Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Veterinary Medicine and Animal Science

Factors influencing variation in birth weight and its impact on later performance in Swedish Yorkshire pigs

Faktorer som inverkar på variation i födelsevikt och hur födelsevikten inverkar på fortsatt tillväxt och fettansättning hos svensk yorkshire

Paulina Wahlgren

Department of Animal Breeding and Genetics
Degree project 30 credits
Uppsala 2018
526

Factors influencing variation in birth weight and its impact on later performance in Swedish Yorkshire pigs

Faktorer som inverkar på variation i födelsevikt och hur födelsevikten inverkar på fortsatt tillväxt och fettansättning hos svensk yorkshire

Paulina Wahlgren

Supervisor: Nils Lundeheim
Department: Department of Animal Breeding and Genetics, SLU

Assistant Supervisor: Katja Nilsson
Department: Department of Animal Breeding and Genetics, SLU

Examiner: Lotta Rydhmer
Department: Department of Animal Breeding and Genetics, SLU

Credits: 30 credits
Level: A2E
Course title: Degree Project in Animal Science
Course code: EX0556
Program: Agricultural Science program – Animal Science

Place of publication: Uppsala
Year of publication: 2018
Title of series: Examensarbete / Sveriges lantbruksuniversitet, Institutionen för husdjursgenetik
Part number: 526
Online publication: http://stud.epsilon.slu.se

Keywords: Piglets, birth weight, field performance test, backfat thickness, growth performance
Nyckelord: Smågrisar, födelsevikt, fältindividprövning, späcktjocklek, tillväxthastighet

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Faculty of Veterinary Medicine and Animal Science
Department of Animal Breeding and Genetics

Abstract

The phenotypic variation in piglet birth weight caused by gender, birth parity number and litter size, and later how this variation in birth weight influenced growth rate until 100 kg and backfat thickness at 100 kg live weight were analysed in this study. Data on purebred Swedish Yorkshire pigs from 13 nucleus herds was the base for the analyses. Records on 32,531 animals born by first and second parity sows were included in the analysis of factors influencing variation in birth weight. Analysis of associations between birth weight and field performance test included 8,827 animals, which were divided into birth weight groups; low birth weight (<1.0 kg), normal birth weight which were divided into nine groups of 0.1 kg (1.1-1.9 kg), and high birth weight (2.0-2.8 kg). Analysis of variance and multiple comparisons of least square means was applied. Piglets born from first parity sows weighed on average 120 grams less, when corrected to the same litter size, and the litters were one average one piglet smaller compared to litters born from second parity sows. Also, liveborn piglets were on average heavier than stillborn piglets by 210 grams (P<0.001). Litter size influenced litter mean birth weight: a decrease with 33 grams per each total born piglet in the litter (P<0.001). Pigs born from first parity sows took on average 4.4 more days to reach 100 kg live weight compared to pigs born from second parity sows (P<0.001), when corrected to the same litter size. Also, males were 2.2 days younger at 100 kg live weight compared to gilts (P<0.001). The heavier the piglet was at birth, the faster it reached 100 kg live weight and the thinner was the backfat thickness at 100 kg live weight. Backfat thickness in pigs born by first parity sows were thinner by 0.2 mm compared to pigs born from second parity sows (P<0.001) and males had thinner backfat thickness than gilts by 0.8 mm (P<0.001). The results indicate, regarding growth performance, that it is better to breed for smaller litters with higher mean birth weight. However, for a farrow-to-finish herd, also litter size is of economic importance.

Keywords: Piglets, birth weight, field performance test, backfat thickness, growth performance

Sammanfattning

Fenotypisk variation i grisars födelsevikt analyserades för att studera inverkan av kön, födelsekullnummer, levandefödd eller dödfödd och kullstorlek samt hur variationen i födelsevikt påverkade tillväxt till, och späcktjocklek vid, 100 kg levande vikt (kallas fält-test eller ibland fältindividprövning). Data från renrasig svenska yorkshire från 13 avelsbesättningar fanns tillgänglig. Registreringar från 32531 smågrisar födda av första- och andragrisare användes för analys av faktorer som påverkar födelsevikt. Samband mellan födelsevikt och fält-test baserades på registreringar för 8827 testade djur, vilka i analyserna delades in i födelseviktsgrupper; låg födelsevikt (<1,0 kg), normal födelsevikt vilka delades in hektovis i 9 grupper (1,1-1,9 kg) och hög födelsevikt (2,0-2,8 kg). Variansanalys och jämförelser mellan minsta kvadratmedelvärde för de olika inverkande faktorerna genomfördes. Smågrisar födda av förstagrisare var i genomsnitt 120 gram lättare jämfört med smågrisar födda av andragrisare (P<0,001), när korrigering skett för skillnad i kullstorlek. Levandefödda smågrisar var i genomsnitt 210 gram tyngre än dödfödda smågrisar (P<0,001). Kullstorleken påverkade kullmedelvikten då medelfödelsevikten minskade med 33 gram per extra född smågris i kullen. Grisar födda av förstagrisare tog 4,4 dagar längre på sig för att nå 100 kg levandevikt jämfört med grisar födda av andragrisare (P<0,001), när skillnad i kullstorlek korrigerats för. Handjur var 2,2 dagar yngre vid 100 kg levandevikt jämfört med gyltor (P<0,001). Ju mindre smågrisen vägde vid födsel desto längre tid tog det för att nå 100 kg levandevikt. Späcktjockleken var i genomsnitt 0,2 mm tunnare hos avkommor efter förstagrisare jämfört med grisar födda av andragrisare (P<0,001). Handjur hade i genomsnitt 0,8 mm tunnare späcktjocklek än gyltor (P<0.001). Resultaten pekar på att det, med avseende på fält-testet, är bättre att avla för mindre kullar med högre medelfödelsevikt. Dock, i en helintegrerad produktion är även kullstorleken av ekonomisk betydelse.

Nyckelord: Smågrisar, födelsevikt, fältindividprövning, späcktjocklek, tillväxthastighet

Preface

In England once there lived a big and wonderfully clever pig
To everybody it was plain that Piggy had a massive brain
He worked out sums inside his head, there was no book he hadn't read
He knew what made an airplane fly, he knew how engines worked and why
He knew all this but in the end, one question drove him round the bend
He simply couldn't puzzle out, what life was really all about
What was the reason for his birth? Why was he placed upon this earth?
His giant brain went round and round. Alas, no answer could be found
Till suddenly one wondrous night all in a flash he saw the light
He jumped up like a ballet dancer and yelled, "By gum, I've got the answer!"
"They want my bacon slice by slice to sell at a tremendous price!
"They want my tender juicy chops to put in all the butchers' shops!
"They want my pork to make a roast and that's the part'll cost the most!
"They want my sausage in strings! They even want my chitterlings!
"The butcher's shop! The carving knife! That is the reason for my life!
Such thoughts as these are not designed to give a pig great peace of mind
Next morning in comes Farmer Bland a pail of pigswill in his hand
And piggy with a might roar bashed the farmer to the floor
Now comes the rather grizzly bit so let's not make too much of it
Except that you must understand that Piggy did eat Farmer Bland
He ate him up from head to toe, chewing the pieces nice and slow
It took an hour to reach the feet, because there was so much to eat
And when he'd finished, Pig, of course, felt absolutely no remorse
Slowly he scratched his brainy head and with a little smile, he said
"I had a fairly powerful hunch that he might have me for his lunch
"And so, because I feared the worst, I thought I'd better eat him first

- Roald Dahl

Table of contents

1 Introduction

The breeding of Swedish Yorkshire pigs began in the end of the nineteenth century and lasted until 2012 when the breeding company, Nordic Genetics, decided to end the breeding program (Hansson & Lundeheim, 2013). Nordic Genetics was established in 2007 through a Nordic cooperation between Sweden, Finland and Norway (Brink, 2012). However, the breeding of Swedish Yorkshire had to be ended when the Norwegian breeding company Norsvin decided to end the cooperation. Norsvin did not regard the Swedish Yorkshire competitive enough on an international market, so Norsvin decided to cooperate with the breeding organization Topigs, in the Netherlands, instead. This lead to the replace of the Swedish Yorkshire genes, in the Swedish crossbreeding programme, with Yorkshire genes (Z-line) from Topigs (Brink, 2012). However, the selection environment does differ. In the Netherlands, it is common to have the sows confined in crates during farrowing and throughout the lactation since this requires less work and less space per sow (Sonesson, 2017). But in Sweden the sows must be loose housed (Jordbruksverket, 2014). Nordic Genetics still has a breeding program and nucleus herds of the sire breed Hampshire, but there is currently no breeding of maternal lines (Landrace and Yorkshire) in Sweden. Nowadays, the sows in Sweden are crossbreds between Dutch Yorkshire and Norwegian Landrace, and they are mated with sires of either Hampshire breed or Duroc breed to produce fattening pigs.

The objectives of this study were to identify factors that influence the individual birth weight and how birth weight influence growth until 100 kg live weight and backfat thickness at 100 kg live weight. The motive was to see which factors that are of importance in piglet and fattening pig production.

2 Literature review

In most breeding programmes, number of piglets born alive per litter, is the major reproduction trait used as large litters are desirable in piglet production. The sow must be provided with a beneficial environment, good management routines and a suitable housing system to be able to show her genetic capacity for reproduction. Besides litter size, maternal behaviour should be given high priority in selection, as number of total born will be fruitless unless the sow is a good mother. (Rydhmer, 2000)

2.1 Birth weight and litter size

2.1.1 Variation in birth weight

The size of the piglet at birth, in most studies weight, is influenced by litter size. When the number of piglets increase, each foetus gets a lower nutrient supply in the late gestation period (Quiniou *et al.*, 2002). This was reported by Père & Etienne (2002) who studied uterine blood flow during the entire gestation period. Between 44 and 108 days of gestation, the uterine blood flow increased continuously and was influenced by the litter weight, as the uterine blood flow was lower in uterine horns with 2 or 3 foetuses compared to uterine horns with 4 or more foetuses ($P < 0.001$). However, the uterine blood flow per foetus decrease with increased litter size, which will result in decreased birth weight when the litter size increase. At 111 days of gestation there was, however, no difference in blood flow to the uterine horns depending on number of foetuses (Père & Etienne, 2000).

In a study by Čechová (2006), the effect of sex, parity number, litter size and breed combination on individual birth weight was studied. Males were heavier than gilts, but the difference was not statistically significant. Individual birth weight increased with increased parity number and peaked at fifth parity ($P \leq 0.01$). Čechová (2006) found that average individual birth weight decreased with increased litter size ($P \leq 0.001$), and this is attested by a study from Quiniou *et al.* (2002). The calculated phenotypic correlation between litter size and individual birth weight in the study was -0.28 ($P \leq 0.001$). The direct genetic correlation between birth weight and litter size has been estimated to -0.18 by Kaufmann *et al.* (2000), who also estimated maternal genetic correlation between birth weight and litter size to 0.25. The effect of breed combination was also of significance in the study by Čechová (2006). Crossbred sows (Czech Large White x Czech Landrace), which were inseminated with Czech Large White, gave birth to the highest individual birth weights in piglets ($P<0.01$), compared to crossbred sows inseminated with other sire breeds.

A larger litter size has been reported to be associated with low mean litter birth weight, which in turn decreases the percentage of survival (Milligan *et al.*, 2002; Quiniou *et al.*, 2002), and a high within-litter variation in birth weight may result in increased piglet mortality, especially if the mean birth weight is low (Milligan *et al.*, 2002). Quiniou *et al.* (2002) found that the proportion of small piglets, weighting less than 1.0 kg, increased from 7 to 23% when the litter size increased from 11 piglets or less to 16 piglets or more. With a birth weight below 1.0 kg, more than 11% piglets were born dead and at least 17% of the remaining alive born piglets died within the first day of life (Quiniou *et al.*, 2002). Low-birth weight piglets, *i.e.* piglets weighing well below normal weight range, were less likely to survive compared to higher birth weight piglets (P=0.01) (Milligan *et al.*, 2002). A gestation period lasting more than 115 days resulted in heavier piglets, but also more stillborn piglets (Amaral Filha *et al.*, 2010).

2.1.2 Variation in litter size

Several factors have been reported to influence number of total born and number of born alive piglets per litter. In primiparous sows, an increase of 10 days in age at first mating has been found to result in an increase of 0.1 piglets in the first parity litter and a decrease in litter size in parities four and five (Tummaruk *et al.*, 2001). Breed influenced litter size in the study by Tummaruk *et al.* (2001). Landrace sows had a lower number of born alive compared to Yorkshire sows, but no difference was found in number of total born between the two breeds in the first parity. In later parities, Landrace compared to Yorkshire, had a higher number of number of born alive piglets (Tummaruk *et al.*, 2001). The standard deviation of birth weight within litter was smaller in purebred Yorkshire litters and the mean weight at birth was higher in Yorkshire x Landrace and Yorkshire x Duroc crossbred litters compared to purebred Yorkshire litters in a study by Damgaard et al. (2003). The survival rate of the piglets seemed to decrease with parity number of the sow, as Milligan *et al.* (2002) showed a somewhat lower survival rate for piglets from sows of sixth or higher parity. Damgaard *et al.* (2003) stated that sows should be selected for their ability to produce homogenous litters as it may be advantageous for the piglets.

On average, the lowest litter size and lowest piglet mean birth weight has been found in first parity litters, both traits increased with parity number and reached a plateau at parity four to six (Milligan *et al.*, 2002; Damgaard *et al.*, 2003). Number of total born and number of born alive has been found to be influenced by the gilts birth litter size. Larger birth litter size indicates good genes, but there might have been a competition about resources during fetal stage, as well as during nursing period (Tummaruk *et al.*, 2001). In old sows, higher than fifth parity, number of piglets born alive decreased (Damgaard *et al.*, 2003). This may have to do with the percentage of piglets born dead which increased in older sows (Milligan *et al.*, 2002). Middle-aged sows had the lowest percentage of piglets born dead according to several studies (Tummaruk *et al.*, 2000; Milligan *et al.*, 2002; Damgaard *et al.*, 2003). Milligan *et al.* (2002) found that the number of total born piglets was significantly phenotypically correlated with number of born dead, and that number of born dead was higher in old sows. Thus, by selecting sows for their number of total born will indirect be a selection for increased number of stillborn.

2.2 Influence of birth weight on growth performance

Male piglets were on average heavier at birth compared to gilts, but on subsequent weight gain sex had no significant effect (Milligan *et al.*, 2001). Low-birth weight piglets stayed smaller at all production phases compared to larger litter mates (Quiniou *et al.*, 2002; Gondret *et al.*, 2005; Bérard *et al.*, 2008; Fix *et al.*, 2010). Bérard *et al.* (2008) reported that low-birth weight piglets used more feed per kg growth (from weaning to 105 kg live weight) due to being less efficient in utilizing feed compared to normal and high-birth weight piglets. The average daily gain from birth to slaughter was reduced by 8% in piglets weighting 1.1 kg and less compared to piglets weighting 1.75 to 2.05 kg (Gondret *et al.*, 2005), which resulted in increased number of days to reach the weight set (Gondret *et al.*, 2005; Beaulieu *et al.*, 2010). In a study by Powell & Aberle (1980), the effect of birth weight on postnatal growth was studied. Pigs from the low birth weight group (1.0-1.1 kg) were older ($P < 0.05$) at both 26 and 96 kg live weight compared to the medium (1.3-1.4 kg) and high (> 1.6 kg) birth weight groups. There was a difference in daily gain between the birth weight groups. Pigs from the high birth weight group had significantly ($P < 0.05$) a higher daily gain of 780 grams from 26 to 96 kg live weight, compared to the low birth weight group who had a daily gain of 720 grams. The medium birth weight group did not differ from the low or high birth weight group on daily gain from 26 to 96 kg live weight (Powell & Aberle, 1980).

2.3 Influence of environmental factors on litter size

2.3.1 Housing

Improving farrowing environment to increase human intervention is commonly done through confining sows in farrowing crates (Edwards, 2002). In Sweden it is not allowed to confine sows in crates routinely. As an exception, if there is a reason for it, *e.g.* if the sow is aggressive, confining in crates is allowed for a short period of time only (Jordbruksverket, 2014). Concerns regarding animal welfare may limit the use of confinement in the future, but today the housing solutions must be reconsidered for both ethical and economic reasons (Edwards, 2002). Farrowing pens are expensive to construct (Edwards, 2002) and the reproduction performance of the sow has not been found to differ between the two housing systems regarding number of total born and piglet survival (Edwards, 2002; Oliviero *et al.*, 2008). Oliviero *et al.* (2008) placed sows either in pens with straw bedding or confined in crates with no bedding material and sampled the animals from 5 days before farrowing to day 1 of lactation. They found no significant difference in litter size, number of total born, number of born alive and number weaned between the two housing systems.

2.3.2 Gilt rearing

Nelson & Robinson (1976) applied cross fostering to establish set 'rearing litter sizes' to rear gilts in either small litters (6 piglets) or in large litters (14 piglets). Being reared in a small litter size increased embryo number by 1.18 ($P < 0.10$) at first parity compared to gilts reared in large litters (Nelson & Robinson, 1976). At farrowing, the small 'rearing litter size' group resulted in 0.88 and 1.18 more total born and number of born alive respectively. Another study regarding rearing of gilts, the gilts were grouped into groups of eight and placed in either an outdoor or indoor production unit (McGlone & Fullwood, 2001). The gilts stayed in their groups until 5 days before farrowing, and were then moved into an indoor gestation unit and placed in individual farrowing crates (McGlone & Fullwood, 2001). No difference was found in number of born alive, total litter birth weight, and number weaned piglets between the different rearing environments.

Amaral Filha *et al.* (2010) found a phenotypic association between rearing of the gilt and number of total born piglets in the litter. When the gilt was reared with a growth rate of 701-870 g/day compared to a growth rate of 600-700 g/day, the number of total born piglets per litter increased. They also found that the percentage of number of stillborn per litter increased with a growth rate of 771-870 g/day compared to a growth rate of 600-770 g/day (Amaral Filha *et al.*, 2010). Another study regarding rearing and litter size was performed by Tummaruk *et al.* (2001). They found that an increase of 100 g/day in growth rate from birth to 100 kg resulted in an increase of number of total born and number of born alive.

Backfat thickness at performance test was a source of variation when it came to total number of born alive throughout a sow's entire production life (Stalder *et al.*, 2005). Gilts with a thicker backfat thickness produced a higher number of total born and a higher number of born alive (Tummaruk *et al.*, 2001; Stalder *et al.*, 2005) during their entire production life (Stalder *et al.*, 2005). With a backfat thickness >2.5 cm at 100 kg live weight, the sows produced on average a higher number of parities and hence a higher number of lifetime number of total born compared to sows with a lower backfat thickness (Stalder *et al.*, 2005). Gilts with a very low backfat thickness, <0.9 cm, had fewer number of born alive throughout their lifetime production (Stalder *et al.*, 2005). However, those gilts did not differ in lifetime number of born alive compared to gilts with a backfat thickness of 1.7-2.5 cm (Stalder *et al.*, 2005).

3 Materials and methods

3.1 Data and data editing

The primary data included 34,225 records of birth weight on purebred Yorkshire piglets, provided by the breeding organization Nordic Genetics (www.nordicgenetics.se). These piglets were born in 13 nucleus herds during the period of February 2011 through March 2012. Males were not castrated. Individual weight records on both liveborn and stillborn piglets were included in the data. Records of extreme birth weight, above 2.8 kg, were deleted from the analyses (n=37). Only piglets born in parities 1 and 2 were kept for analyses.

For the analyses of the association between birth weight and field performance test, pigs born after October 2011 were removed. The reason for this was that in March 2012, the breeding activities with the Swedish Yorkshire breed within Nordic Genetics ceased. Pigs were for the analyses grouped according to birth weight. The mean birth weight was 1.4 kg with a standard deviation of 0.3 kg. Piglets with a birth weight of 1.1 to 1.9 kg were considered normal birth weight piglets and were divided into nine groups of 0.1 kg, piglets of 1.0 kg and below were considered low-birth weight (LBiW) piglets, and piglets of 2.0 kg and above were considered high-birth weight (HBiW) piglets, see Table 1.

After editing, information from 32,531 animals for analyses on individual birth weight remained. In step two, association between birth weight and field performance test was studied. After further editing, information from 8,827 animals remained with complete records on both individual birth weight and field performance test.

Table 1. Grouping of piglets according to birth weight.

Group	Birth weight range	N	Percent
LBiW	0.2 - 1.0	948	10.74
BiW = 1.1	1.1	608	6.89
BiW = 1.2	1.2	889	10.07
BiW = 1.3	1.3	1104	12.51
BiW = 1.4	1.4	1263	14.31
BiW = 1.5	1.5	1192	13.50
BiW = 1.6	1.6	945	10.71
BiW = 1.7	1.7	761	8.62
BiW = 1.8	1.8	488	5.53
BiW = 1.9	1.9	284	3.22
HBiW	2.0 - 2.8	345	3.91

LBiW = low birth weight, BiW = birth weight, HBiW = high birth weight.

3.2 General management in the nucleus herds

Piglets, both liveborn and stillborn, were weighted individually within 24 hours from birth. The weighing was performed by personnel at the nucleus herds on a weighing scale of 100 grams accuracy. A breeding technician from Nordic Genetics registered backfat thickness and live weight at field performance test on all gilts and males when the pigs weighted on average 100 kg live weight (range from 60 kg to 150 kg). The recorded backfat thickness ranged from 3.0 mm to 23.7 mm. Since the weight of the pigs at field performance test varies, a pre-correction of this information was applied (same pre-correction as in the routine breeding evaluation within Nordic Genetics).

BF100 = pre-corrected backfat depth (mm) at 100 kg live weight
= backfat thickness - 0.1 × (body weight - 100)

D100 = pre-corrected age (days) at 100 kg live weight
= age at test - 1 × (body weight - 100)

3.3 Statistical analysis

Statistical analysis was performed by using the Statistical Analysis Software SAS version 9.4 (SAS Institute, 2012). Descriptive statistics was obtained through the option means in PROC GLM and trough PROC FREQ. PROC GLM together with PROC MIXED was applied for analysis of variance. For multiple comparisons between least square means, the option probability of differences (PDIFF) was used. PROC CORR was used to obtain correlation coefficients.

3.4 Statistical models

Statistical model used for analysing the individual variation in birth weight;

$$Y_{ijklmnop} = \mu + H_i + P_j + T_k + D_l + S_m + (PD)_{jl} + (PS)_{jm} + (DS)_{lm} + b \times TB_n + LH_{o(i)} + e_{ijklmnop}$$

Where Y is the observed value (weight of the individual piglet), μ is the mean value, H is the fixed effect of herd (i = 1-13), P is the fixed effect of birth parity number (j = 1, 2), T is the fixed effect of time (month-year combination), D is the fixed effect of liveborn or stillborn piglet, S is the fixed effect of sex (m = 1,2), PD is the fixed effect of the interaction between parity number and liveborn or stillborn, PS is the fixed effect of the interaction between parity number and sex, DS is the fixed effect of the interaction between liveborn or stillborn and sex, b is the fixed regression on number of total born in the litter (TB), LH is the random effect of litter identity nested within herd, and e is the random residual effect.

Statistical model used to analyse variation in D100 and BF100;

$$Y_{ijklmnop} = \mu + H_i + P_j + S_k + T_l + (PS)_{jk} + b \times TB_m + W_n + LH_{o(i)} + e_{ijklmnop}$$

Where Y is the observed value (either backfat thickness at 100 kg or days at 100 kg), μ is the mean value, H is the fixed effect of herd, P is the fixed effect of birth parity, S is the fixed effect of sex, T is the fixed effect of time of birth (month-year combination), PS is the interaction between parity number and sex, b is the fixed regression on total born in the litter (TB), W is the fixed effect of birth weight classified as in Table 1, LH is the random effect of litter identity nested within herd, and e is the random residual effect.

4 Results

4.1 Descriptive statistic

Descriptive statistics for birth weight and litter size are presented in Table 2. Liveborn piglets had a higher birth weight compared to stillborn piglets, see Figure 1. There was only a minor difference in birth weight between sexes and males were somewhat heavier than gilts, see Figure 2. Piglets born by second parity sows had a higher mean birth weight compared to piglets born from first parity sows, see Figure 3. Birth weight decreased when the litter size increased from a litter size of 4 piglets (n = 54) to a litter size of 25 piglets (n = 22), see Figure 4. For descriptive statistics on birth weight and litter size by herd, see Table 3.

Table 2. *Descriptive statistics for birth weight and litter size between first and second parity sows.*

Parameter	Parity 1 (n = 21,756)			Parity 2 (n = 10,775)		
	Mean	SD	Range	Mean	SD	Range
BiW (kg)	1.38	0.28	0.2 - 2.6	1.51	0.32	0.2 - 2.8
LB (kg)	1.33	0.30	0.2 - 2.6	1.45	0.35	0.2 - 2.8
SB (kg)	1.13	0.31	0.2 - 2.2	1.18	0.36	0.2 - 2.3
Males (kg)	1.33	0.31	0.2 - 2.6	1.44	0.36	0.2 - 2.8
Gilts (kg)	1.29	0.30	0.2 - 2.5	1.41	0.35	0.3 - 2.8
NTB (no.)	13.5	2.88	2.0 - 23.0	14.6	3.30	2.0 - 25.0
NBA (no.)	12.2	2.70	0.0 - 21.0	13.5	3.08	0.0 - 23.0

BiW = birth weight, LB = birth weight of liveborn, SB = birth weight of stillborn, NTB = number of total born piglets in the litter where the piglet was born, NBA = number of born alive piglets in the litter where the piglet was born.

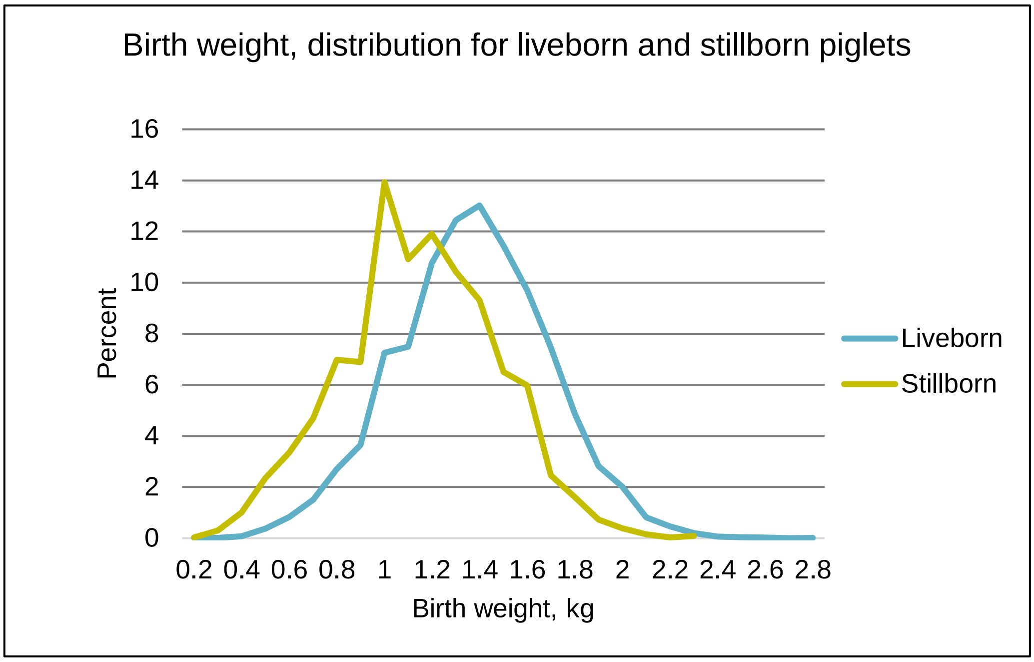

Figure 1. Distribution of birth weight for liveborn and stillborn piglets.

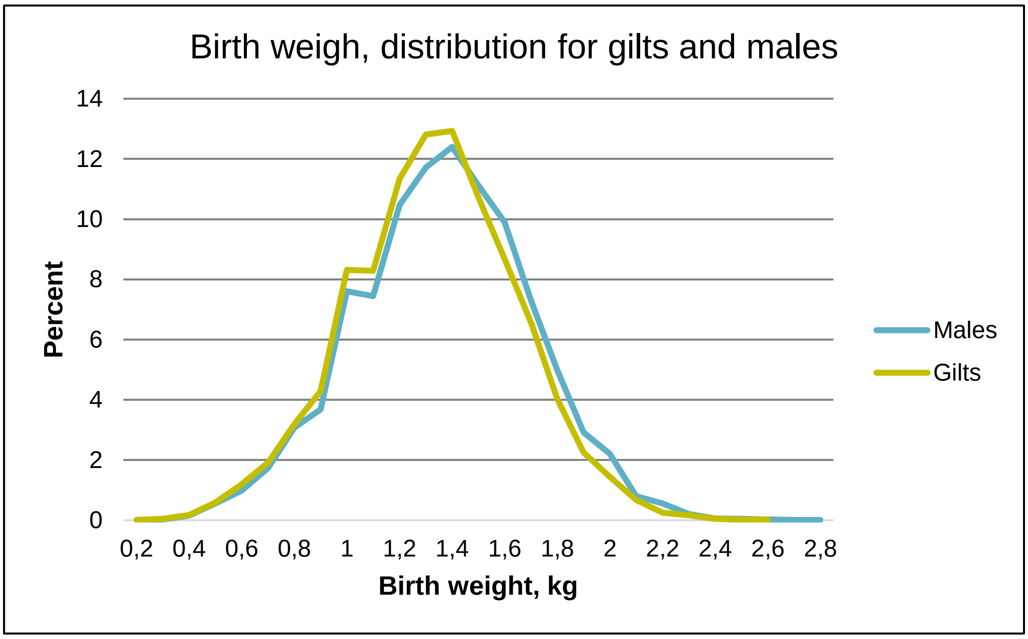

Figure 2. Distribution of birth weight for gilts and males.

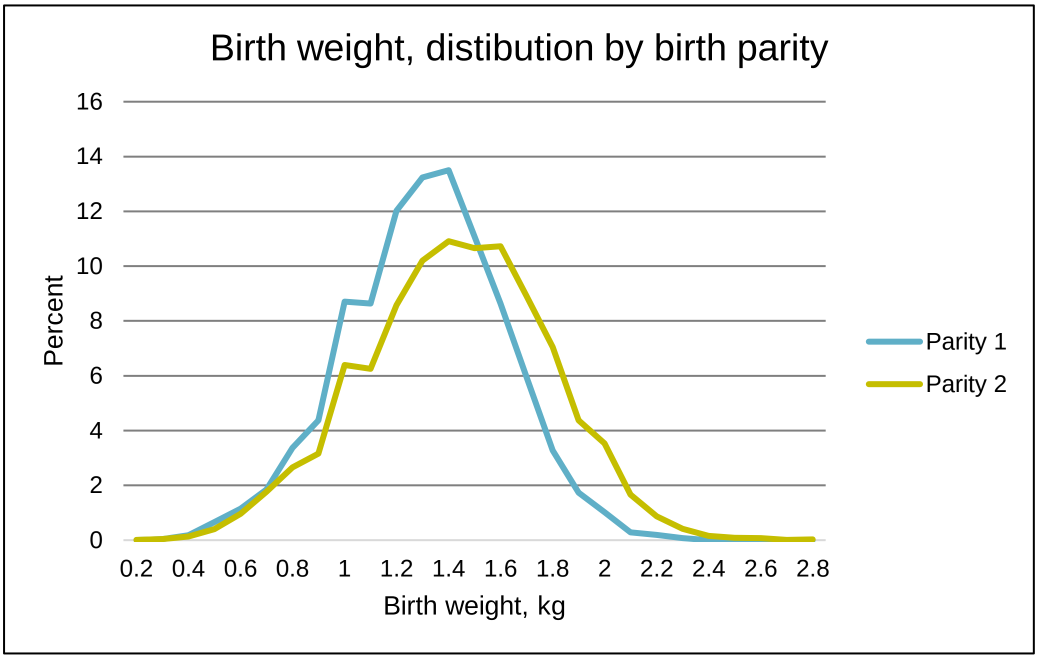

Figure 3. Distribution of birth weight for piglets born in parity 1 or parity 2.

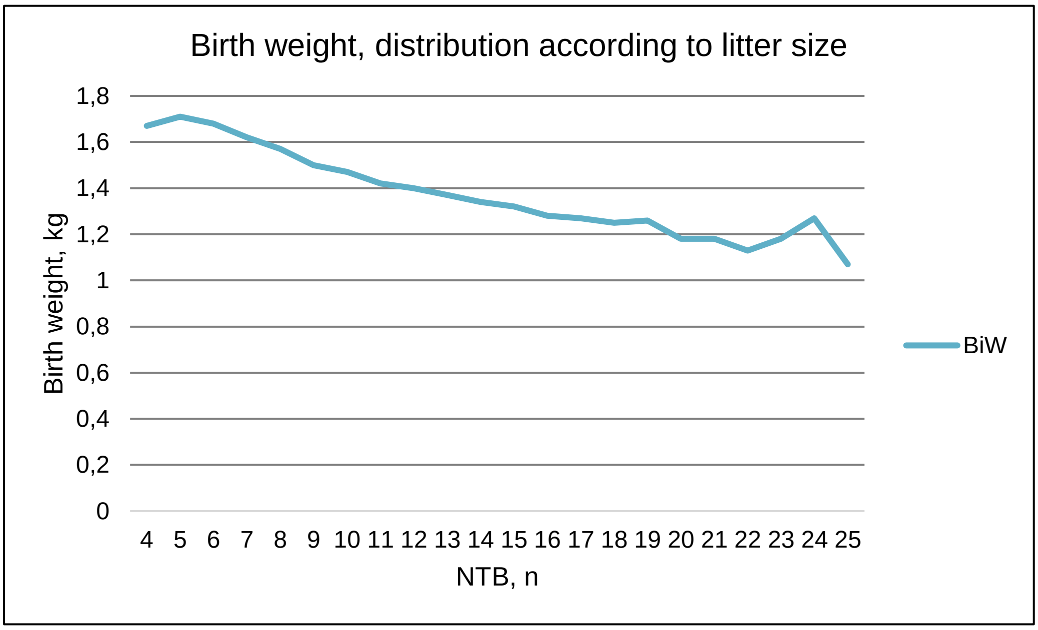

Figure 4. Average birth weight by litter size.

Table 3. *Descriptive statistics for birth weight and litter sizes by herd.*

Herd	BiW (kg)			NTB (no.)		
	Means	SD	Range	Means	SD	Range
1	1.34	0.25	0.3 - 2.6	13.0	2.90	2.0 - 22.0
2	1.38	0.22	0.4 - 2.5	13.4	3.15	2.0 - 23.0
3	1.39	0.22	0.3 - 2.5	13.4	3.09	2.0 - 24.0
4	1.39	0.23	0.3 - 2.5	13.5	3.20	2.0 - 22.0
5	1.37	0.23	0.4 - 2.6	12.7	3.53	4.0 - 23.0
6	1.38	0.23	0.3 - 2.6	14.1	3.22	2.0 - 23.0
7	1.43	0.23	0.4 - 2.8	13.1	3.07	4.0 - 21.0
8	1.34	0.20	0.4 - 2.5	12.4	3.04	4.0 - 19.0
9	1.25	0.22	0.2 - 2.4	13.6	2.88	3.0 - 20.0
10	1.44	0.25	0.4 - 2.8	12.6	3.30	2.0 - 24.0
11	1.38	0.21	0.2 - 2.7	13.4	2.66	6.0 - 25.0
12	1.36	0.20	0.3 - 2.4	13.4	2.62	3.0 - 23.0
13	1.39	0.21	0.6 - 2.6	12.7	2.77	4.0 - 20.0

BiW = birth weight, NTB = number of total born piglets in the litter where the piglet was born.

For descriptive statistics for field performance test traits, see Table 4. LBiW piglets had the thickest backfat thickness at 100 kg and took the longest time to reach 100 kg. HBiW had the thinnest backfat thickness and took the fewest days to reach 100 kg. Pigs born from first parity sows had thinner backfat thickness and grew slower to 100 kg than pigs born from second parity sows. Descriptive statistics on herd level is presented in Table 5.

Table 4. *Descriptive statistics for backfat thickness at 100 kg and adjusted days to 100 kg*.

Parameter	BF100 (mm)			D100 (days)		
	Means	SD	Range	Means	SD	Range
LBiW	11.0	2.1	1.9 - 22.4	166.2	16.8	107 - 226
BiW = 1.1	10.9	2.1	6.1 - 17.6	162.4	17.6	116 - 229
BiW = 1.2	10.6	2.1	4.6 - 17.3	161.2	16.9	116 - 230
BiW = 1.3	10.6	2.2	4.7 - 18.0	159.1	17.0	95 - 218
BiW = 1.4	10.5	2.1	4.1 - 18.9	156.1	16.7	110 - 218
BiW = 1.5	10.2	2.1	4.8 - 18.1	156.7	17.0	115 - 209
BiW = 1.6	10.0	2.2	4.6 - 23.7	153.5	16.7	112 - 208
BiW = 1.7	9.9	2.1	4.7 - 16.0	153.3	16.9	114 - 206
BiW = 1.8	9.7	2.2	3.6 - 19.1	152.6	17.4	114 - 212
BiW = 1.9	9.6	2.2	3.0 - 16.4	148.5	17.2	113 - 198
HBiW	9.5	2.1	4.1 - 15.8	147.0	17.4	102 - 202
Parity 1	10.4	2.2	1.9 - 23.7	158.2	17.5	95 - 230
Parity 2	10.2	2.1	3.0 - 19.1	155.0	17.8	102 - 215

BF100 = pre-corrected backfat thickness at 100 kg, D100 = pre-corrected days to reach 100 kg, LBiW = low birth weight, BiW = birth weight, HBiW = high birth weight.

Table 5. *Descriptive statistics for backfat thickness at 100 kg and days to 100 kg at herd level.*

Herd	BF100 (mm)			D100 (days)		
	Means	SD	Range	Means	SD	Range
1	11.8	2.0	4.9 - 16.7	166.7	17.8	115 - 230
2	10.4	1.7	5.5 - 23.7	173.8	16.0	129 - 229
3	10.7	1.9	5.9 - 18.5	174.9	14.3	129 - 207
4	10.0	1.7	4.8 - 15.4	149.6	11.2	116 - 182
5	8.8	2.0	3.0 - 19.2	153.5	12.6	116 - 186
6	9.6	1.8	4.4 - 18.0	145.8	12.5	102 - 184
7	9.3	1.9	3.6 - 18.9	169.1	14.2	129 - 214
8	9.9	1.7	6.1 - 15.2	161.4	13.9	95 - 207
9	10.0	1.9	5.6 - 15.4	166.2	13.5	127 - 206
10	10.2	2.1	5.8 - 22.4	140.3	11.9	107 - 189
11	9.5	1.8	4.8 - 15.5	149.7	14.4	110 - 204
12	11.5	2.2	1.9 - 18.1	148.5	13.2	116 - 195
13	11.2	2.0	6.4 - 17.0	161.7	14.5	119 - 202

BF100 = pre-corrected backfat thickness at 100 kg, D100 = pre-corrected days to reach 100 kg.

4.2 Variation in birth weight

Since number of total born in the litter is included as a fixed regression in the models, birth weights are compared at the same litter size. Thus, the effects of the other factors included in the models are corrected for variation in litter size. Mean piglet birth weight was significantly influenced by herd, parity number, number of total born, month-year combination, whether it was liveborn or stillborn, gender, and the interaction between birth parity number and liveborn or stillborn, see Table 6. Second parity sows gave birth to on average heavier (P<0.001) piglets compared to first parity sows with 120 grams when regression on litter size was included in the statistical model. When omitting the regression on litter size from the statistical model, piglets born from first parity sows where still lighter. Male piglets were on average heavier (P < 0.001) than gilt piglets. Liveborn piglets were one average heavier (P < 0.001) than stillborn piglets with 210 grams. For pairwise comparisons of least square means for factors influencing birth weight, see Appendix 1. Mean birth weight decreased with 33 grams per total born piglet in the litter (P < 0.001).

Table 6. *Levels of significance for the effect in model 1.*

	Trait analysed
Factors	BiW (Model 1)
Herd (H)	***
Parity number (P)	***
Regression on litter size (TB)	***
Month-year combination (T)	***
LB or SB (D)	***
Sex (S)	***
P × D[a]	***
P × S[a]	n.s.
D × S[a]	n.s.

BiW = birth weight, LB = liveborn, SB = stillborn.

[a] Interaction between main effects.

* P ≤ 0.05, ** P ≤ 0.01, *** P ≤ 0.001, n.s. = not significant.

4.3 Field performance test

Since number of total born is included as a fixed regression in the models, the effect of birth weights was compared at the same birth litter size. Thus, the effects of the other factors in the models are corrected for the same treatment. Backfat thickness at 100 kg live weight was significantly influenced by herd, birth parity number, sex, year-month of birth, the interaction between birth parity number and sex, litter size and birth weight class, see Table 7.

Table 7. *Levels of significance for the effects in models 2 and 3.*

	Traits analysed	
Factors	BF100 (Model 2)	D100 (Model 3)
Herd (H)	***	***
Parity number (P)	***	***
Sex (S)	***	***
Time of birth m/y (T)	***	**
P × S[a]	*	*
Regression on litter size (TB)	**	***
Birth weight class (W)	***	***

BF100 = pre-corrected backfat thickness at 100 kg, D100 = pre-corrected days to reach 100 kg.

[a] Interaction between main effects.

* $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$, n.s. = not significant.

Backfat thickness at 100 kg live weight decreased with increased birth weight, see Figure 5. When performing pairwise comparisons of least square means, pigs born from first parity sows had thinner backfat thickness (P<0.05) than pigs born from second parity sows, and males had thinner backfat thickness (P<0.001) than gilts, see Appendix 2. No significant difference in backfat thickness were found between 'proximal' weight groups; 1.1 and 1.2 kg, 1.2 and 1.3 kg, 1.3 and 1.4 kg, 1.5 and 1.6 kg, 1.6 and 1.7 kg, 1.7 and 1.8 kg, 1.7 and HBiW, and neither between the three highest birth weight groups; 1.8 kg, 1.9 kg and HBiW, see Appendix 3. LBiW pigs had 0.5 mm thinner backfat thickness (P<0.001) compared to the pigs weighing 1.4 kg, and 1.2 mm thinner backfat thickness (P<0.001) compared to the HBiW group. A significant (P < 0.001) correlation of -0.20 was found between individual birth weight and backfat thickness at 100 kg.

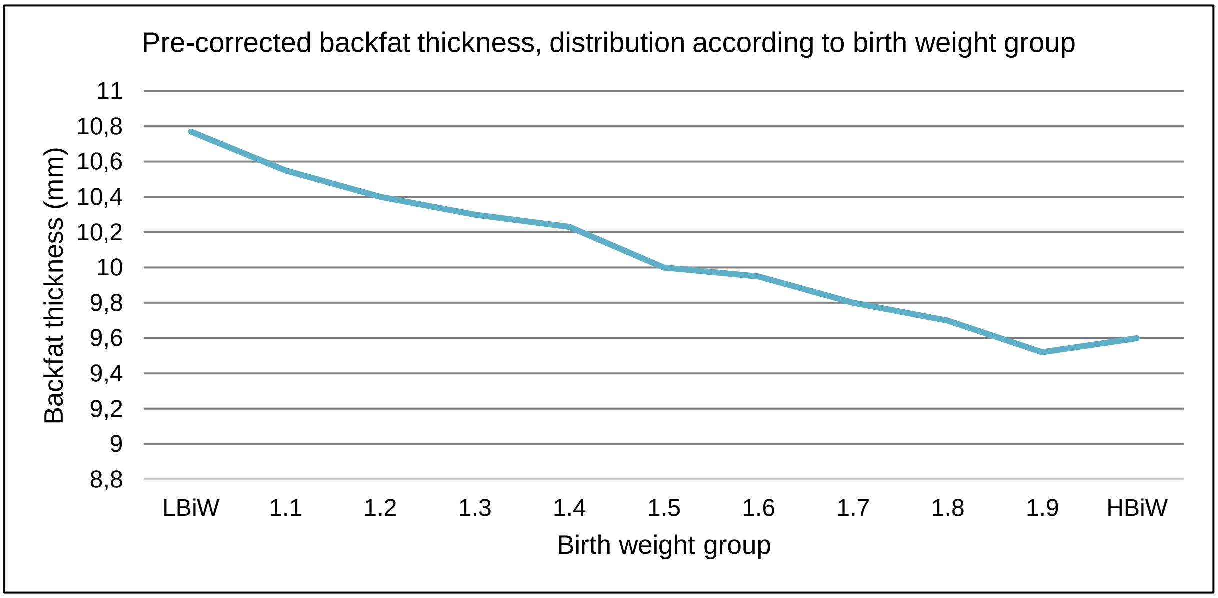

Figure 5. Distribution of least square means on birth weight group effect on backfat thickness at 100 kg live weight.

Days to 100 kg was influenced by herd, parity number, sex, month of birth, birth weight class, the interaction between parity number and sex and litter size, see Table 7. Days to 100 kg live weight decreased with increased birth weight, see Figure 6. Pairwise comparisons of least square means showed that males were younger by 2.3 days (P<0.001) at 100 kg than gilts, and pigs born from first parity sows were older by 4.4 days (P<0.001) than pigs born from second parity sows, see Appendix 4. Three pairwise comparisons of birth weight effects on days at 100 kg were not significant; 1.1 and 1.2 kg, 1.6 and 1.7 kg, and 1.7 and 1.8 kg, see Appendix 5. All other comparisons on birth weight effects was of significance. LBiW piglets took 10.4 and 19.9 more days to reach 100 kg than 1.4 kg pigs and HBiW pigs respectively, see Appendix 5. There was a significant (P < 0.001) correlation of -0.27 between individual birth weight and days to 100 kg.

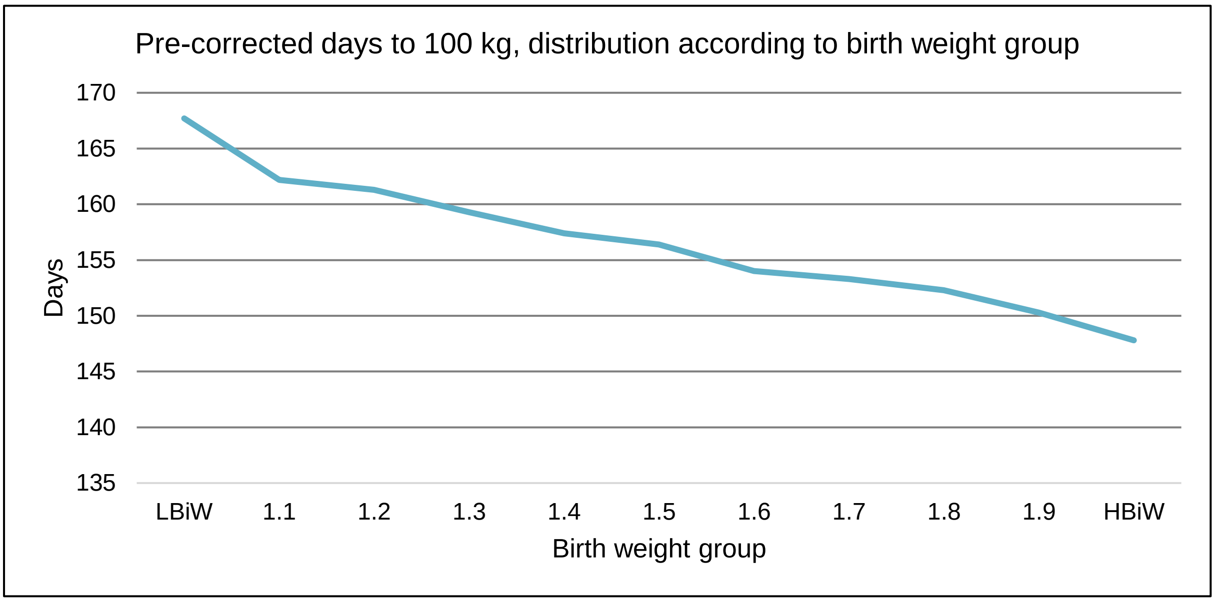

Figure 6. Distribution of least square means on birth weight group effect on days to 100 kg live weight.

5 Discussion

5.1 Variation in birth weight

The results in this study agrees in many aspects with results from previous performed studies. In the study by Čechová (2006), the effect of sex, birth parity number and litter size influenced individual birth weight. The same results were obtained in this study, also that male piglets were significantly heavier than female piglets, though this was not obtained by Čechová (2006). The difference in results between these two studies may be that Čechová (2006) had 960 registrations, while 32,531 registrations were available in this study. If Čechová (2006) would have had a larger number of registrations, she might have got different results. When litter size increase, mean birth weight decrease which can be explained by the decrease of uterine blood flow (Père & Etienne, 2000) and nutrient supply per foetus (Quiniou *et al.*, 2002). In this study, when litter size increased, the mean birth weight per piglet decreased with 33 grams. Other studies also found that the individual birth weight decreased with increased litter size (Quiniou *et al.*, 2002; Čechová, 2006). Piglets born by first parity sows weighted less than piglets born from second parity sows, both when adjusted for the influence of litter size, as well as when not correcting for differences in litter size. This corresponds with other studies which found that first parity sows had the lowest litter size and lowest mean piglet birth weight (Tummaruk *et al.*, 2000; Milligan *et al.*, 2002; Damgaard *et al.*, 2003). Even though the litter size was on average larger in second parity litters than in first parity litters, the piglets were heavier in this study. Number of stillborn per litter has been reported to increase with litter size (Milligan *et al.*, 2002). However, by proper management during farrowing and by applying cross fostering, it may decrease piglet mortality in litters with a high variation in birth weight (Britt, 1986). Though, it would probably be more beneficial and less time consuming to not breed for extreme large litters, but more even litters instead of applying cross-fostering. Table 3, showing mean birth weight and mean litter size in the herds used, shows that there is a variation between the herds. Biggest difference between herds in mean birth weight was 190 grams and biggest difference in number of total born were 1.7 piglets per litter. This indicates that management and routines are involved, even though it was not studied, since all sows had the same genetic capacity.

As there no longer is a breeding program for female lines in Sweden, large litters and variation in birth weight might be a problem because of a possible reduction of maternal behaviour in the Dutch sows. In the Swedish production system, the sows are always loosed housed, compared to the Netherlands where the sows are confined in crates throughout the entire lactation period (Sonesson, 2017). It may not be easy to evaluate maternal behaviour in Swedish production systems, when the nucleus sows are confined. Rydhmer (2000) concluded that it would be preferable to select sows with high birth weight, born in large litters. When the mean birth weight decreases, the survival rate of the piglets decreases, and the pre-weaning mortality increases (Milligan *et al.*, 2002; Quiniou *et al.*, 2002). The disadvantage for piglets in large litters in Swedish production systems might increase even more because of the housing system. As the Dutch Yorkshire is more competitive on an international market (Brink, 2012) and produces a higher number of piglets, the maternal behaviour of the sow might not get enough attention in the Dutch breeding program for Swedish pig production. In Swedish systems, number of total born is futile if the maternal behaviour is lacking (Rydhmer, 2000).

5.2 Field performance tests

In this study, piglets with the lowest birth weight had the thickest backfat at 100 kg live weight. They were also the ones who took the most days to reach 100 kg live weight. Animals born from first parity sows took 4.4 more days to reach 100 kg than those born from second parity sows. HBiW pigs were younger by 19.9 days at 100 kg compared to LBiW pigs, this correspond with other studies which found that low birth weight pigs grew slower than high birth weight pigs (Powell & Aberle, 1980; Gondret *et al.*, 2005). For a pig producer, 19.9 days is a long time, almost 3 weeks difference in days at 100 kg live weight. If cross fostering has been applied in the nursery, the live weight in the batch is quite even when put into the finishing stable. Otherwise they should be regrouped when put in, so all pigs get the same conditions to access feed and the feed can be adjusted for every group. If regrouping is applied it will lead to fighting between the pigs, and this may lead to lameness and wounds on the pigs which will require medication. If the stable must be emptied for the next batch, these pigs will be underweighting at slaughter. If the stable does not have to be emptied, then the LBiW pigs needs to be fed for almost 20 more days compared to the HBiW. That will be an additional cost for the farmer that could have been avoided. Pigs weighting 1.4 kg at birth, which was the mean birth weight in this study, took 9.6 days longer to reach 100 kg compared to the HBiW groups. When birth weight increased, days to 100 kg decreased so striving to achieve an increased mean birth weight will result in more efficient growing pigs. This study also found that pigs born from first parity sows had thicker backfat thickness than pigs born from second parity sows. For subsequent performance production of fattening pigs, it would be beneficial to breed for piglets with a higher mean birth weight instead of breeding for many low-birth weight piglets as in fattening pigs, a high feed efficiency and a high meat percentage is desirable. Table 5, showing mean backfat thickness at 100 kg live weight and mean days to 100 kg live weight in the herds used, shows that there is a difference between herds. Largest difference in number of days to reach 100 kg live weight between two herds were 34.6 days, and the biggest difference in backfat thickness were 2.9 mm. This indicates that management, routines and feeding are involved on the performance at field performance test as the pigs had the same genetic capacity for growth performance.

6 Conclusion

Gender, birth parity number, litter size, month-year of birth, herd, liveborn or stillborn, and the interaction between birth parity number and liveborn or stillborn all influenced mean birth weight in piglets. Birth weight, herd, birth parity number, gender, year-month of birth, litter size and the interaction between birth parity number and gender influenced backfat thickness and days to 100 kg live weight at field performance test. For fattening pigs, it would be beneficial to breed for higher birth weight piglets as they grew faster and were leaner at field performance test than piglets with lower birth weight. However, litter size is of economic importance for piglet producing herds, as well as for farrow-to-finish herds, which should not be forgotten.

Acknowledgements

Thank you to my supervisors Nisse and Katja for their help and guidance throughout the entire working progress. Special thanks to Nisse, even when he was on vacation leave and later sick leave he took his time to review my paper, answering my emails and my questions. A big thank you from the bottom of my heart to Patricia for always answering my cries for help whenever SAS decided to work against me or when I confused myself, it would have been so much harder without you. I would also like to thank my dogs Luna and Snape for supporting me in their own special way.

References

Amaral Filha, W. S., Bernardi, M. L., Wentz, I., Bortolozzo, F. P. 2010. Reproductive performance of gilts according to growth rate and backfat thickness at mating. Animal Reproduction Science 121, 139-144.

Beaulieu, A. D., Aalhus, J. L., Williams, N. H., Pateince, J. F. 2010. Impact of piglet birth weight, birth order, and litter size on subsequent growth performance, carcass quality, muscle composition, and eating quality of pork. Journal of Animal Sceince 88, 2767-2778.

Bérard, J., Kreuzer, M., Bee, G. 2008. Effect of litter size and birth weight on growth, carcass and pork quality, and their relationship to postmortem proteolysis. Journal of Animal Science 86, 2357-2368.

Brink, E. 2012. Nordic Genetics slutar med svensk Yorkshire. *Sveriges Grisföretagare*, 26 mars. Available: http://www.svenskgris.se/?p=21186&m=3258&pt=114 [2017.09.14]

Britt, J.H. 1986. Improving sow productivity through management during gestation, lactation and after weaning. Journal of Anima Science 63, 122-1296.

Čechová, M. 2006. Analysis of some factors influencing the birth weight of piglets. Slovak Journal of Animal Science 39, 139-144.

Damgaard, L. H., Rydhmer, L., Løvendahl, P., Grandinsson, K. 2003. Genetic parameters for within-litter variation in piglet birth weight and change in within-litter variation during suckling. Journal of Animal Science 81, 604-610.

Edwards, S.A. 2002. Perinatal mortality in the pig: environmental or physiological solutions? Livestock Production Science 78, 3-12.

Fix, J. S., Cassady, J. P., Herring, W. O., Holl, J. W., Culbertson, M. S., See, M. T. 2010. Effect of piglet birth weight on body weight, growth, backfat, and longissimus muscle area of commercial market swine. Livestock Science 127, 51-59.

Gondret, F., Lefaucheur, L., Louveau, I., Lebret, B., Pichodo, X., Le Conzler, Y. 2005. Influence of piglet birth weight on postnatal growth performance, tissue lipogentic capacity and muscle histological traits at market weight. Livestock Production Science 93, 137-146.

Hansson, M. & Lundeheim, N. 2013. Den Svenska yorkshirerasens bakgrund och utveckling. *Sveriges Grisföretagare*, 30 augusti. Available: http://www.svenskgris.se/?p=21680&m=3258&pt=114 [2017.09.14]

Jordbruksverket. 2014. *Djurskyddsbestämmelser Gris*. Jönköping: Jordbruksverket. Available: http://www2.jordbruksver-ket.se/webdav/files/SJV/trycksaker/Pdf_jo/jo14_3.pdf [2017.10.27]

Kaufmann, D., Hofer, A., Bidanel, J. P., Künzi, N. 2000. Genetic parameters for individual birth and weaning weight and for litter size of Large White pigs. Journal of Animal Breeding and Genetics 117, 121-128.

McGlone, J.J. & Fullwood, SD 2001. Behavior, reproduction, and immunity of crated pregnant gilts: Effects of high dietary fibre and rearing environment. Journal of Animal Science 79, 1466-1474.

Milligan, B. N., Fraser, D., Kramer, D. L. 2001. Birth weight variation in the domestic pig: effects on offspring survival, weight gain and suckling behaviour. Applied Animal Behaviour Science 73, 171-191.

Milligan, B. N., Fraser, D., Kramer, D. L. 2002. Within-litter birth weight variation in the domestic pig and its relation to pre-weaning survival, weight gain, and variation in weaning weights. Livestock Production Science 76, 181-191.

Nelson, R.E. & Robinson, O.W. 1976. Effects of postnatal maternal environment on reproduction of gilts. Journal of Anima Science 43, 71-77.

Nordic Genetics, 2017. Avelsmål. Available: http://www.nordicgenetics.se/sv-se/avel/avelsm%C3%A5l.aspx [2017.11.13]

Oliviero, C., Heinonen, M., Valros, A., Hälli, O., Peltoniemi, O.A.T. 2008. Effect of the environment on the physiology of the sow during late pregnancy, farrowing and early lactation. Animal Reproduction Science 105, 365-377.

Père, M.C. & Etienne, M. 2000. Uterine blood flow in sows: Effects of pregnancy stage and litter size. Reproduction Nutrition Development 40, 369-382.

Powell, S. E. & Aberle, E. D. 1980. Effects of birth weight on growth and carcass composition of swine. Journal of Animal Science 50, 860-868.

Quiniou, N., Dagorn, J., Gaudré, D. 2002. Variation of piglets' birth weight and consequences on subsequent performance. Livestock Production Science 78, 63-70.

Rydhmer, L. 2000. Genetics of sow reproduction, including puberty, oestrus, pregnancy, farrowing and lactation. Livestock Production Science 66, 1-12.

SAS Institute, 2012. SAS/STAT Software. Version 9.4. SAS Institute Ins., Cary, North Carolina.

Sonesson, E. 2017. Är nederländsk nisch lika med svensk grisuppfödning? Sveriges Grisföretagare, 26 februari. Available: http://www.grisforetagaren.se/?p=23980&m=3258&pt=114 [2017.11.03]

Stalder, K. J., Saxton, A. M., Conatser, G. E., Serenius, T. V. 2005. Effect of growth and compositional traits on first parity and lifetime reproductive performance in U.S. Landrace sows. Livestock Production Science 97, 151-159.

Tummaruk, P., Lundeheim, N., Einarsson, S., Dalin, A.-M. 2000. Reproductive Performance of Purebred Swedish Landrace and Swedish Yorkshire Sows: 1. Seasonal Variation and Parity Influence. Acta Agriculturae Scandinavica, Section A – Animal Science 50, 205-216.

Tummaruk, P., Lundeheim, N., Einarsson, S., Dalin, A.-M. 2001. Effect of birth litter size, birth parity number, growth rate, backfat thickness and age at first mating of gilts on their reproductive performance as sows. Animal Reproduction Science 66, 225-237.

Appendices

Appendix 1. *Pairwise comparisons of least squares means for effects (sex; liveborn/stillborn; birth parity number: and their interactions) influencing birth weight. Difference between 1st column minus 2nd column.*

Column 1	Column 2	Difference and level of significance
Main effects		
Male	Gilt	0.04 ***
LB	SB	0.21 ***
P1	P2	- 0.12 ***
Interactions		
P1 LB	P1 SB	0.17 ***
	P2 LB	-0.16 ***
	P2 SB	0.09 ***
P1 SB	P2 LB	-0.33 ***
	P2 SB	-0.09 ***
P2 LB	P2 SB	0.25 ***
P1 male	P1 gilt	0.04 ***
	P2 male	-0.12 ***
	P2 gilt	-0.08 ***
P1 gilt	P2 male	-0.17 ***
	P2 gilt	-0.12 ***
P2 male	P2 gilt	0.04 ***
LB male	SB male	0.21 ***
	LB gilt	0.04 ***
	SB gilt	0.25 ***
SB male	LB gilt	-0.17 ***
	SB gilt	0.04 ***
LB gilt	SB gilt	0.21 ***

LB = liveborn, SB = stillborn, P1 = parity 1, P2 = parity 2.

*P<0.05; **P<0.01; ***P<0.001, n.s. = not significant

Appendix 2. *Pairwise comparisons of least square means for effects (birth parity; gender; and interactions) influencing BF at 100 kg. Difference between 1st column minus 2nd column.*

Column 1	Column 2	Difference and level of significance
Main effects		
P1	P2	-0.2 *
Male	Gilt	-0.8 ***
Interactions		
P1 male	P1 gilt	-0.9 ***
	P2 male	-0.3 **
	P2 gilt	-1.0 ***
P1 gilt	P2 male	0.7 ***
	P2 gilt	-0.1 n.s.
P2 male	P2 gilt	-0.7 ***

P1 = parity 1, P2 = parity 2.
*P<0.05; **P<0.01; ***P<0.001, n.s. = not significant.

Appendix 3. *Pairwise comparisons of least square means for effects of birth weight on BF at 100 kg. Difference between 1st column minus 2nd column.*

Column 1	Column 2	Difference and level of significance	Column 1	Column 2	Difference and level of significance
LBiW	1.1	0.2 *	1.3	1.5	0.3 ***
	1.2	0.4 ***		1.6	0.4 ***
	1.3	0.5 ***		1.7	0.5 ***
	1.4	0.5 ***		1.8	0.6 ***
	1.5	0.8 ***		1.9	0.8 ***
	1.6	0.8 ***		HBiW	0.7 ***
	1.7	1.0 ***	1.4	1.5	0.2 ***
	1.8	1.1 ***		1.6	0.3 ***
	1.9	1.3 ***		1.7	0.4 ***
	HBiW	1.2 ***		1.8	0.5 ***
1.1	1.2	0.2 n.s.		1.9	0.7 ***
	1.3	0.3 **		HBiW	0.6 ***
	1.4	0.3 **	1.5	1.6	0.1 n.s.
	1.5	0.6 ***		1.7	0.2 *
	1.6	0.6 ***		1.8	0.3 **
	1.7	0.8 ***		1.9	0.5 ***
	1.8	0.9 ***		HBiW	0.4 ***
	1.9	1.0 ***	1.6	1.7	0.2 n.s.
	HBiW	1.0 ***		1.8	0.3 **
1.2	1.3	0.1 n.s.		1.9	0.4 ***
	1.4	0.2 *		HBiW	0.4 **
	1.5	0.4 ***	1.7	1.8	0.1 n.s.
	1.6	0.5 ***		1.9	0.3 *
	1.7	0.6 ***		HBiW	0.2 n.s.
	1.8	0.7 ***	1.8	1.9	0.2 n.s.
	1.9	0.9 ***		HBiW	0.1 n.s.
	HBiW	0.8 ***	1.9	HBiW	-0.1 n.s.
1.3	1.4	0.1 n.s.			

LBiW = low birth weight, HBiW = high birth weight.
*P<0.05; **P<0.01; ***P<0.001, n.s. = not significant.

Appendix 4. *Pairwise comparisons of least square means for effects (birth parity; gender; and interactions) influencing days at 100 kg. Difference between 1st column minus 2nd column.*

Column 1	Column 2	Difference and level of significance
Main effects		
P1	P2	4.4 ***
Male	Gilt	-2.3 ***
Interactions		
P1 male	P1 gilt	-1.6 ***
	P2 male	5.2 ***
	P2 gilt	2.1 **
P1 gilt	P2 male	6.8 ***
	P2 gilt	3.7 ***
P2 male	P2 gilt	-3.1 ***

P1 = parity 1, P2 = parity 2,

*P<0.05; **P<0.01; ***P<0.001, n.s. = not significant

Appendix 5. *Pairwise comparisons of least square means for effects of birth weight on days at 100 kg. Difference between 1st column minus 2nd column.*

Column 1	Column 2	Difference and level of significance	Column 1	Column 2	Difference and level of significance
LBiW	1.1	5.5 ***	1.3	1.5	3.0 ***
	1.2	6.4 ***		1.6	5.3 ***
	1.3	8.4 ***		1.7	6.0 ***
	1.4	10.4 ***		1.8	7.1 ***
	1.5	11.3 ***		1.9	9.1 ***
	1.6	13.7 ***		HBiW	11.5 ***
	1.7	14.4 ***	1.4	1.5	1.0 *
	1.8	15.5 ***		1.6	3.4 ***
	1.9	17.5 ***		1.7	4.0 ***
	HBiW	19.9 ***		1.8	5.1 ***
1.1	1.2	0.9 n.s.		1.9	7.1 ***
	1.3	2.9 ***		HBiW	9.6 ***
	1.4	4.8 ***	1.5	1.6	2.4 ***
	1.5	5.8 ***		1.7	3.0 ***
	1.6	8.2 ***		1.8	4.1 ***
	1.7	8.9 ***		1.9	6.1 ***
	1.8	10.0 ***		HBiW	8.6 ***
	1.9	12.0 ***	1.6	1.7	0.7 n.s.
	HBiW	14.4 ***		1.8	1.8 **
1.2	1.3	2.0 **		1.9	3.7 ***
	1.4	4.0 ***		HBiW	6.2 ***
	1.5	4.9 ***	1.7	1.8	1.1 n.s.
	1.6	7.3 ***		1.9	3.1 **
	1.7	8.0 ***		HBiW	5.5 ***
	1.8	9.0 ***	1.8	1.9	2.0 *
	1.9	11.0 ***		HBiW	4.5 ***
	HBiW	13.5 ***	1.9	HBiW	2.5 **
1.3	1.4	2.0 ***			

LBiW = low birth weight, HBiW = high birth weight.
*P<0.05; **P<0.01; ***P<0.001, n.s. = not significant