective (Schrøder-Petersen and Simonsen, 2001; Sutherland and Tucker, 2011; Weerd, 2005; Zonderland et al., 2008). Also, tail docking is utilized and it does reduce the amount of tail biting compared to the undocked tails, but it does not stop the behaviour so it cannot be seen as a cure (Sutherland and Tucker, 2011). As Schrøder-Petersen and Simonsem (2001) stated, the presence of tail biting is in itself an indicator of an environment that is insufficient to meet the natural needs of a pig.

However, according to the literature and the experts, deep litter pens with roughage food hidden in the straw, and enough space to perform natural behaviours greatly reduce the damaging oral behaviours (personal communication with Dr. L. Bolhuis; Olsen, 2001; Sutherland and Tucker, 2011).

It is interesting that all of the farmers we interviewed believed that their farm housing structure had the lowest rate of damaging oral behaviours. This may be due to the fact that the amount of biting is not constantly counted and the farmers do not directly compare these numbers. Also, the threshold might be different; each farmer type may have a different idea what a 'low' rate of tail biting or aggressive biting is.

Given a properly managed outdoor farm, there are less skin lesions in outdoor farms than in conventional indoor farms (Cagienard et al., 2005). According to dr. L. Bolhuis (personal communication), even a farm that looks perfect to a human could suffer from fighting and tail biting because of designs that do not consider pigs' natural behaviour, e.g. the lack of multiple food dispensers, lack of separate lying areas, etc. In addition, shade and a place to wallow are sufficient to prevent sunburn (Olsen, 2001). Appropriately managed outdoor farms are better for the welfare of the pig than indoor housing because they allow for natural behaviour like foraging, which reduces skin lesions. Therefore, it is advised the pigs should be able to go outdoors when considering the behaviour and skin lesions, if the farm is well managed.

Challenges for farmers

The main problems that the interviewed farmers seem to face when making the transition from indoor to outdoor pig husbandry, are lack of land / constricting environmental regulations (number of animals per hectare) and not enough overt demand for free range or organic meat products.

Looking at the first problem, it will be difficult to increase the amount of land per farm, since land is expensive. A possible way to solve this is to use arable land when the crops are harvested, although it has to be kept in mind that organic animals can only range on organic land. Also this requires a system that is more like that used in the UK; the outdoor hut system, which means that the farmers will have less control over their animals. Since many farmers do have some land, another possibility would be to make environmental regulations less strict, although this has to be done with care because these regulations are there for a reason.

To solve the second problem, consumers need to become willing to pay for free range or organic meat. This can be done by creating more awareness about the living circumstances of pigs in the different farming systems. This is already being done by non-governmental organisations such as Wakker Dier and the Dierenbescherming. Farmers, or a representative farmers organisation, could also play an important role in this, by making their business transparent and telling their stories. Another possibility could be to reduce or abolish the taxes on free range and organic meat, which makes it more attractive to buy them.

Conclusion

Taking into account all of the above recommendations it appears that in general, housing pigs outdoors from a health perspective is well possible and in some situations even beneficial. Especially for locomotion and skin / behaviour, and also partly for respiration it is beneficial for the pigs' health to be housed outdoors. The problems that can occur with e.g. digestion and respiration can be solved by good management, i.e. the use of anthelmintics, and preventing dust and draught. However, in the interviews with the farmers, several challenges were mentioned for farmers that have the desire to house their animals outdoors, which are not so much related to the health of the animals. These challenges which are seen as the biggest hurdles are more related with practical and economic issues such as lack of land, constricting environmental regulations, and insufficient market demand for free range and organic meat are important problems. These issues need to be solved in order to make it possible to house more pigs outdoors.

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Appendix

Questions for outdoor farmers

General questions:

- How many animals do you have?
- From what kind of breed are the animals?
- Why did you choose to have your animals outdoors? When was this decision made?
- Is outdoors to your opinion better for the animals?
- What kind of outdoor run/area do they have? How many acres? Space/animal?
- What is the outdoor schedule (per day and per year)?
- What are the production results?
- Were the animals always outdoors? (Reared in an outdoor system)
- Were the animals bred here or bought?
- Was there scaling up in the last 20 yrs?
- Stars from Dierenbescherming? Or EKO keurmerk? Compensation for extra costs?
- How did your neighbours react to having pigs outdoors?
- What were the main challenges in reaching outdoor husbandry?

Health-related questions:

- What were/are the main health-related problems on your farm? (separate for sows, piglets and finishers)
- What do you think are the causes for these health problems?
- What are the main adaptations you made for letting the animals go outdoors, in relation to health? E.g.:
    - Deworming/parasites
    - Sunburn
    - Reproductive challenges
    - Food
    - Adaptations to outdoor area (e.g. for safety/comfort of animals)
- Do you have other ideas/future plans to solve these problems?
- The main health problems in outdoor pig husbandry seem to be parasites, sunburns, lameness and injuries. Do you recognize these problems at you own farm, or other farms you know?
- How did/do you solve these problems?
- What are the mortality and morbidity rates? (if possible compared to old indoor situation)
- How is the antibiotic use? (frequency, type, reason)
- Longevity of the animals? (for sows)
- Are there any health-related aspects of outdoor housing that you would like to know or see investigated?
- If you would get more many for your products in the future, what changes would you make regarding to the health of the animals?

Practical issues:

- Is it more or less work for yourself to have pigs outdoors?

- How do you handle the animals, can they choose to go outdoors themselves?

Other questions:

- Do you feel supported by the government?
- Are there a lot of regulations you need to meet? (e.g. environmental)
- Do you get a compensation from cooperations/food processing companies for letting the animals outdoors?
- How are your sales going, can you make enough profit? Do you sell to NL or to abroad?
- How do you see the future of pig husbandry in relation to indoor/outdoor husbandry (for yourself & for NL)
- Can we have permission to take pictures, and to publish pictures and quotes in our products (report, presentations, draft brochure).
- Would you like to come to the congress?

Questions for farmers with free range pigs

General questions:

- Which kind of pigs do you have (e.g. piglets, sows, boars)? How many animals do you have?
- From what kind of breed are the animals? (Is this the same as organic?)
- Were the animals bred here or bought?
- What is your farm history? Did you always have had free range pigs? If not, why did you choose to keep free range pigs? When was this decision made?
- Was there scaling up in the last 20 yrs?
- Is free range to your opinion better for the animals?
- What is the difference between organic and free range?
- What is the free range schedule/ are they always outdoors (per day and per year)? If not, what type of barn do you have?
- What kind of free range run/area do they have? How many acres? Space/animal?
- How did your neighbours react to having free range pigs?
- What were the main challenges in reaching free range husbandry?

Production-related questions:

- What are the production results?
- In cooperation with the Dutch government agency PVE, PROduCERT has established rules for the certification and obtaining the corresponding label. What does PROduCERT actually and which rules you have to meet to become a free range farmer.
- How do they control. What does a butcher and company have to do to receive this label.
- Stars from Dierenbescherming? Besides the free range label are there other labels what you must have? Compensation for extra costs?
- Where do you get your pig feed from. Is this a special feed company?
- Do you get a compensation from cooperations/food processing companies for some kind of enrichments for the animals?
- You use 'lijnzaad' in your feed. Is this only by free range pigs or also by organic? What is the reason to use lijnzaad?
- Do you believe that free-range meat is healthier than conventional and/or organic.
- How are your sales going, can you make enough profit? Do you sell to NL or to abroad?
- Is free range meat more expensive than conventional but cheaper than organic?

Health-related questions:

- What were/are the main health-related problems on your farm? (separate for sows, piglets and finishers)
- What do you think are the causes for these health problems?
- How did you (try) to solve these problems?
- Do you at the moment have ideas/future plans to solve these problems?
- The main health problems in free range pig husbandry seem to be:.... Do you recognize these problems at you own farm, or other farms you know?

- What are the mortality and morbidity rates? (if possible compared to old indoor situation)
- How is the antibiotic use? (frequency, type, reason)
- Longevity of the animals? (for sows)
- Are there any health-related aspects of indoor housing that you would like to know or see investigated?
- If you would get more money for your products in the future, what changes would you make regarding to the health of the animals?
- Do you have future plans to turn to organic? If yes, for what reasons?

Other questions:

- Are there a lot of regulations you need to meet? (e.g. environmental)
- Do you feel supported by the government?
- How do you see the future of pig husbandry in relation to indoor/outdoor husbandry (for yourself & for NL)
- Can we have permission to take pictures, and to publish pictures and quotes in our products (report, presentations, draft brochure).
- Would you like to come to the congress?

Questions for indoor farmers

General questions:

- How many animals do you have?
- From what kind of breed are the animals?
- Why did you choose to have your animals indoors? When was this decision made?
- Is indoors to your opinion better for the animals?
- What type of barn do you have? Space/animal?
- What are the production results?
- Were the animals bred here or bought?
- Was there scaling up in the last 20 yrs?
- Stars from Dierenbescherming? Compensation for extra costs?
- (if they would like outdoor husbandry): what do you see as the main challenges for this?
- Did you ever have any reaction from neighbours to your pig farm? (positive/negative)

Health-related questions:

- What were/are the main health-related problems on your farm? (separate for sows, piglets and finishers)
- What do you think are the causes for these health problems?
- How did you (try) to solve these problems?
- Do you at the moment have ideas/future plans to solve these problems?
- The main health problems in indoor pig husbandry seem to be:.... Do you recognize these problems at you own farm, or other farms you know?
- What are the mortality and morbidity rates? (if possible compared to old indoor situation)
- How is the antibiotic use? (frequency, type, reason)
- Longevity of the animals? (for sows)
- Are there any health-related aspects of indoor housing that you would like to know or see investigated?
- If you would get more many for your products in the future, what changes would you make regarding to the health of the animals?
- Do you have future plans to turn to outdoor? If yes, for what reasons?

Other questions:

- Are there a lot of regulations you need to meet? (e.g. environmental)
- Do you feel supported by the government?
- Do you get a compensation from cooperations/food processing companies for some kind of enrichments for the animals?
- How are your sales going, can you make enough profit? Do you sell to NL or to abroad?
- How do you see the future of pig husbandry in relation to indoor/outdoor husbandry (for yourself & for NL)
- Can we have permission to take pictures, and to publish pictures and quotes in our products (report, presentations, draft brochure).
- Would you like to come to the congress?

Meeting the expert: Eddie Bokkers

The effects of outdoor and indoor housing on pig health

Questions

1. What is your specialization?
2. What is your opinion about outdoor and indoor housing of pigs? (What is good, what needs to be improved, what is better etc.)
3. In your opinion, does pig health improve with outdoor housing?
4. Which health issues occur most frequently in outdoor farms? And indoor farms? E.g.:
   - Locomotion
   - Digestion
   - Respiration
   - Reproduction
   - Skin lesions/injuries / Behaviour causing damage
5. What causes these problems?
6. How can these problems be solved?
7. What risk factors could you identify in outdoor pig husbandry? In relation to indoor?
8. Are there major differences in the health of outdoor housed meat pigs or breeding sows and piglets?
9. What are the (dis)advantages of outdoor farming compared to indoor farming in health related aspects?
10. Do you think farmers are willing to do something about the health problems?
11. Do farmers have the needed knowledge to improve pig health?
12. Is it expensive to improve health on the current farms?
13. Are there more or less behavioural problems in outdoor housing? What do you think is the main reason for this?
14. Do you know anything about antibiotics use in outdoor and indoor farming?
15. What changes do you think have to be made to lower the use of antibiotics?
16. Can the benefits of outdoor housing also be accomplished by changing the indoor housing design?
17. What do you think is the best housing system to house pigs that is existing at the moment? Can also be other, newer housing systems.
18. Do you know any conventional outdoor farms?

Meeting the expert:
Mart de Jong

The effects of outdoor and indoor housing on pig health

Questions

1. Which health issues occur most frequently in outdoor farms? And indoor farms?
   - Locomotion
   - Digestion
   - Respiration
   - Reproduction
   - Skin lesions/injuries / Behaviour causing damage
2. What risk factors could you identify in outdoor pig husbandry? In relation to indoor?
3. What are the major risks of having pigs outdoors with regard to public health?
4. Does the probability of a major outbreak increases with outdoor farming? (ease of spreading) What measures in your opinion if taken would minimize this risk?
5. A problem that outdoor is facing is parasitic burden. What in your opinion or are you aware of a monitoring system?
6. What are the (dis)advantages of outdoor farming compared to indoor farming in health related aspects?
7. Do you have any epidemiological data concerning outdoor pig farming that we could use?
8. What are the main obstacles for pig farmers to have their pigs outdoors?

Meeting the expert: Liesbeth Bolhuis

The effects of outdoor and indoor housing on pig health

Questions

1) What is your expertise?
2) In general, what are the natural behaviours that are also seen as damaging oral behaviours, or stereotype behaviours?
3) What are the differences in behaviour between; indoor, free range, and organic?
4) Are there any differences in behaviour between barn with patio organic and huts in outdoor organic?
5) What are the risk factors in general for behavioural disorders?
6) In your opinion, what is the best housing system in The Netherlands, and why?

Meeting the expert: Herman Vermeer

The effects of outdoor and indoor housing on pig health

Questions

1. What is your specialization?
2. What is your opinion about outdoor and indoor housing of pigs? (What is good, what needs to be improved, what is better etc.)
3. In your opinion, does pig health improve with outdoor housing?
4. Which health issues occur most frequently in outdoor farms? And indoor farms? E.g.:
   - Locomotion
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8. Are there major differences in the health of outdoor housed meat pigs or breeding sows and piglets?
9. What are the (dis)advantages of outdoor farming compared to indoor farming in health related aspects?
10. Do you think farmers are willing to do something about the health problems?
11. Do farmers have the needed knowledge to improve pig health?
12. Is it expensive to improve health on the current farms?
13. Are there more or less behavioural problems in outdoor housing? What do you think is the main reason for this?
14. Do you know anything about antibiotics use in outdoor and indoor farming?
15. What changes do you think have to be made to lower the use of antibiotics?
16. Can the benefits of outdoor housing also be accomplished by changing the indoor housing design?
17. What do you think is the best housing system to house pigs that is existing at the moment? Can also be other, newer housing systems.
18. Which aspects of outdoor housing need more research? What is still unclear?
19. What are the biggest challenges to house pigs outdoors?
20. How do you see the future for pig husbandry in The Netherlands?