Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science

Variation in fattening pig exterior, gait and weight gain in commercial organic herds

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Variation in fattening pig exterior, gait and weight gain in commercial organic herds

Variationer i benhälsa och tillväxt i kommersiella ekologiska gårdar

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Preface

This master thesis was carried out at the Department of Animal Breeding and Genetics at the Swedish University of Agricultural Science (SLU), located in Uppsala. My interest for pigs and pig production started during my senior year at High School. When Anna asked me if I would like to be a part of this project as a research technician during the summer and use some of the data for a master thesis, I did not hesitate much.

I would like to send my thanks to:

Anna Wallenbeck, my supervisor. Every time I needed support, ideas or help to move forward, you was always there. I'm very grateful to have you as my supervisor.

Nils Lundeheim, my examiner. Thank you for all the thoughtful inputs and ideas.

The four producers, I visited during the data collection. Thank you for the positive ideas and thoughts you shared with me. And thank you for all the fika!

Rolf Grahm, who has been a great help at the slaughter plant. Without you this would had been a nightmare.

The staff at the slaughter plant, who helped me with the data collection and the people at the slaughter line for coping with me being in the way.

Jon-Erik Karlsson, Ida Svensson and Elle Öholm, who helped me with the weight collection.

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My classmates at the department, who wrote their theses at the same time as I. We had lots of laughs!

Sofia Lloyd, who helped me with comments on the text.

My family, who has supported me during my whole school time.

Christina Eliasson

Uppsala, December 2012

Innehåll

Abstract

Pigs in Swedish organic production systems have been shown to have more findings of arthritis at slaughter, compared to pigs in conventional pig production. With this in mind a study was performed, to primary, investigate variation in exterior, gait and weight gain between sire breeds and, secondly, to investigate variation between herds, season, gender, age and assessment occasion on these recordings. Swedish commercial hybrids, crosses between Norwegian Landrace and Swedish Yorkshire were inseminated with either Hampshire or Duroc as terminal sire. All the pigs had known pedigree as each semen dose contained sperms from one individual boar. All piglets were individually tagged closely after birth, and exterior and gait assessment were performed at two separate occasions, early and late during the fattening period. At the assessment, exterior and gait parameters (lameness, back, leg, swollen joints and movement) were investigated. Data was collected and analyzed using SAS software, using three different statistical models. For the first two settings the results show that sire breed had little effect, while herd, gender, season, age and assessment occasion has some effect on the exterior and gait parameters. For the third setting the result showed that all the parameters; sire breed, birth herd, gender and season had some effect on weight and growth performance.

Sammanfattning

Grisar i ekologisk grisproduktion i Sverige har på senare tid fått en högre andel slaktanmärkningar angående ledproblem, jämfört med grisar från konventionell grisproduktion. Med detta i åtanke utfördes en studie med syftet att undersöka variationer i benhälsa och tillväxt mellan olika faderraser, samt undersöka variation mellan besättning, säsong, kön, ålder och bedömningstillfälle. Svenska kommersiella sugghybrider, Lantras- och Yorkshire korsningar, seminerades med antingen Hampshire- eller Duroc-galt. Alla suggor och galtar hade känd härstamning och varje semindos innehöll sperma från en individuell galt. Alla smågrisar öronmärktes strax efter födsel och exteriörbedömningar utfördes vid två tillfällen, tidigt och sent under slaktgrisens tillväxtperiod. Vid exteriörbedömningarna bedömdes 5 olika parametrar; hälta, rygg, benställning, svullna leder och rörelser. Data samlades in och analyserades statistiskt med SAS-programmet, i tre olika analyser. Resultaten från de två första analyserna visade att faderras hade liten effekt, medan besättning, kön, säsong, ålder och bedömningstillfälle hade viss effekt på exteriör parametrarna. I den tredje analysen visades att vikt och tillväxt påverkades av alla undersökta parametrar; faderras, smågrisbesättning, kön och säsong.

Introduction

The interest for organic pig production is increasing in Sweden, which shows in the increasing number of slaughtered pigs from organic production. In year 2011 about 25 000 pigs from certified organic production was slaughtered, which corresponds to about 1 % of the total pig production in Sweden (KRAV, 2012a).

In Swedish commercial pig production, both conventional and organic, the traditional breed combination is to use Landrace * Yorkshire (LY) F1 sows and this hybrid inseminated with a terminal sire of Hampshire or Duroc breed. However, in the Swedish organic commercial pig production, increased proportion of slaughter remarks on arthritis (Heldmer & Lundeheim, 2006) has raised producers’ interest in alternative sire breeds with more robust legs, as the organic production environment is rougher than commercial. In Sweden the most realistic alternative is to use the Duroc breed, since this breed already is available and import of new breeds is difficult (Hansson & Lundeheim, 2009; Wallenbeck, pers. comm., 2012).

Literature study

Breeding and breeding structure in commercial pig production

As described by Rydhmer & Lundeheim (2008), the breeding of pigs has a hierarchical structure, often described with a pyramid (Figure 1). In the top of the pyramid the nucleus herds perform selection with purebred animals, selecting boars to become AI-boars, on AI-stations, trough thorough recordings of the boar's performances. The hybrid sows from the nucleus and multiplier herds are used to transfer the genetic progress to the commercial herds. Purebred gilts from nucleus herds are sold to multiplier herds were they are inseminated with the other dame breed, Landrace or Yorkshire. Crossbred gilts (L*Y) from these litters are then sold to commercial piglet producing herds. The crossbreeding of the gilts can also occur in the nucleus herds, which then sells the crossbred gilts directly to the commercial piglet producing herds. These crossbred gilts, which are crosses from two dam breeds, are then bred with a third breed, producing piglets for fattening pig production at the bottom of the pyramid.

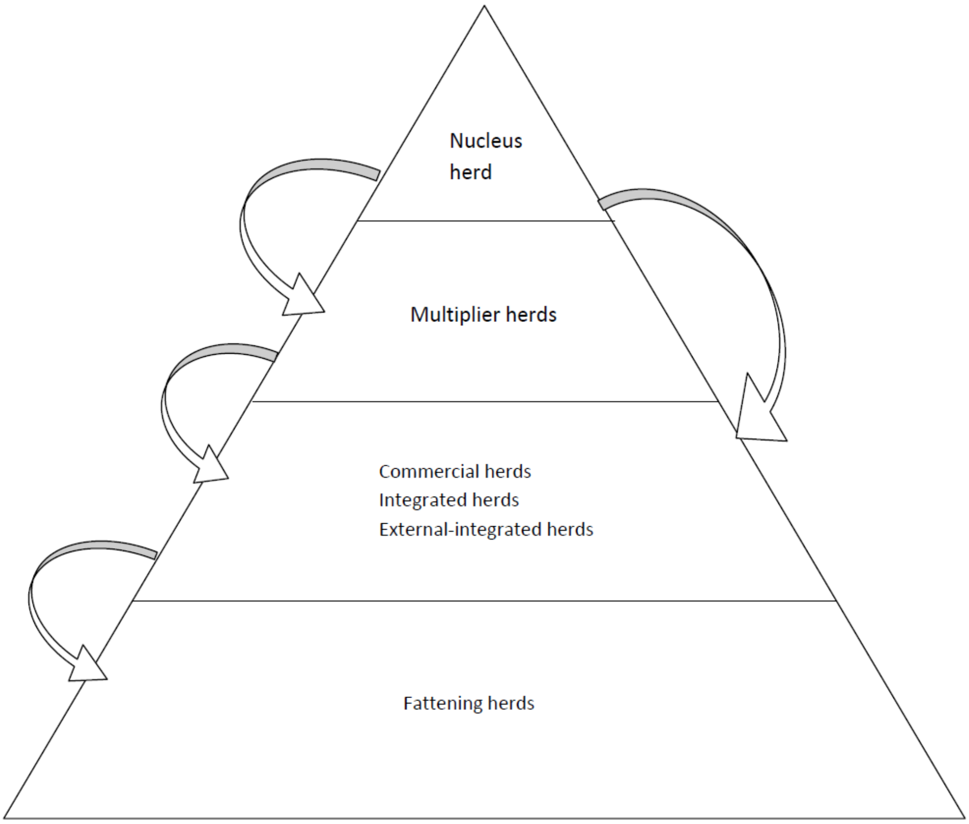

Figure 1. Breeding structure, explaining the hierarchical system, modified from Engblom, 2008.

This system of combining breeds is used to gain the effects of heterosis, where the offspring performs better than the average parents (Hansson & Lundeheim, 2009). Traits affected by heterosis are mainly litter size and piglet survival. In Sweden the sows in commercial herds, used for fattening pig production, are crosses between Landrace and Yorkshire, and the sire breeds that are used as terminal sires are usually Hampshire (H) or Duroc (D) (Mattsson *et al.*, 2005).

Organic farming and production environment for pigs

According to IFOAM (International Federation of Organic Agriculture Movements) organic agriculture is defined as: "*a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved*". From this definition the four principles of organic production are derived. The four principles are; Health, Ecology, Fairness and Care (IFOAM, 2012).

The European Union (EU) established rules for organic production for the EU members in 1991 (EC, 2012). These rules are the minimum criterias to follow to be allowed to label your products as organic. The majority of the organic production in Sweden is certified by "Kontrollföreningen för alternativ odling", KRAV (KRAV, 2012c). KRAV is a non-profitable, economic co-operation, with 26 member-organizations and companies, and over 4000 farmers connected. The organization strives towards a sustainable production, for all agriculture production. The regulations that KRAV has developed covers the whole production chain (production, processing, distribution, etc.). These rules are additional to the rules EU has established for organic production. For pig production, KRAV has criteria to follow concerning, among other things; feeding, management, housing, straw bedding, medical treatment, castration routines and slaughter.

There are some differences between organic and conventional production in Sweden. For example, in organic production according to EU-organic and KRAVs regulations, the pigs are kept on pasture during the vegetative period, and all the pigs have access to outdoor space the rest of the year. There is also a longer nursing period in organic production, which means that the piglets are weaned at 6-7 weeks of age instead of 4 weeks of age, see Table 1 (Jordbruksverket, 2011 & KRAV, 2012b).

Table 1. KRAV regulations, EU-organic regulations and the Swedish welfare legislations concerning housing and management in pig production, modified from Wallenbeck, et al (2009)

Issue	Organic (KRAV)	EU-organic	Conventional
Feeding and medical care			
Feedstuff	Organically grown (≥95 - 100%)[a], home grown (≥50%), *ad libitum* roughage allowance	Organically grown (≥95 - 100%)[a], home grown (≥50%), *ad libitum* roughage allowance	No specific regulations
Grazing	During the vegetative period	During the vegetative period	No grazing required
Weaning age	≥ 7 weeks[b]	≥7 weeks[c]	≥ 4 weeks
Medical care	No preventive medication other than certain vaccinations Double withdrawal period	No preventive medication other than certain vaccinations Double withdrawal period	Withdrawal period x 1
Housing, minima space allowance			
Gestation period (per sow)	Group and loose housed during gestation ≥ 2.5 m^2 indoor and ≥1.9 m^2 outdoor on concrete or on pasture in group huts	Group and loose housed during gestation ≥ 2.5 m^2 indoor and ≥1.9 m^2 outdoor on concrete	Group and loose housed during gestation ≥ 2.5 m^2 indoor
Nursing period (per sow and litter)	Single and loose-housed first 2 weeks ≥6.0 m^2 indoor or on pasture in group huts, loose-housed 2 weeks pp until weaning, ≥7.5 m^2 indoor and ≥2.5 m^2 outdoor on concrete or on pasture in family huts	Single and loose-housed from farrowing until weaning, ≥7.5 m^2 indoor and ≥2.5 m^2 outdoor on concrete	Loose-housed from farrowing until weaning, ≥6.0 m^2 indoor
Growing/finishing period (per pig, 85 kg)	Loose-housed, ≥1.2 m^2 indoor and ≥0.8 m^2 outdoor on concrete	Loose-housed, ≥1.2 m^2 indoor and ≥0.8 m^2 outdoor on concrete	Loose-housed, ≥0.83 m^2

[a]Conventional protein feedstuff up to 5% is allowed until 2015, when the feed should be 100% organically grown
[b]Weaning 40 days post partum allowed for the youngest piglets in a group when batchwise piglet production is applied
[c]Weaning at 40 days post partum.

Growth performance

The growth performance of pigs is well studied and has been closely investigated and evaluated for decades. Andersson (1980) performed studies with the aim to evaluate different crossbreeding systems with several different breeds in conventional pig production system. The results showed that the three-breed cross with (LY)*H combination had a shorter fattening period and higher percent of lean meat in the carcasses than the back-crosses with L or Y breeds. The average daily gain for the (LY)*H pigs were 0.496 kg carcass meat/day during their whole life (1.5-99.2 kg). As a result of the study the Hampshire breed was established in Sweden. Wallenbeck *et al.*, (2009) performed a study were Swedish Hampshire boars were re-evaluated for their breeding value in organic production. In this study the fattening pigs ((LY)*H) had an average daily gain of 0.578 kg liveweight/day from birth to slaughter (1.5-100kg).

The use of Duroc as a terminal sire was evaluated by Smith *et al*. (1988) in New Zealand. In combination with a sow hybrid, Landrace and Large White cross, the fattening pigs in this study had a daily gain of 0.767 kg/day for the growth period (25-85kg). Blasco *et al*. (1994) used the same type of three breed cross in their study, performed in Spain. In this study the fattening pigs had a daily gain of 0.888 kg/day for the growth period (23-97kg). Both Smith *et al.* (1988) and Blasco *et al.* (1994) conducted their studies in conventional production environment, compared to Kelly *et al.* (2007). This latter study was performed under organic production conditions in United Kingdom. With the same type of pig cross breed as Smith *et al.* (1988) and Blasco *et al.* (1994), Landrace * Large White sows and Duroc sire, the fattening pigs in this study had a daily gain of 0.74 kg/day for the growth period (31-91kg).

In Sweden a study to compare the production results between Hampshire and Duroc was performed by Mattsson *et al*. (2005). The study was performed in conventional production environment on two herds and the sows were hybrids of Landrace and Yorkshire. The sows were inseminated with semen from either Hampshire or Duroc. The fattening pigs of LY*H (590 pigs) crossbreed had a daily gain of 0.848 kg/day for the growth period (31.5-87kg slaughtered weight), while the fattening pigs of LY*D (600 pigs) crossbreed had a daily gain of 0.894 kg/day for the growth period (31.5-88kg slaughtered weight). In that study the fattening pigs with Duroc as sire had a higher daily gain, higher slaughter weight and were younger at slaughter than the fattening pigs with Hampshire as terminal sire.

Stern *et al*. (2003) performed a study to compare the production results between outdoor and indoor rearing in Swedish production environment. In this study one group of the fattening pigs were crossbreeds of (Landrace*Large White)*Hampshire. These pigs had a daily weight gain of 0.841 kg/day for the growth period (22-108kg). The other group of pigs were crossbreeds of (Landrace*Duroc)*Hampshire. When comparing the results from all the fattening pigs in the study, there were differences in daily gain for outdoor and indoor rearing, where the pigs reared outdoors had a lower total daily gain. However, during the first growth period (22-60kg) the pigs reared outdoors had a higher daily gain than the pigs reared indoors. Enfält *et al.* (1996) compared the difference in growth between Yorkshire and Duroc as sire breed. The results showed that even though there were a difference in daily gain, the difference was not significant.

Leg-health

Leg health in pigs has been evaluated for decades. One possible reason to poor leg health in organic pig production may be infectious inflammations caused by Erysipelas, *Erysipelothrix rhusiopathiae* or osteochondrosis (non-infectious) (Ström, 2009, Heldmer *et al*., 2006).

Lundeheim *et al.* (1987) studied leg weakness traits on purebred Landrace and Yorkshire pigs on the basis of station testing of nucleus pigs. The study found that osteochondrosis prevalence and severity in elbow joints is heritable for pigs and the heritability was found to be 0.21±0.03 for Landrace and 0.25±0.04 for Yorkshire. Moreover the study also reported that the heritability for clinical leg weakness were 0.14±0.03 for Landrace and 0.11±0.03 for Yorkshire. The conclusion that osteochondrosis and leg weakness is heritable for pigs were also confirmed by Stern *et al.* (1995), who performed a study on four generations of Yorkshire pigs to evaluate the effects from selective breeding for lean tissue growth rate on leg weakness and osteochondrosis. The pigs were fed two different feeds, either low protein content or high protein content. This study found the heritability for osteochondrosis in elbow joints to be 0.46±0.14 for pigs fed with low protein feed, and 0.33±0.12 for pigs fed with high protein feed. The study also found that clinical leg weakness had a heritability of 0.16±0.008

for pigs fed with low protein feed and 0.20±0.009 for pigs fed with high protein feed, concluding that leg weakness also are heritable for pigs.

Heldmer *et al*. (2006) evaluated the slaughter remarks registered on pigs slaughtered on the Swedish slaughter plants in the period 1997-2005. The study concluded that the prevalence of arthritis were up to six times higher among pigs from organic production than those from conventional production. Besides the reduced welfare for the pigs, caused by the lesions, leg problems affect profitability negatively. The slaughter industries have payment reductions for this kind of remarks, in addition to the possible loss in payment for discarded parts to the production herds. Further studies showed that the cause of these lesions were likely to be osteochondrosis (Berg, 2009; Gångare, 2009), rather than having infectious causes.

Individual identification and on farm studies

To ensure individual traceability during the pigs life, from birth to slaughter, good identification methods are required, especially in scientific on-farm studies. Plastic ear tags with visual id numbers and tattooed id. are some common ways of identification of pigs (Wallenbeck *et al.*, 2009). The problem is that ear tags easily fall off, and tattoos can be difficult to read. These visual identification methods can also be difficult to read if the pig is dirty.

One option is to use electronic identification devices (EID). Ear tags with electronic transponders has been evaluated by several studies (Caja *et al.*, 2005; Babot *et al*., 2006; Schembri *et al*., 2007; Gosálvez *et al*., 2007). These studies concluded that, using transceivers to read the tags, EID was a fast way to identify the pigs. However, the studies also found a risk of lost identification, due to losing the tag or malfunction of the electronic part of the tag. The risk of loosing a tag is depended on the size of the tag and the housing environment.

Aim

The primary aim of this study was to investigate variation in leg health and weight gain between sire breeds in organic pig production. Secondary aim was to investigate variation between herds, season, gender, age and assessment occasion, for these measurements.

Material and methods

This study was a part of the project “Animal welfare in organic pig production – does leg health in growing-finishing pigs improve by change of sire breed?”, funded by SLU EkoForsk. In the project there was seven organic pig herds that participated. This part of the project was carried out from October 2011 to November 2012. The aim of the project was to investigate the effect of sire breed on pig leg health and performance. This was investigated based on information registrations in organic herds and slaughter plants. Sows were inseminated with semen from either Hampshire or Duroc boars and the offspring were followed individually from birth to slaughter. Leg health was registered twice during the growing/finishing period and health remarks, slaughter weight, meat percentage were registered at slaughter. Additionally, in one fattening herd, live weight was individually recorded at arrival to the herd and just before slaughter.

Animals

The sows kept in the herds included in this study were Swedish commercial hybrids crosses between Norwegian Landrace and Swedish Yorkshire. Since replacement gilts in most cases were raised in the herd trough criss-cross breeding, the proportion of each of the two dame breeds in each animal varied between 33 and 66% (Hansson & Lundeheim, 2009). The identities of each sow’s parents were registered. The sows were inseminated with a terminal sire of either purebred Swedish Hampshire or purebred Norwegian Duroc with known pedigree. In each group of sows, half of the sows were inseminated with Hampshire and the other half with Duroc. Each semen dose contained semen from one individual boar to secure known pedigree on the fattening pigs.

Herds/housing

All herds included in this study (Figure 2) were certified according to KRAVs regulations for organic production (KRAV, 2012b). The herds were located in the central parts of Sweden between latitude 59° and 61°. Piglet farms PH1 and PH2 were piglet producing herds, from which growing pigs are sold to fattening pig herds at 30 kg live weight. The fattening pig herd FH1 received weaners from both PH1 and PH2. Sometimes PH1 also delivered 30kg-piglets to the integrated herd IH1. The integrated herds IH1, IH2, and IH3 had between 40-80 sows in production.

In the herds, all sows farrows indoors in Swedish conventional, individual loose-housed farrowing pens. Two weeks after farrowing the sows and their piglets are kept in deep-strawed family pens or on pasture in groups with 4 – 10 sows per group. In the family pens the sows are loose-housed with the possibility to access an outdoor area with concrete floor. On pasture the pigs have access to either huts where they can sleep and find shadow, or access to stables. The piglets are weaned 6-7 weeks after farrowing, when the sows are removed.

The fattening pigs are kept on pasture during the vegetative period of the year. The rest of the year all pigs have outdoor access with concrete flooring. During summer time, when the pigs are out on pasture and the grass does not provide enough roughage, this is provided by the herdsmen in form of grass/clover silage bales. The growing pigs stay in the same groups until they are ready for slaughter. If the pigs are on pasture, they are moved into loose-housed fattening pig stables, a couple of weeks before slaughter. The pens in the fattening pig stables all have outdoor access.

All animals are fed according to the SLU feeding norm and the feeding rules in KRAV regulation (SLU, 2011, KRAV, 2012b). Connections between the herds and the slaughter house are presented in figure 2. All the integrated herds and the fattening pig herd in this study deliver the fattening pigs to the same slaughter plant, when the pigs have a live weight of approximately 120kg.

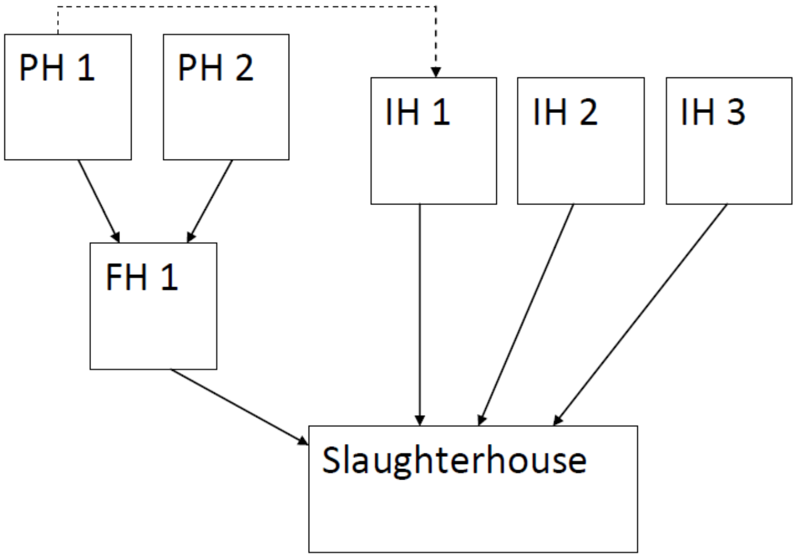

Figure 2: Description of the six herds and the connections between them. PH 1 and 2 are Piglet producing Herds, FH1 is a Fattening Herd and IH 1, 2 and 3 are Integrated Herds.

Registrations

The registrations made were divided in three parts, one part recorded by the herdsmen on herd, one part recorded by a trained research technician, me, in the herds (exterior and gait assessment, and on one herd, weights) and one part where a research technician recorded data from the slaughter house. A time axis with the events recorded during the study is shown in figure 3.

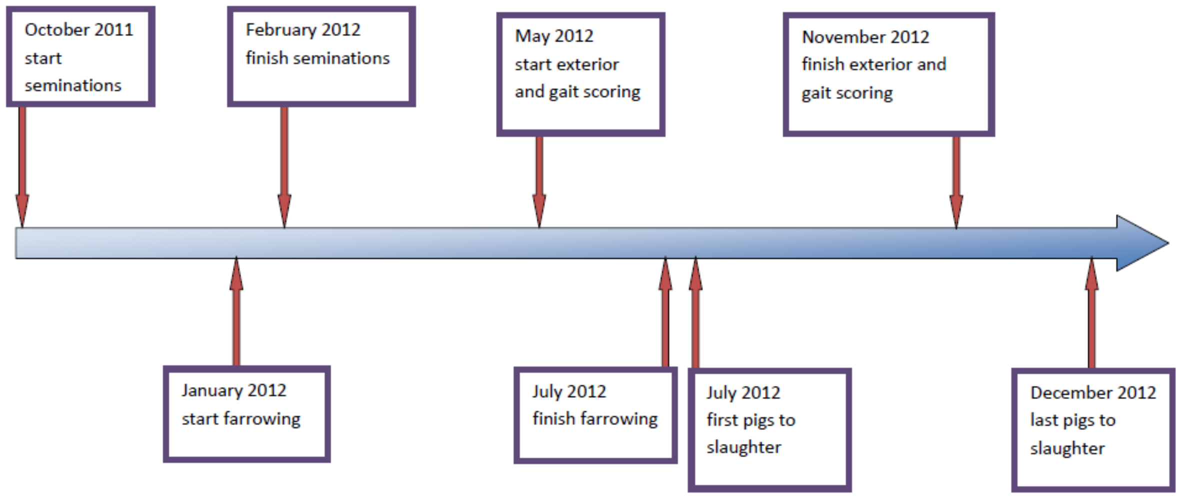

Figure 3. Time axis showing the events during the project. Registrations on gait and exterior assessment and on one herd weights performed until November 2012 are included in this study.

- **Herdsmen**

The management of the animals and parts of the registrations made in this study were performed by the herdsmen. All the herds in this study received a binder with preprinted papers where the herdsmen were able to gather individual information about the herds, sows, terminal sires, piglets and growing pigs involved in this study.

Before inseminations, herdsmen registered identity (id) of the sows in question, birth date for the sow, parity number, id and breed of the sow's parents and vaccinations given. At insemination the herdsmen registered date, sow id, sire id, sire breed and expected farrowing date. At farrowing, herdsmen registered sow id, date of farrowing, if the farrowing was indoors or outdoors, what kind of lactation environment the sow has, number of piglets live born and still born, probable cause of deaths, date and number of piglets ear tagged (before two weeks of age), date of castration, date and number of piglets moved to group box and date and number of piglets weaned. If cross-fostering occurred the date and id of transferred piglets and reason of moving were registered.

The piglets were tagged with electronic ear-tags for animals (EID) called 'Combi E®', size 23mm Ø (OS ID Stallmästaren, 2012). The tag has an electronic chip transponder, based on Radio Frequency Identification (RFID) technology, with an individual number and a corresponding number imprinted on surface of the tag. This tag is approved by International Committee for Animal Recording (ICAR), valid for the international standards for tagging of animals ISO11784 and ISO11785 (ICAR, 2012). When the piglets were ear-tagged, herdsmen registered ear tag number, sow id and gender of piglet.

Medical treatments of the sow and piglets during the lactation period were registered, along with date, drug, reason for treatment and if a piglet was euthanized or found dead. If a piglet died the id, date, probable cause of death and estimated days the piglet had been dead was registered. After weaning, during the growing/fattening period, the herdsmen registered if the pigs were medically treated, drug used for treatment and id of the pig. If a pig died during the growing/fattening period, the id of the pig, date of death and probable cause of death were registered.

- **Exterior and gait scoring**

To be able to perform a correct exterior and gait scoring, a protocol with several different assessment points were followed, with several degrees of severity for each assessment point. In Appendix 1a and 1b the protocol shows how to assess if a pig has a normal exterior and gait scoring or if there were aberrances.

All the gait and exterior assessments were performed by the same trained research technician, me, to ensure a uniform assessment. Appendix 2 shows the gait scoring scheme, translated from Swedish to English, and Appendix 3 shows an example of the gait scoring scheme with completed comments about some pigs in this study. The assessments were conducted two times for every growing pig at approximately 12 and 22 weeks of age. To identify the individual pig, a hand-scanner was used to read the identification number from the ear-tag. The scanner was a HHR 3000 Pro V2 HandHeld Reader, approved for reading ISO 11784/11785 transponders (BioControl AS, 2012).

The aim was that the first assessment should occur when the pigs had a live weight of approximately 30 kg. In reality the first assessment occurred at a mean age of 88.8 ± 11 days. The second assessment occurred as close to slaughter as possible, with a mean age of 167.1 ± 13 days. As the pigs grow with different growth rates the assessment time for the whole group was decided to take place when the first pigs where ready for slaughter. Additionally, at the fattening herd (FH1) all the pigs were weighed during both assessments. At the second assessment all pigs were tattooed with an individual number, to ensure identification at the slaughter plant, since the ear-tags might get lost in the slaughter process.

If an identification tag was missing at the assessments, this was recorded as ‘lost tag’ and the pig was not included in the study. At the second assessment, when all pigs were tattooed, some of the pigs had ear-tags that couldn’t be read due to malfunction on the transponder. These pigs were scored and tattooed, even though the electronic identification number was missing (since the identification number was readable by eye from the tag). This was done, since there was a chance that the identification number could be recovered at the slaughter plant.

- **Slaughter plant**

A research technician was present at the slaughter house, to collect information every time pigs included in the study were sent to slaughter. The technician collected every fattening pig´s individual ear tag number; using the same type of scanner as for the assessments, or tattoo number (if ear tag was missing), as well as the serial number given to the carcass by the slaughter house. The information about carcass weight, meat percentage and slaughter remarks were then collected from the slaughter plant´s data base.

Statistical analysis

The data included in this study were from PH1 and PH2, IH1 and IH2 and FH1 until second assessment. The limitations were done to make the size of this master thesis feasible. Moreover, data from IH3 was not included since the second assessment on this herd was not finished, and all fattening/finishing pigs were not slaughtered in time for the analyses of this master thesis study, thus this information could not be included.

Statistical analyses was performed using the Statistical Analysis Systems; SAS 9.2 (SAS, 2012). Data from registrations about sire and litter id registered by herdsmen and data from exterior and gait assessment and weights registered by technician (master student) were merged and edited. Descriptive statistics were estimated using proc FREQ and proc MEANS. Assessment scores from the exterior and gate assessment were transformed into binomial parameters were 0 = normal and 1 = aberrance from normal.

- **Exterior and gait**

Differences in frequencies of the binomial leg health parameters (lameness, back, leg, swollen joint, movement) from the exterior and gait scoring were analysed with logistic regression using procedure GLIMMIX (logit link and binomial distribution), using Model 1 below. Least-square-means and standard errors were estimated.

Model 1: y = breed + terminal herd + month of birth + gender + age + e

Breed (sire breed: Duroc or Hampshire), terminal herd (IH1, IH2 or FH1), gender (barrow or gilt) and season (expressed as month of birth: Jan, Feb, March, April, May) were included as fixed class effects. Age at the assessments was included as a continuous variable and regression coefficients were estimated (b-values).

Additionally, a specific analysis of associations between gait and exterior scores in assessment 1 and 2 was performed. A data set was created where the parameter ‘assessment occasion’ (1 or 2) was added and each pig had one observation per assessment (i.e two observations per pig). The input variables were transformed into one parameter per assessment instead of two (lameness instead of lameness 1 and lameness 2, back instead of back 1 and back 2, etc.). Differences between assessment 1 and assessment 2 were analyzed with logistic regression using procedure GLIMMIX (logit link and binomial distribution), and Model 2 below.

Model 2: y = breed + assessment occasion + terminal herd + gender + season + e

- **Weight and growth**

An analysis was conducted to investigate the variation in growth rate based on the weight information registered in the fattening herd (FH1). The pigs in this analysis were pigs born in PH1 and PH2 and then delivered to FH1. Data was analyzed with analysis of variance, using the procedure GLM and Model 3, where y = growth rate

Model 3: y = breed + birth herd + season + gender + age + e

Breed (sire breed: Duroc or Hampshire), birth herd (PH1, PH2), gender (barrow or gilt) and season (based on month of birth: Jan, Feb, March, April, May) were included as fixed class effects. Age and weight at the assessment (age = age at weighing or in the case of growth age = age at first weighing, second weighing or first and second weighing) was included as continuous variables and regression coefficients were estimated (b-values).

Growth performance between birth and assessment 1, growth performance between birth and assessment 2 and growth performance between assessment 1 and assessment 2 were also analyzed.

Results

This study consists of three different sets of analyses and corresponding results: 1) Analyses of the effect 'sire-breed', 'gender', 'herd' and 'season' on exterior and gait score, 2) Analysis of the effect of time (pig age) on exterior and gait score and 3) analysis of the effects of sire-breed, gender, birth herd and season on pig growth. The results are presented separately for the different analyses.

The total number of animals included in the analyses of exterior and gait score was 984. Of these, 385 (39%) had a D-sire and 599 (61%) had a H-sire. Moreover, 502 were barrows (52%) and 470 were gilts (48%), in addition 12 pigs had unknown gender. The number of piglets born in each piglet producing herd was 196, 281 and 506 in herd IH 2, IH 1 and PH 1, respectively.

Information about gender was missing for 12 pigs and herd was missing for one pig, thus these pigs were not included in the analyses. The missing herd for one pig was due to human error, where the herd id was missed to be registered when editing the data.

Exterior and gait assessment

The result from the analysis indicates a low impact of 'sire breed' and 'gender' on the exterior and gait parameters investigated. The significant effects observed for these two parameters were of registrations made at the second assessment, just before slaughter. 'Herd' and 'season' on the other hand was found to have impact on several leg health parameters, both early and late during the fattening period (Table 1).

Table 1. P-values for effects included in the model for analyses of leg health parameters in assessment 1 and 2. ns = not significant

		Sire breed	Herd	Gender	Season	Age ass. 1	Age ass. 2
Assessment 1, %	Lameness	ns	ns	ns	ns	0.081	
	Back	ns	ns	ns	ns	0.009	
	Leg	ns	0.091	ns	0.012	ns	
	Swollen joint	ns	ns	ns	ns	ns	
	Movement	ns	0.066	ns	0.003	0.001	
Assessment 2, %	Lameness	ns	ns	ns	0.005		0.004
	Back	ns	0.094	ns	ns		ns
	Leg	ns	0.018	0.017	0.008		0.054
	Swollen joint	0.027	0.091	0.054	ns		0.001
	Movement	ns	0.001	ns	0.001		0.015

The more detailed analysis of the effects of pig age on exterior and gait parameters included 1403 observations. Of these, 614 of the pigs had registrations from both the first and the second assessment. The total number of pigs with registrations from the first assessment was 667 pigs, and the corresponding number for the second assessment was 740 pigs. The main reasons for the missing assessments were piglets being moved to remote pastures in the forest at three weeks of age and they were not brought back until time for slaughter, pigs that died between assessment 1 and assessment 2, ear tags had been lost or fattening pigs sent to slaughter earlier than expected.

- **Sire breed**

Breed had a negligible effect on exterior and gait parameters. The only exterior and gait parameter found affected significantly by breed was ‘swollen joint’ at the second assessment. This indicates that the offspring of Hampshire boars have a higher prevalence of swollen joints in the end of the fattening period compared with offspring of Duroc boars (Table 2).

- **Herd**

There were tendencies of herd effects on the parameters ‘leg’ and ‘movement’ at the first assessment, and for ‘back’ and ‘swollen joint’ at second assessment. Moreover, herd had significant effect on ‘leg’ and ‘movement’ at the second assessment. The results indicate that a higher proportion of pigs from herd IH1 had aberrance on the leg health in assessment 1 and that herd IH2 had a higher proportion of pigs with aberrance at assessment 2, with the exception of movement, where herd FH1 had the highest proportion of affected pigs (Table 3).

- **Gender**

Significant differences in exterior and gait parameters were found between genders, showing that a higher proportion of barrows had leg remarks (24.8±0.26) compared to gilts (17.1±2.16, $p = 0.017$) at the second assessment and that a higher proportion of gilts had swollen joints (6.8±1.48) compared to barrows (3.8±1.04, $p = 0.054$) at the second assessment.

- **Season, month of birth**

Season had a significant effect on exterior and gait parameter ‘movement’ ($p=0.003$) and ‘leg’ ($p=0.012$) at assessment 1 and ‘lameness’ ($p=0.005$), ‘leg’ ($p=0.008$) and ‘movement’ ($p=0.001$) at assessment 2. The pairwise differences in Figures 4-8 indicate that pigs born later during spring (March, April and May) had worse leg health compared with pigs born earlier in the year.

- **Age**

Age at the assessment had significant effects on most of the parameters, both early and late during the fattening period. The estimated regression coefficients (b-values) indicates that leg health decreases with age, except for ‘back’ which has a negative b-value at first assessment, indicating that this parameter improves with age or that there are fewer pigs with back problems over time. On the other hand, ‘back’ has a positive b-value at second assessment, which may indicate that the improvement only was temporary (Table 4).

- **Assessment occation**

The detailed analysis investigated if there were any significant differences in prevalence of exterior and gait scoring between assessment 1 and assessment 2. All the binary parameters significantly increased between first the second assessment, except the parameter ‘back’ which was significantly lower at the second assessment (Table 5).

Table 2. Effect of sire breed on exterior and gait parameters among pigs with D or H sire. Least square means ± standard errors are presented in % of pigs with score 1 = aberrance from normal

		D-sire	H-sire	p
Assessment 1, % of pigs	**Lameness**	7.4±2.04	6.2±1.47	ns
	Back	1.4±2.78	1.1±2.06	ns
	Leg	4.2±1.56	5.4±1.44	ns
	Swollen joint	0.7±0.56	1.4±0.78	ns
	Movement	7.1±1.94	8.2±1.73	ns
Assessment 2, % of pigs	**Lameness**	19.3±2.5	21.3±2.2	ns
	Back	6.5±1.59	4.9±1.14	ns
	Leg	23.5±2.76	18.2±2.07	ns
	Swollen joint	3.4±1.1	7.6±1.47	0.027
	Movement	26.8±2.84	29.1±2.46	ns

Table 3. Effect of herd on exterior and gait parameters among pigs from the different herds. Least square means ± standard errors are presented in % of pigs with score 1 = aberrance from normal
Pairwise differences with p<0.05 are indicated with superscript letters. Values with one letter in common does not differ significantly

		Herd IH2	Herd IH1	Herd FH1	p
Assessment 1, % of pigs	**Lameness**	2.3±1.74	13.9±5.42	9.4±3.52	ns
	Back	12.8±3.28	11.0±2.77	14.8±3.20	ns
	Leg	4.1±2.08	9.7±4.32	2.6±1.39	0.0905
	Swollen joint	2.4±2.3	1.7±1.80	0.2±0.29	ns
	Movement	2.4±1.82	16.5±5.70	10.4±3.67	0.0663
Assessment 2, % of pigs	**Lameness**	18.1±3.17	19.9±2.65	23.1±3.05	ns
	Back	8.8±2.44	3.4±1.16	5.8±1.61	0.0940
	Leg	27.5±3.84^{a}	15.4±2.37^{b}	20.5±2.88^{ab}	0.0181
	Swollen joint	8.1±2.30	5.6±1.52	3.0±1.06	0.0910
	Movement	24.2±3.47^{ab}	19.7±2.57^{a}	42.6±3.72^{b}	<0.001

Table 4. Effect of age at assessment on the different exterior and gait parameters at the two assessments. Results presented by regression coefficients (b-value) and its p-value

		b-value	p-value
Assessment 1	**Lameness**	0.03	0.081
	Back	-0.04	0.009
	Leg	0.02	ns
	Swollen joint	0.01	ns
	Movement	0.05	0.001
Assessment 2	**Lameness**	0.02	0.004
	Back	0.01	ns
	Leg	0.02	0.054
	Swollen joint	0.04	0.003
	Movement	0.02	0.015

Table 5. Effect of assessment occasion on exterior and gait parameters at the two assessment occasions. Least square means ± standard errors are presented in % of pigs with score 1 = aberrance from normal

	Assessment 1	Assessment 2	p
Lameness	7.1±1.10	21±1.67	<0.001
Back	14.9±1.78	5.2±0.89	<0.001
Leg	5.0±0.91	21.2±1.71	<0.001
Swollen joint	1.2±0.42	5.8±1.01	<0.001
Movement	8.8±1.18	27.8±1.86	<0.001

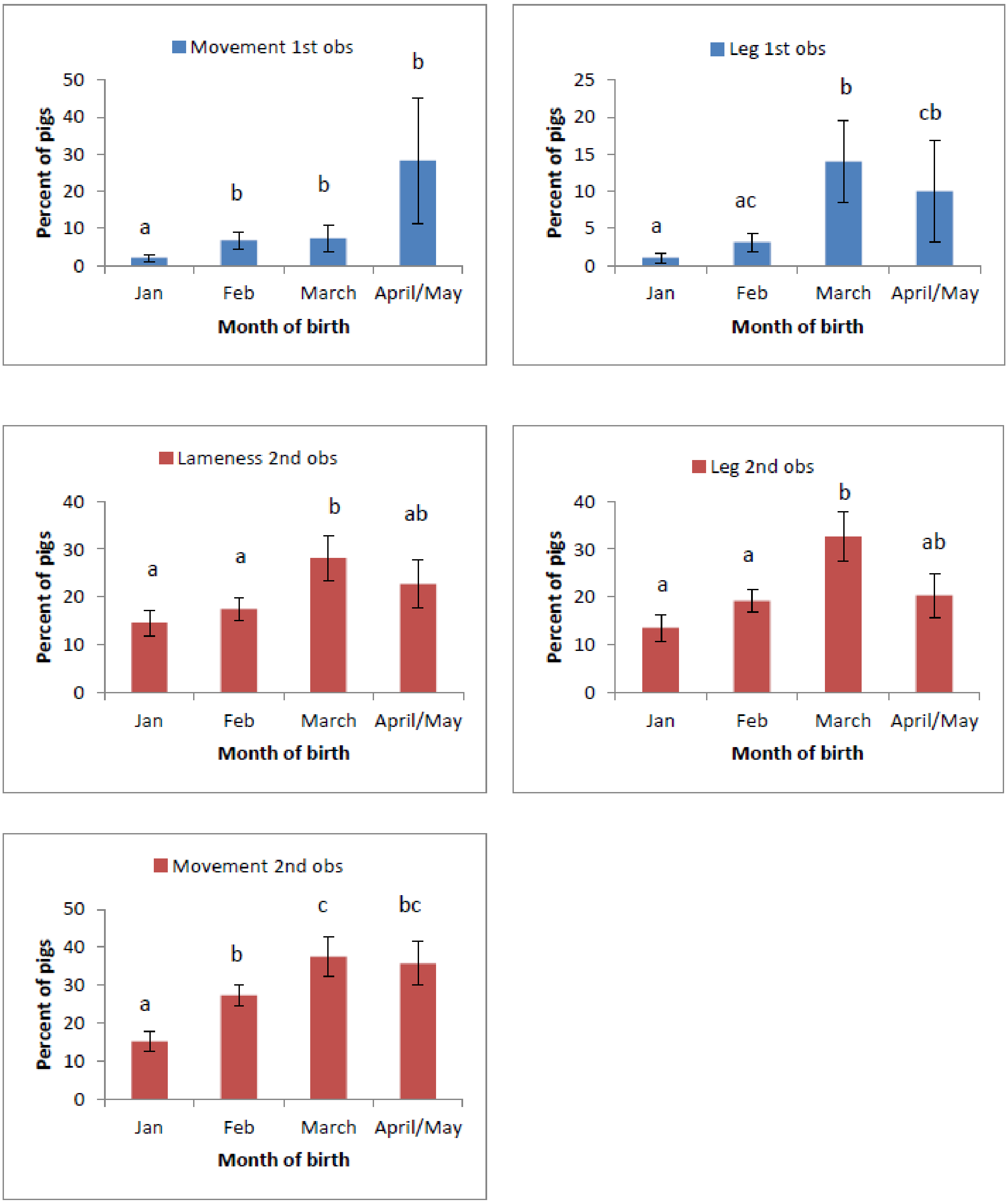

Figure 4-8. Pairwise differences between months of birth for the leg health parameters where month had significant effect, presented as percentage of pigs, with standard error bars. Small letters indicate a significant difference. Bars with one letter in common does not differ significantly.

Weights and growth rate

Pigs in FH1 were weighed at assessment 1 and 2 and differences in weight and growth rate were analyzed.

The total number of animals included in the analyses of growth performance was 352. Of these, 190 were barrows (54%) and 162 were gilts (46%). Moreover, 153 (51%) had a D-sire and 149 (49%) had a H-sire. Information about sire breed was missing for 50 animals and these animals were not included in the analyses.

Mean age for pigs with D-sire at first assessment was 94.8±9.7 days and 96.3±14.7 days for pigs with H-sire. Mean age at second assessment for pigs with D-sire was 168.6±11.2 days and 169.6±17.2 days for pigs with H-sire.

- **Sire breed**

Breed had significant effect on almost all growth performance parameters in this study (Table 6). There is only a tendency of effect on weight at the first assessment. The results indicate that pigs with H-sire are slightly heavier at arrival on the fattening herd. Pigs with H-sire grow faster from the first assessment and during the rest of the fattening period.

- **Herd of birth**

Herd had significant effects on all weight and growth performance parameters for the pigs in this study, except for the growth between the first and second assessment (Table 7). The result indicates that pigs from Herd 1 are heavier at arrival and continues to grow faster during most of the fattening period.

- **Gender**

Gender has significant effect on all weight and growth performance for the pigs in this study, with exception for weight and growth up to the first assessment, where there is only a tendency of difference (Table 8). There is no clear significant difference between barrows and gilts at arrival at the fattening herd, but the barrows weigh significantly more at the second assessment. Barrows also grew faster from the first assessment and through the rest of the fattening period.

- **Season, Month of birth**

Season had significant effect on weight at the second assessment, where fattening pigs born in January had a lower live weight than pigs born in February or March (Table 9). Season also had a significant effect on the pigs growth from birth to slaughter, where pigs born in January had a slower growth than pigs born in February or March.

Table 6. Effect of sire breed for weight and growth for pigs at fattening herd. Least square means ± standard errors for weight is presented in kg and for growth presented in g/day.

	D-sire	H-sire	p
Weight 1	32.1±0.80	33.6±0.93	0.069
Weight 2	89.4±1.62	94.9±1.84	0.001
Growth 01[a]	327±8.7	346±10.1	0.031
Growth 12[b]	796±23.6	859±28.7	0.006
Growth 02[c]	519±9.6	554±10.9	0.001

[a]Growth 01 = growth from birth to the first assessment
[b]Growth 12 = growth between the first and second assessment
[c]Growth 02 = growth from birth to the second assessment

Table 7. Effect of birth herd on weight and growth for pigs in one herd. Least square means ± standard errors for weight is presented in kg and for growth presented in g/day.

	Herd PH1	Herd PH2	p
Weight 1	34.7±0.50	31.0±1.40	0.009
Weight 2	98.1±1.02	86.2±2.70	<0.001
Growth 01[a]	352.0±5.32	320.5±15.27	0.044
Growth 12[b]	843±16.7	812±49.8	ns
Growth 02[c]	572±6.0	501.7±15.9	<.001

[a]Growth 01 = growth from birth to the first assessment
[b]Growth 12 = growth between the first and second assessment
[c]Growth 02 = growth from birth to the second assessment

Table 8. Effect of gender on weight and growth for pigs at fattening herd. Least square means ± standard errors for weight is presented in kg and for growth presented in g/day.

	Barrow	Gilt	p
Weight 1	33.6±0.86	32.1±0.86	0.055
Weight 2	94.9±1.75	89.5±1.72	0.001
Growth 01[a]	343±9.4	329±9.4	0.096
Growth 12[b]	854±25.8	801±26.4	0.016
Growth 02[c]	552±10.3	520±10.1	0.001

[a]Growth 01 = growth from birth to the first assessment
[b]Growth 12 = growth between the first to the second assessment
[c]Growth 02 = growth from birth to the second assessment

Table 9. Effect of season for weight and growth for pigs at fattening herd. Least square means ± standard errors for weight are presented in kg and for growth presented in g/day.
Pairwise differences with p<0.05 are indicated with superscript letters. Values with one letter in common does not differ significantly

	January	February	March	p
Weight 1	33.2±0.70	31.9±0.95	33.5±1.34	ns
Weight 2	88.2±1.34[a]	94.0±1.97[b]	94.3±2.76[b]	0.004
Growth 01[a]	340.±7.6	327±10.4	342±14.6	ns
Growth 12[b]	796±32.2	848±26.3	840±37.2	0.091
Growth 02[c]	516±7.9[a]	546±11.6[b]	549±16.3[b]	0.012

[a]Growth 01 = growth from birth to the first assessment
[b]Growth 12 = growth between the first to the second assessment
[c]Growth 02 = growth from birth to the second assessment

Discussion

The main aim of this study was to investigate variation between sire breeds for leg health parameters and weight gain. The secondary aim was to investigate variation caused by herd, season, gender, age and assessment occasion.

Exterior and gait

The main results from this study show that sire breed had a negligible effect on leg health parameters. The only significant effect of sire breed found was on 'swollen joints' at the second assessment indicating that a higher proportion of pigs with Hampshire-sire had swollen joints compared to pigs with Doroc-sire. Altogether, these results indicate that there were minor differences in leg health between offspring of the two sire breeds during the fattening period. These results are in accordance to the findings of Lundeheim (1987), who included two groups of purebred Hampshire and Duroc, but no difference in leg weakness score was found between the two breeds. The results from the present study do however indicate high prevalence of abnormal exterior and gait (0.7 – 29.1 % depending on parameter and sire breed) in offspring to both sire breeds, indicating that leg weakness needs to be improved in both breeds.

Herd had effect or tendencies of effect on several exterior and gait parameters. This influence is probably due to environmental differences between the herds (e.g. buildings, floors, differences in soil type and amount of rain causing differences in surface for the pigs to walk on in the pastures), rather than management (e.g. vaccination strategy, treatment and culling strategy).

Gender had effect on exterior and gait in this study. While barrows had higher proportion of leg remarks during the second assessment, gilts had a higher proportion of swollen joints at the same assessment. Lundeheim (1987) found similar results, where barrows had a higher prevalence of osteochondrosis (after slaughter) scoring in elbow and knee joints than gilts, and gilts had a higher prevalence of leg weakness score than barrows. Even though the pattern in differences between barrows and gilts is not clear, it can be argued that the faster growing barrows (Enfält *et al.*, 1996) have a higher prevalence of leg remarks compared to gilts.

Season had effect on several exterior and gait parameters, at both first and second assessment. The results indicate that pigs born later during spring have inferior leg health than those born earlier during the year. This may be the result of a higher provocation on their legs caused by the fact that these pigs had a larger proportion of their time outdoors during the rainy late summer/autumn period. None of the studies on pig leg health in outdoor environments reported in the literature had included season in their analyses.

Age at the assessments had significant effect on almost all the parameters investigated. The only parameter that has a negative regression coefficient (indicating improvement with age) is 'back' at first assessment, all the other parameters with a significant p-value have a negative regression coefficient. This indicates that the exterior and gait problems increases with age, possibly as joints are more provoked the longer the pig has been in the outdoor environment.

All the exterior and gait parameters investigated, except 'back', in this study has an increased prevalence over time from first to second assessment. The probable cause that 'back' has a decreased prevalence is that many of the pigs that had an affected back either had been euthanized by the herdsmen, and these pigs were therefore not present at the second assessment. A small proportion of pigs affected, may have gained a better backs by “growing in to their backs”. The main result though is that the prevalence of all the other parameters increased from first to second assessment, indicating that this is the period where most of the leg suffering in outdoor pigs starts.

When the results of this study are interpreted, it is important to remember that in the statistical analyses, the exterior and gait scoring were transformed into binomial values 0 or 1. The binomial value 1 was given to the scores that did differ for normal, regardless of severity. The results from the analyses would have been different if severity of the scores was taken in to consideration, for example if 1 = the most severe score for the exterior and leg parameters.

Weights and growth rate

Sire breed had effect on most of the weight and growth performance parameters investigated on the fattening farm in this study, indicating a higher growth rate among offspring to Hampshire sires compared to offspring to Duroc sires. The only parameter where there only was a tendency of sire breed was weight at first assessment indicating that Hampshire offspring were slightly heavier at arrival to the fattening farm. During the rest of the fattening period, after first assessment, the pigs with Hampshire sire grew faster and had a heavier weight at second assessment. These results are in opposition to the results of Mattson, *et al*. (2005), who found that Duroc offspring grew slightly faster than Hampshire sires. When interpreting the results of the present study, it is important to remember that only pigs from one herd were included, and thus the results are applicable for that herd.

Birth herd had a significant effect on almost all weight and growth performance parameter. The only result that wasn’t significant was the growth rate between first and second assessment. The result indicates that pigs from PH1 are heavier at arrival and had a higher growth for most of the fattening period compared to pigs from PH2. This was possibly an effect of different production environment, feeding systems and management in the piglet producing herds.

As expected, and in accordance to many previous studies (e.g. Lundeheim, 1987; Stern *et al.*, 1995; Enfält *et al.*, 1996) barrows had a higher growth rate than gilts during the fattening period, even though there were no clear differences in weight between barrows and gilts at arrival.

Season had significant effect on weight at second assessment and on growth from birth to second assessment. From the result presented in table 9, it would seem to be preferable to be born in February or March instead of January. This could have been due to diseases, as an increased disease and culling rate were seen in the batches born in January (Lundquist, pers. comm., 2012). It could however also have been due to the lower temperature the pigs born in January experienced. Of the studies on growth performance in outdoor environments reported, none has taken season in consideration when analyzing the data.

Methods

The EID-tags were tagged to the pigs ears with the same tagging devise as ordinary ear tags, as this was easy and convenient for the herdsmen. There were some difficulties with scanning of the EID-tags, as for some (0.84 % (n=12) of 1429 tagged pigs) of the tags, the electronic devises malfunctioned. As the pigs were assessed when moving around, and because the ear tags often were dirty, a malfunctioning tag was difficult to read visually. Another problem with the ear tags was that some of the tags were physically lost during rearing. All this problems resulted in difficulties to link the individual data from birth to slaughter for all pigs in the study. This problem needs to be sorted out to be able to get a higher percent of pigs with data from birth to slaughter. However, at the second assessment, 68 percent of the pigs born were identified.

When performing the statistical analyses on exterior and gait, sow was first set as a random effect. This setting did not work, as sow is nested with several other fixed effects; sire breed, herd and age. As a result of this, sow was excluded from the model.

When performing the statistical analyses on the weight and growth data, it was tested to exchange the fixed effects ‘herd’ and ‘month of birth’ to the random effect ‘sow’. In this setting sow was nested with sire breed. This was done to investigate if sow had significant effect on any of the weight and growth parameters. Sow did not have significant effect on any of the parameters, while the fixed effects ‘herd’ and ‘month of birth’ did have significant effect on almost all investigated parameter. As a result of this, the fixed effect of ‘sow’ were not included in the model and ‘herd’ and ‘month of birth’ were kept as fixed effects in the model.

Conclusion

This study concluds that sire breed have little effect on pig exterior and gait in organic production environments. It is also concluded that herd, gender, age and season cause variation in pig exterior and gait. Moreover, prevalence of abnormal exterior and gait increases over time during the fattening period.

In the herd where pig growth was recorded in this study, offspring to Hampshire sires had a higher growth rate compared to offspring to Duroc sires. Growth rate was also found to be influenced by birth herd, gender and season.

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Wallenbeck, A. (2012). Personal communication, 2012-12-03. Swedish University of Agricultural Science, Department of Animal Breeding and Genetics

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Appendix

Appendix 1a. Translated version of exterior and gait scoring protocol, part a

Exterior/Gait scoring and movements

Back

1	2	3
Arched	Straight	Kyphosis

Leg conformation (overall for all legs)

1	2	3
Normal leg conformation	Somewhat abberance in leg conformation	Extreme abberance in leg conformation

If leg conformation is assessed to be abberance from normal, comment

Swollen joints

0	1
No	Yes

If Yes, which leg/joint

Locomotion

1	2	3	4	5
Very wormly movements, long steps		Normal, regular locomotion, flexible movements, no lameness		Very stiff and tripping movements, short steps

Hälta

0	1	2	3
No lameness	Visible lameness, relatively normal pace (using all 4 legs)	Visible lemeness, nods with head, unburden the affected leg (legs)	Very lame, not supporting the affected leg (legs)/unable to walk

If the animal is lame, continue assessment, otherwise next animal.

Lameness front/hind

F	B	X
Foreleg	Hind leg	don't know/unable to assess

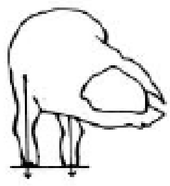
hoofs

0	1	X
Normal	Un-normal (damaged, uneven, soft etc.)	don't know/unable to assess

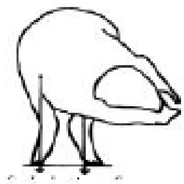
X might be that the hoofs are to muddy/dirty or gound material to bad to be able to assess .

Appendix 1b. Translated version of exterior and gait scoring protocol, part b

Leg conformation

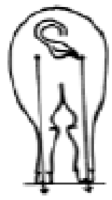


Foreleg, large at knee, narrow at toe



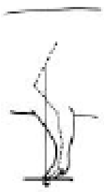
Foreleg, narrow at knee, large at toe

Hind leg, large at knee, narrow at toe

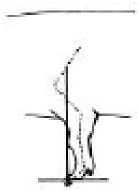


Hind leg, narrow at knee, large at toe

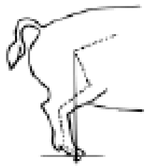
Knee/Hock



Sabre shaped foreleg



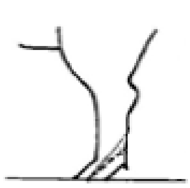
Knock-kneed foreleg



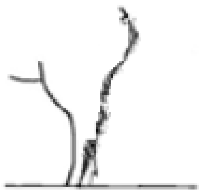
Hooked hind leg

Straight hind leg

Vertebras

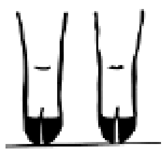


Soft, weak legs



Stiff, straight legs

Klövar



Normal hoofs

Exemple on hoofs not normal; uneven, small, tight etc.

Appendix 2. Translated version of gait scoring scheme

Journal Gait scoring/Movements

Herd: ____________________ Date: ____________________

Animal - ID	Back (1-3)	Leg conformation (1-3)	comments (if conformation differs from okey)	Locomotion (1-5)	Lameness (0-3)	Lameness front/back (F, B, 0)	hoves (0, 1, X)

Appendix 3. Example of gait scoring scheme with comments about pigs added

Protokoll Exterörbedömning/Rörelser

Besättning: ______________________ Datum: ______________

Djur - ID	Rygg (1-3)	Benställning (1-3)	Kommentar (om avvikande benställning)	Rörelser (1-5)	Hälta (0-3)	Halt fram/bak (F, B, 0)	Klövar (0, 1, X)
168296	ok						♀
200353			välvd rygg				♀
200346	ok						♂
200379	ok						♂
168279	ok						♀
200408	ok						♂
200352	ok						♀
200377	ok						♀
168286	ok						♀
168263			liten stel höft				♀
168270	ok						♂
168285	ok						♀
168264			utåtvända klövar bak	basset-st[illegible]			♂
200383	ok						♂
168271			stel bredbent gång				♂
168265			välvd rygg				♂
200391	ok						♀
168357	ok						♂
200392	ok						♀
168344	ok						♀
200363	ok						♀