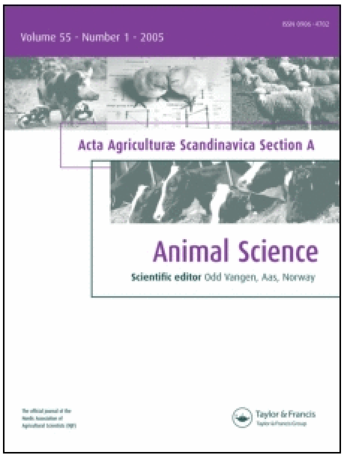

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Sow body condition at weaning and reproduction performance in organic piglet production

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ORIGINAL ARTICLE

Sow body condition at weaning and reproduction performance in organic piglet production

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Abstract

The objective was to investigate the variation in backfat at weaning and its relations to reproduction results in organic sow herds in Denmark. The study included eight herds and 573 sows. The average backfat at weaning (mean = 13 mm; SD = 4.2 mm) ranging from 10.5 to 17.3 mm among herds shows that it is possible to avoid poor body condition at weaning even with a lactation length of seven weeks or more. No main effect of backfat at weaning on reproduction performance was found, but the probability of a successful reproduction after weaning tended to decrease with decreasing backfat for first parity sows, whereas the opposite was the case for multiparous sows.

Keywords: *Backfat, lactation length, litter size.*

Introduction

According to EU Regulation No. 1804/1999, organically produced pigs must be at least 40 days of age before weaning. In Denmark (Danish Plant Directorate, 2008) and Sweden (KRAV, 2008) stricter rules apply and piglets must be minimum 49 days of age. In comparison, in conventional production the mean weaning age is approximately four weeks (Jultved, 2006). The motivation for the stricter requirements in organic production is that early weaning (e.g. four weeks) is considered a threat to piglet welfare as indicated in the study by Dybkjær (1992).

The prolonged lactation length in organic sow herds has been suggested as a potential threat to sow welfare due to the expectation of large weight losses during lactation. However, Andersen et al. (2000) showed in an experimental study that a long lactation period did not necessarily provoke a poor body condition at weaning, since weight loss differences between sows weaned at five weeks and at seven weeks were insignificant. On the other hand, practical experiences indicate that sows in organic herds are leaner than in conventional herds (Rydhmer et al., 2005). Systematic information on the level and variability in sow body condition at weaning in organic herds is, however, missing in the literature.

Poor body condition at weaning may not only be a problem for animal welfare. Low fat reserves at weaning may impair the subsequent reproduction performance by extending re-mating intervals and reducing litter sizes (Whittemore, 1996; Han et al., 2000) and may increase the risk of involuntary culling (Young et al., 1990, 1991; Kongsted, 2006).

Only limited data are available on the reproduction performance of organic sows. Data from four organic sow herds indicate lower farrowing rates and litter sizes in organic sow herds compared to conventional herds (Lauritsen et al., 2000), and an expert panel of 10 Danish and Swedish pig husbandry advisers concluded that poor reproduction performance was a common problem in organic sow herds (Bonde & Sørensen, 2003). Whether these problems are related to poor body condition at weaning is unknown.

Results from a previous Danish study indicate small seasonal fluctuations of some reproduction parameters in conventional outdoor sow herds (Larsen & Jørgensen, 2002). Organic piglet production in

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Denmark is characterised by outdoor housing, as the sows are outdoors during lactation and most of the gestation period. This means that the organic sows to a much larger degree than conventional indoor-housed sows are exposed to changes in climate, e.g. changes in temperature and photoperiod. These are the factors that have been associated with seasonal manifestations in reproduction in sows (Reilly & Roberts, 1992; Peltoniemi, 1999).

The purpose of this study was to investigate the level of and variation between and within herds in sow's body condition at weaning and its possible effect on reproduction performance (e.g. litter size and farrowing to farrowing interval) in organic sow herds in Denmark.

Materials and methods

Herds and sows

The study was conducted during a 12-month period from June 2005 to June 2006 at eight Danish commercial organic sow herds. These herds were identified with the assistance of pig advisors throughout Denmark. The eight herds represented approximately 40% of all organic sow herds in Denmark with more than 50 sows per herd and they included the two largest organic sow herds in Denmark at the time (Serup 2005, pers. comm.).

Table I presents herd size, layout and management practices in the herds. Herd size varied from 50 to 400 sows (mean 176 sows). In all herds, the sows were kept outdoors during the entire lactation period and also during most of the pregnancy period. In five herds, the service unit was placed indoors. In herds number 1 and 2, uncontrolled mating was practised. Seven of the eight herds used individual paddocks of approximately 500–1.500 m^2 throughout the lactation. All sows were outdoors from farrowing to weaning. Each sow and her litter had access to farrowing huts of about 3–3.5 m^2. The sows studied were either crossbred Landrace × Yorkshire (LY) or Landrace × Yorkshire × Duroc (LYD) in various combinations. In Denmark there are no specific organic breeding programmes so the breeds had their origin in the conventional breeding programme. The age at first service varied from 7–9 months in all herds.

Backfat measurements

Ten focal sows were randomly chosen in the lactation paddocks in each of the approximately 12 batches in each herd (one per month) just before the sows were moved to the service unit on the day of weaning. The randomisation procedure was carried out the following way: 10 numbers (1–10) were randomly drawn from *x* numbers with *x* representing the number of sows in the particular batch of sows (for example 30) in the lactation unit. So if numbers 1, 4, 8, etc. were drawn, the sows placed in the farrowing huts number 1, 4, 8 etc. were chosen as focal sows. If less than 10 sows weaned, all sows in the batch were chosen as focal sows. In herd number 8, backfat measurements were only carried out from January to June 2006. Focal sows did not include sows selected for removal shortly after weaning.

Backfat thickness was measured on all focal sows by means of the digital ultrasound backfat indicator LEAN MEATER (Baltic Korn A/S, Naestved, Denmark) on the day of weaning. Backfat measurement is an objective and precise method to assess the body condition of sows (Charette et al., 1996; Maes et al., 2004). All backfat measurements were performed by trained technicians. The backfat was measured 65 mm from either side of the spinal column at the 10th and 12th rib and all three layers of fat were measured. A total of four measurements were taken (two at each rib). The average value of the four measurements was used to characterise the backfat of the sow. Observations with more than 5 mm deviation between the lowest and highest measurements were excluded from the material (eight sows). The edited data contained backfat measurements from 674 weanings from in total 573 sows.

Reproduction data

The employees at the farms carried out all the recordings that included sow number, parity, weaning date, date of first mating (if known), date of re-mating of the sows that returned to oestrus after the first mating (if known), farrowing date and the number of born piglets (alive and stillborn) for all sows weaned during the data collection period. In herds with uncontrolled matings (herds 1 and 2), the estimated mating date was calculated as farrowing date minus 116 days. For sows culled from the herd due to reproduction failure, the date of removal was recorded.

Before analysing data, all data were checked for inconsistency. If, for example, days between events varied significantly from the expected value, all the records for these sows were checked. Data from herd 1 were excluded from the analysis that included the interval from weaning to farrowing. This was done because the different management regime of utilising lactational oestrus caused data patterns that differed from the other herds. The edited data contained observations from 2242 weanings from in total 1369 sows.

Table I. Herd sizes, layouts and management procedures in eight organic sow herds in Denmark.

Herd	1	2	3	4	5	6	7	8
Herd size, sows	50	70	400	200	75	130	85	400
Breed combination	LY	LYD	LYD	LY/LYD	LY/LYD	LY/LYD	LY	LY/LYD
Batch interval	Three weeks	No regular	Two weeks	One week	Three weeks	Two weeks	4–5 weeks	Three weeks
Service unit								
Indoor/outdoor	Outdoor	Outdoor	Indoor with outdoor run (four weeks)	Indoor (six days)	Outdoor	Indoor with outdoor run (5–7 days)	Indoor with outdoor run (four weeks)	Indoor with outdoor run (seven weeks)
Group size	5–10	10–15	25–30	One (in a pen)	Three	6–7[a]	10–15	5–6
Group dynamics	Stabile	Dynamic	Stabile	–	Stabile	Stabile	Stabile	Stabile
Mating system	Uncontrolled	Uncontrolled multi-sire	Artificial insemination	Artificial insemination	Artificial insemination	Artificial insemination	Artificial insemination	Artificial insemination
Pregnancy unit								
Indoor/outdoor	Outdoor	Outdoor	Outdoor	Outdoor	Outdoor	Outdoor	Outdoor	Outdoor
Group dynamics[b]	Dynamic	Dynamic	Stabile	Dynamic	Stabile	Dynamic	Dynamic	Dynamic
Group size	20–35	10–15	25–30	25–30	9–10	70	25–30	150–200
Farrowing/lactation unit								
Indoor/outdoor[c]	Outdoor, in groups of 5–10 sows[d]	Outdoor, individual paddocks	Outdoor, individual paddocks	Outdoor, individual paddocks	Outdoor, individual paddocks	Outdoor, individual paddocks	Outdoor, individual paddocks	Outdoor, individual paddocks
Feeding strategy during lactation, MJ ME day^{-b} (sows)	Day 0–5: 80, thereafter increasing to 150–190	Day 0–8: 100, thereafter increasing to 205	Day 0–2: 13–90, thereafter increasing to 165	Day 0–2: 40–75, thereafter increasing to 140	Day 1–7: 38–65, thereafter increasing to 155	Day 0–8: 65, thereafter increasing to 190	0-2: 25–65, thereafter increasing to 155	Day 0–14: 65–180, thereafter increasing to 165–180
Supplementary feeding of piglets	From seven weeks	From two weeks	From five weeks	From birth	From five weeks	Only access to sow feed	From six weeks	From four weeks

[a]The smallest/weakest sows (2–3) are placed in an outdoor pen together with a boar. [b]In stable groups, once the group is established no new sows are moved into the group. In dynamic groups, new sows are constantly moved into and out of the group, e.g. up till once a week. [c]Refers to both farrowing and lactation environment. [d]A boar is introduced in the lactation paddock 3–5 weeks after farrowing.

Statistical analyses

The effect of parity, lactation length, season, herd and batch on the backfat at weaning was investigated by the following model:

$$E(Y_{ijklm}) = \mu + \alpha_i + \beta_j + \gamma \cdot x_{ijklm} + A_l + B_{m(l)}. \qquad (1)$$

Where Y_{ijklm} is the thickness of backfat at weaning transformed by natural logarithm to obtain an approximately normal distribution; μ is the general intercept; α_i is the effect of parity at weaning ($i = 1$, 2, 3 and ≥ 4); β_j is the effect of weaning season (j = January–March, April–June, July–September, October–December); x_{ijklm} is the effect of lactation length transformed by natural logarithm, and γ is the corresponding regression parameter. A_l and $B_{m(l)}$ are the normally distributed random effects of herd ($l = 1, 2, \ldots, 8$) and batch within herd ($m = 1, 2, \ldots$ 6–12), respectively. Interactions between parity and the other independent variables were included in the model.

The effect of parity, lactation length, season, herd and batch on the reproduction performance was investigated by the following model:

$$E(Y_{ijklm}) = \mu + \alpha_i + \beta_j + \gamma \cdot x_{ijklm} + A_l + B_{m(l)}. \qquad (2)$$

Where Y_{ijklm} is the interval from weaning to farrowing, weaning to first mating for sows mated within the first week after weaning, farrowing within 130 days of weaning (yes or no), removed from the herd (yes or no) and litter size (total born). For the independent variables the notation is the same as in Model 1 with the exception that it was unnecessary to transform lactation length to obtain an approximate normal distribution. Days from weaning to first mating were only calculated for those sows that were mated within the first week, because it was otherwise not possible to obtain approximate normality. For the same reason, a maximum limit of 220 days was set for the interval from weaning to farrowing (this affected 20 weanings). Interactions between parity and the other independent variables were included in the model.

When analysing the relation between backfat and reproduction the following model was applied:

$$E(Y_{ijklmn}) = \mu + \alpha_i + \beta_j + \gamma \cdot x_{ijklm} + v \cdot y_{ijklmn} + A_l + B_{m(l)}. \qquad (3)$$

Where Y_{ijklmn} corresponds to weaning in first service interval, weaning to farrowing interval, $\pm$ farrowing within 130 days from weaning (yes or no), removed from the herd (yes or no) and litter size. For the independent variables, the notation is the same as in Model 1. y_{ijklmn} is the effect of backfat transformed by natural logarithm and v is the corresponding regression parameter. Interactions between parity and the other independent variables were included in the model.

For the categorical dependent variables (farrowing within 130 days from weaning (yes or no), removed from the herd (yes or no)), Y_{ijklmn} corresponds to logit to the probability of the observed outcome, p_{ijklmn}. For the continuous dependent variables (backfat at weaning, first service interval, weaning to farrowing interval and litter size), $Y_{ijklmn} \sim N(E(Y_{ijklmn}), \sigma^2_{ijklmn})$, whereas for the categorical variables, $Y_{ijklmn} \sim B(1, p_{ijklmn})$.

When analysing the effect of breed on backfat and reproduction performance in the four herds with both breed combinations, δ_n – which indicates the effect of breed (n = LY, LYD) – was included in Models 1 and 2.

For modelling the repeated measurement on the same sow an AR (Autoregressive) correlation structure was fitted to the residual error in all of the above-mentioned statistical models. However, the autocorrelation was always estimated to zero and therefore excluded from the final models. All interactions and main effects with P values above 0.1 were eliminated from the model one by one and the analysis was repeated. For all continuous variables the statistical analyses were performed with a linear mixed model using the MIXED procedure (Littell et al., 1996) in SAS (SAS Institute Inc., 1990). The GLIMMIX procedure in SAS was used to analyse the categorical variables.

Results

Backfat at weaning

Table II shows the inter-farm variability in backfat for all the focal sows ($N = 674$). Herd 1 had the highest average backfat depth (17.3 mm), whereas herd 7 had the lowest average (10.5 mm). Across herds, the average backfat depth was 13 mm varying from 5 to 28 mm as shown in Figure 1. Twenty-five percent of all sows had backfat measuring less than

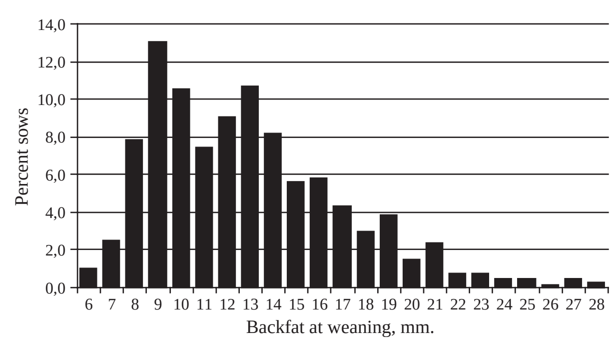

Figure 1. The distribution of backfat at weaning for all focal sows ($N = 674$).

Table II. Average backfat thickness at weaning (mm) for the focal sows ($N = 674$) and reproduction data for all weanings with known reproduction status ($N = 2242$) in eight organic sow herds from June 2005 to June 2006.

Herd	1	2	3	4	5	6	7	8
Backfat at weaning								
Number of focal sows	82	85	108	103	71	90	75	60
Average backfat at weaning	17.3	12.4	11.7	14.1	12.0	11.1	10.5	12.9
Standard deviation	4.7	3.7	3.1	4.2	3.4	3.2	2.5	3.5
Backfat 25% quartiles	14.3	9.3	9.1	11.0	9.0	8.75	8.5	10.3
Backfat 75% quartiles	20.5	15.0	13.4	17.3	14.0	13.0	12.5	15.3
Reproduction								
Number of weanings (with known reproduction status)	90	96	631	353	115	188	116	653
Percentage of first parity sows	21	8	19	27	29	21	21	28
Average lactation length, days	71	73	50	49	47	51	60	49
Farrowing to farrowing interval, days	181	211	175	171	168	182	182	172
Weaning to farrowing interval, days	110	143	125	122	121	132	122	122
Weaning to removal interval, days	57	104	99	113	87	48	83	78
Percentage (%) of sows mated within the first week after weaning[a]	–	–	90	–	–	–	96	92
Weaning to mating interval, days[b]	–	–	3.8	4.1	4.6	4.3	3.6	3.9
Weaning to estimated mating interval, days[c]	−6.0	27.1	–	–	–	–	–	–
Percentage (%) of weaned sows farrowing within the first 130 days after weaning	64	42	79	81	86	67	84	85
Percentage (%) of known matings resulting in a farrowing within the first 125 days after mating[d]	–	–	85	87	90	58	86	89
Percentage (%) of sows removed due to reproductive failures	11	1	2	8	11	7	8	5
Total litter size in subsequent cycle, born piglets per litter	12.4	12.9	14.8	14.5	13.8	13.4	14.0	14.2

[a]Of sows mated within the first four weeks after weaning (this is only calculated for the three herds with controlled services the first four weeks after weaning). [b]For sows mated within the first week after weaning. [c]Only for sows with a farrowing date. [d]Only possible to calculate for the six herds with controlled services.

9.5 mm at weaning and 25% of all sows had backfat above 15.3 mm. The variation between the individual sows ($\varepsilon = 0.27^2$) was larger than the variation between herds ($\sigma_1^2 = 0.13^2$) and batches ($\sigma_{m(l)}^2 = 0.08^2$).

Table III presents the least square (LS)-means for parity group and season as well as the parameter estimates for lactation length. A significant main effect of parity group was observed on backfat at weaning. Sows older than third parity had significantly more backfat at weaning compared to younger sows. There were no significant main effects of lactation length or season, but the thickness of backfat varied significantly between herds ($P < 0.05$) and also between batches within herds ($P < 0.01$). In herds number 4, 5, 6 and 8, where both breed combinations were represented, the backfat at weaning was significantly thicker in LYD sows compared to LY sows as shown in Table IV.

Reproduction

The average reproduction performances of the eight organic sow herds are given in Table II. A large variation occurred between farms for almost all traits. Days from weaning to farrowing varied from 110 to 143 days (average 124 days) and litter size ranged from 12.4 to 14.8 born piglets per litter (average 13.7 piglets).

The results of the analysis of the reproduction traits are presented in Table III, and Table IV presents LS-means for the main effect of breed combination. No significant interactions were found between parity group, season and lactation length.

Effect of parity, breed combination and lactation length

Parity had a significant effect on the interval from weaning to first service, the probability of farrowing within 130 days after weaning, the litter size and the risk of being removed. First parity sows showed a longer interval from weaning to first service than sows of parity 2 or older. Sows older than third parity were more likely to farrow later than 130 days after weaning compared to the other parities and litter size increased from parity 1 to 2 and declined from parity 3 to 4. Sows older than third parity were at the higher risk of being culled due to reproductive problems compared to the other parity groups.

Table III. Effect of parity group and season (LS: least square and effect of lactation length (parameter estimate) on backfat and six reproduction traits (NS: $P > 0.05$).

	Parity group (LS-means)				Season, quarter (LS-means)				
	1	2	3	≥4	1	2	3	4	Lactation, days[1)] (parameter estimate, γ)
Backfat, ln (mm)									
N	148	152	124	261	171	176	170	168	685
LS-means[2)]/estimate	11.7[a]	11.1[a]	11.4[a]	13.2[b]	11.3	11.8	12.2	12.0	0.005
P-value	<0.001				NS				NS
Weaning to first service, days									
N	450	455	364	574	456	388	563	436	1841
LS-means/estimate	4.2[a]	4.0[b]	4.0[b]	4.0[b]	3.8[a]	4.1[b]	4.2[b]	4.1[b]	0.001
P-value	<0.001				<0.01				NS
Weaning to farrowing, days									
N	460	451	391	635	525	357	562	487	1941
LS-means/estimate	125	125	126	126	125[a]	125[a]	129[b]	124[a]	0.065
P-value	NS				<0.01				NS
Probability of farrowing within 130 days									
N	515	504	427	772	592	460	630	536	2218
LS-means[3)]/estimate	81.4[a]	79.8[a]	80.3[a]	72.1[b]	74.5[a]	79.0[ab]	76.2[a]	83.9[b]	−0.016
P-value	<0.001				NS ($P < 0.1$)				NS ($P < 0.1$)
Total litter size in subsequent cycle, piglets per litter									
N	476	462	396	671	530	401	577	497	2005
LS-means/estimate	13.7[a]	14.4[b]	14.1[ab]	13.5[a]	14.3[a]	14.4[a]	13.3[b]	13.8[a]	0.017
P-value	<0.001				<0.01				NS
Probability of removal due to reproduction failure									
N	518	505	430	781	596	469	632	537	2234
LS-means[3)]/estimate	4.6[a]	4.7[a]	3.3[a]	7.5[b]	5.5	5.1	4.2	5.4	−0.009
P-value	<0.05				NS				NS

[1)]Ln(days) in the backfat analysis. [2)]Back-transformed by e^x. [3)]Transformed to the probability scale.

Table IV. Least square means for the effect of breed combination and the number of sows in parenthesis from the statistical analyses of backfat and reproduction performance (four herds with both breed combinations). LYD: Landrace × Yorkshire × Duroc; LY: Landrace × Yorkshire. NS: $P > 0.05$.

	LYD	LY	*P*-value
Backfat[a], mm	13.1 (124)	11.0 (165)	<0.0001
Interval weaning to first service, days	4.2 (601)	4.3 (401)	NS
Interval weaning to farrowing, days	123 (602)	125 (399)	<0.001
Probability of farrowing within 130 days after weaning[b]	82.9 (669)	78.8 (448)	NS
Litter size, total born piglets per litter	13.4 (602)	14.8 (399)	<0.001
Probability of removal[b]	6.3 (669)	6.6 (448)	NS

[a]Back-transformed by e^x. [b]Transformed to the probability scale.

The weaning to farrowing interval and litter size were significantly higher in LY than in LYD sows as shown in Table IV. The breed combination did not affect the other reproduction parameters significantly.

Lactation length tended to have a negative influence on the probability of farrowing within 130 days ($P < 0.1$), but had no significant effect on the other reproduction parameters.

Effect of weaning season

A significant effect of season was found on weaning to first service interval, weaning to farrowing interval and litter size. Sows weaned in the first quarter had a shorter interval from weaning to first service compared to sows weaned from April to December. Sows weaned from July to September had longer weaning to farrowing interval and lower litter size compared to sows weaned in the first, second and fourth quarter. The probability of farrowing within 130 days from weaning was highest in the fourth quarter.

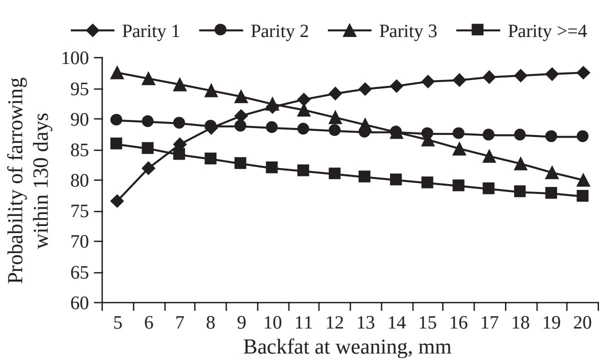

Figure 2. The relation between backfat at weaning and the probability of farrowing within 130 days after weaning for the four parity groups weaned in the fourth quarter (*P*-value for interaction <0.1).

Relation between backfat thickness at weaning and reproduction

No significant relations were observed between backfat thickness at weaning and weaning to first mating (parameter estimate = −0.124, SE (Standard Error) = 0.106, $n = 434$, $P > 0.2$), weaning to farrowing interval (estimate = −1.604, SE = 2.715, $n = 461$, $P > 0.5$) and probability of removal (estimate = 0.985, SE = 0.634, $n = 585$, $P > 0.1$). There was no main effect of backfat thickness on the probability of farrowing within 130 days from weaning, but backfat tended ($P < 0.1$) to interact with parity as shown in Figure 2. For first parity sows the probability increased with increased backfat thickness at weaning, whereas for sows older than second parity the reverse relation was observed. Litter size in the subsequent cycle was significantly influenced negatively by (estimate = −1.30, SE = 0.587, $n = 511$, $P < 0.05$) backfat thickness at weaning. This indicates that a change in backfat from e.g. 14–15 mm reduces next litter size with 0.1 piglets (backfat was transformed by natural logarithm).

Discussion

Backfat thickness at weaning

The average backfat thickness at weaning of 13 mm varying from 5 to 28 mm between sows is comparable with the results of an earlier Swedish study including 19 gilts housed outdoors and weaned at seven weeks of lactation (Björkner, 2003). The thickness of backfat varied substantially between the sows included in the present study. The overall variation between sows was 32%. This coefficient of variation is only slightly higher than previous findings in conventional sow herds with 3–4 weeks of lactation (Maes et al., 2004). However, in the organic sow herds the frequency distribution of backfat was not normally distributed, but skewed to the right, indicating a large proportion of thin sows. In fact, 30% of all sows had backfat thickness below 10 mm at weaning in the present study, which is markedly below recommended levels (Whittemore, 1996). The proportion of very thin sows is also considerably higher than in a recent study that included 14 conventional indoor sow herds (Kongsted et al., 2007). Across herds, the conventional sows ($n = 551$) had an average backfat thickness of 15 mm at weaning and only 12% of all sows had less than 10 mm backfat.

First to third parity sows had significantly less average backfat at weaning compared to sows older than third parity and 37% of all first to third parity sows had less than 10 mm backfat at weaning compared to only 20% among older sows. These findings support previous reports (Grandinson et al., 2005) that the loss of body fat in lactation is especially high in young sows which have to maintain both body growth and milk production and also have a lower voluntary feed intake compared to older sows (Anonymous, 2006). These results emphasise how important it is to focus on the young sows if the incidence of poor body condition at weaning is to be reduced in organic sow herds.

The Duroc breed and its crosses are common in outdoor production because of their robust character (Guy & Edwards, 2002; Edwards, 2005). The results of the current study may indicate that Duroc crosses are more suitable for outdoor production because they have significantly more backfat at weaning than the crosses of Landrace and Yorkshire. This is in accordance with Heyer et al. (2005) who hypothesised that the lower weight loss during lactation is due to a lower litter size, as also found in the current study, in addition to a higher feed consumption during lactation. The higher backfat at weaning together with a higher growth rate before (Heyer et al., 2005) and after weaning (Stern et al., 2003) in Duroc crosses might counteract the potential negative impact on the production economy caused by lower litter sizes.

Herds 1 and 4, which had by far the highest average backfat thickness at weaning (17.3 and 14.1 mm, respectively), represented lactation lengths of 10 and 7 weeks, respectively. These results confirm that the required lactation length for organic production in Denmark does not necessarily provoke low fat reserves at weaning. In addition, no negative relation was observed between lactation length and body condition at weaning in the current study where 90% of all sows had lactation lengths between 44 and 69 days. The lack of relation indicates that the sows do not mobilise further body reserves if the weaning age increases from seven to e.g. 10 weeks of age in outdoor production like the current where the sows have the ability to get away from the piglets. This is probably because the nursing frequency (Wallenbeck et al., 2008) and milk production (Walker & Young, 1992) have already decreased markedly after 5–6 weeks coinciding with an increase in the piglets' intake of solid feed (Pajor et al., 1999; Damm et al., 2003). Heyer et al. (2005) similarly observed that sows housed outdoors had a significant loss of backfat from farrowing to five weeks in lactation, but even had a small gain in backfat from five weeks to weaning four weeks later.

The results indicate that the apparently poorer body condition in organic production compared to conventional indoor production cannot exclusively be explained by the later weaning in organic sow herds. It may, however, be explained by differences in the environment. In previous experimental studies, sows housed outdoors during the suckling period lost significantly more backfat (Wülbers-Mindermann et al., 2002) and body weight (Oldigs et al., 1995) during lactation compared to sows housed indoors, although the lactation lengths were identical (5–6 weeks in both studies). In addition, Wülbers-Mindermann et al. (2002) report that piglets reared outdoors have significantly higher growth rates compared to piglets reared indoors. Based on these outcomes they suggest that the outdoor environment may stimulate the sows to invest more of their body energy into the rearing of their offspring in terms of higher nursing frequency causing heavier piglets at weaning but also higher backfat losses in the sows.

Reproduction performance

The group with prolonged weaning to farrowing interval includes sows with prolonged weaning to first service interval and sows returning to oestrus because of conception failure or embryonic death. The proportion of sows with "normal" weaning to farrowing intervals (sows farrowing within 130 days after weaning) varied markedly between the organic herds from 42 to 86%. The two herds that practised uncontrolled outdoor mating (herds number 1 and 2) had the lowest average proportions of "normal" sows and also the smallest average litter sizes. In uncontrolled mating systems there is no control of the individual mating because the copulations take place with no or little supervision. In herd number 1, one boar was introduced to a group of 4–10 lactating sows to induce lactational ovulations. If many of the sows show lactational oestrus within a few days, the boar might become overworked. This heightens the risk of low conception rates and litter sizes due to a low sperm count (Frangez et al., 2005). If these two herds are excluded, the average total litter size was 14.1 born piglets per litter. This is 0.5 piglets less per litter compared to Danish conventional pig production, which is primarily based on artificial insemination (Jultved, 2006). The number of potential litters per sow per year is of course lower in organic production compared to conventional production due to the prolonged weaning age. The farrowing to farrowing interval was in average 180 days in the present study. This corresponds to 2.02 produced litters per sow per year. In conventional production the sows produce an average 2.24 litters per year (Jultved, 2006).

In the six herds that practised artificial insemination it was possible to calculate the rate of services (first services and re-services) that resulted in a farrowing within 125 days. The average percentage of services followed by a farrowing was 83 in the present study. This is markedly higher than the farrowing rate of 74% previously found in four Danish organic sow herds (Lauritsen et al., 2000) but corresponds with the farrowing rate of 85% reported from conventional production in Denmark (Jultved, 2006).

Sows older than third parity had a significantly lower chance of farrowing within 130 days after weaning compared to younger sows. This is in accordance with Koketsu et al. (1997), who found that the proportion of sows that did not farrow had a tendency to increase as parity increased. Some of this can probably be related to the significantly higher risk of removal for sows older than third parity observed in the current study. The increase in total litter size from parity 1 (i.e. sows giving birth to their second litter) to parity 2 (i.e. sows giving birth to their third litter) followed by a plateau and subsequent decrease in litter size is well-documented (Dewey et al., 1995; Hughes, 1998) and may be caused by changes in ovulation rate and uterine capacity with increasing parity (Tummaruk et al., 2000).

Seasonal infertility has been recognised as a common problem in the pig industry in e.g. Finland (Peltoniemi et al., 1999), Australia (Love et al., 1995) and the UK (Reilly & Roberts, 1992). In the current study, the season in which weaning occurred affected all the reproduction traits except for removal rate. Weaning to farrowing interval was significantly longer and litter sizes were significantly smaller if the weaning took place in July to September. The summer and early autumn has previously been associated with reduced fertility in the Nordic countries (Peltoniemi et al., 1999; Tummaruk et al., 2000). This period corresponds to the non-breeding season of the wild sow in Northern Europe (Meynhardt, 1990). Photoperiod has been suggested as a more likely trigger of seasonal infertility than high ambient temperatures in the Nordic countries (Peltoniemi et al., 1999, Tummaruk et al., 2000).

Lactation lengths of seven weeks or more increases the probability of lactational ovulations which may cause prolonged and unsynchronised weaning-to-oestrus intervals in herds based on post-weaning services (Rydhmer et al., 2005; Hulten et al., 2006). In the three herds with controlled services the first four weeks after weaning it was possible to calculate the proportion of sows mated within the first week after weaning. The proportion varied from 90 to 96%. This is higher compared with levels from conventional pig herds with lactation lengths of 4–5 weeks (Pedersen & Thorup, 1995) and indicates no serious problem with lactational ovulations in the herds. This might be due to the individual housing of the lactating sows since individual housing decreases the probability of ovulation during lactation compared to group-housing (Alonso-Spilsbury et al., 2004).

Relation between backfat thickness and reproduction

Overall, there were no strong relations between backfat thickness at weaning and the subsequent reproduction, indicating that other factors such as mating procedure are more important for reproductive results in organic sow herds. The probability of a successful reproduction after weaning did, however, tends to decrease with decreasing backfat at weaning for first parity sows. This confirms that the reproduction performance is more sensitive to backfat thickness at weaning in first parity sows than in older sows, as also proposed by Whittemore and Morgan (1990) and previously found in conventional sow herds (Kongsted, 2006).

Surprisingly, a negative relation was found between backfat thickness at weaning and the following litter size. This is probably not due to an effect of body condition at weaning on the subsequent litter size but rather an effect of litter size on the body condition at the subsequent weaning. Sows with large litters at birth (and thereby genetically predisposed to large litter sizes – also in the next parity) lose more weight during lactation, and hence, are at higher risk of reduced backfat at weaning compared to sows with small litters. High repeatability of litter size between two successive parities is well-documented (Hughes, 1998).

Low fat reserves at weaning have previously been associated with the higher risk of culling, primarily due to reproductive failures (Young et al., 1990; Kongsted, 2006). In this study no significant relation was found between backfat thickness at weaning and the risk of removal due to reproduction failures in the non-lactating period. Any possible relation between low backfat thickness at weaning and risk of removal might have been blurred due to a very "light" removal policy in the two largest herds (herds 3 and 8) because they were expanding the production volume and therefore kept as many sows as possible in the herd.

Conclusions

The average backfat thickness at weaning was 13 mm across herds, ranging at herd level from 10.5 to 17.3 mm. The larger variation between herds shows that it is possible to avoid poor body condition at weaning even with a lactation length of seven weeks or more. Almost all reproduction traits showed a large variation between farms. Average litter sizes at herd level varied e.g. from 12.3 to 14.8 total born piglets per litter with an overall average of 13.7 piglets per litter. Overall, there were no strong relations between backfat thickness at weaning and the subsequent reproduction, indicating that other factors such as mating procedure are more important for reproduction results in organic sow herds. The probability of a successful reproduction after weaning did, however, tends to decrease with decreasing backfat at weaning for first parity sows.

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References

Alonso-Spilsbury, M., Mayagoitia, L., Trujillo, M. E., Ramirez-Necoechea, R. , & Mota-Rojas, D. (2004). Lactational estrus in sows, a way to increase the number of farrowings per sow per year. *Journal of Animal and Veterinary Advances*, *3*, 294–305.

Andersen, L., Jensen, K. K., Jensen, K. H., Dybkjær, L., & Andersen, B. H. (2000). Weaning age in organic pig production. In J. E. Hermansen, V. Lund and E. Thuen (eds.) *Ecological Animal Husbandry in the Nordic Countries*, DARCOF Report 2. Danish Research Centre for Organic Farming, Denmark. pp. 119–124.

Anonymous (2006). Grosser Folgewurf bei hohem Futterverzehr. *SUS*, *1*, 38–39.

Björkner, S. (2003). *Nursing Behaviour of Sows in Outdoor Production. Examensarbete 255* (Institutionen för Husdjursgenetik, SLU, Sweden), pp. 1–29.

Bonde, M., & Sørensen, J. T. (2003). Control of health and welfare problems in organic sow herds. *DARCOFenews*. Danish Research Centre for Organic Farming, Denmark. 3, 4.

Charette, R., Bigras-Poulin, M., & Martineau, G-P. (1996). Body condition evaluation in sows. *Livestock Production Science*, *46*, 107–115.

Damm, B. I., Pedersen, L. J., Jessen, L. B., Thamsborg, S. M., Mejer, H., & Ersbøll, A. K. (2003). The gradual weaning process in outdoor sows and piglets in relation to nematode infections. *Applied Animal Behaviour Science*, *82*, 101–120.

Danish Plant Directorate (2008). Danish Research Centre for Organic Farming, Denmark. Available at: http://www.netpublikationer.dk/FVM/8774/pdf/Bedrifts_vejledning_version_15_010408a.pdf. (Accessed 20 December 2008), (in Danish).

Dewey, C. E., Martin, S. W., Friendship, R. M., Kennedy, B. W., & Wilson, M. R. (1995). Associations between litter size and specific sow-level management factors in Ontario swine. *Preventive Veterinary Medicine*, *23*, 101–110.

Dybkjær, L. (1992). The identification of behavioural indicators of 'stress' in early weaned piglets. *Applied Animal Behaviour Science*, *35*, 135–147.

Edwards, S. A. (2005). Product quality attributes associated with outdoor pig production. *Livestock Production Science*, *94*, 5–14.

Frangez, R., Gider, T., & Kosec, M. (2005). Frequency of boar ejaculate collection and its influence on semen quality, pregnancy rate and litter size. *Acta Veterinaria Brunensis*, *74*, 265–273.

Grandinson, K., Rydhmer, L., Strandberg, E., & Solanes, F. X. (2005). Genetic analysis of body condition in the sow during lactation and its relation to piglet survival and growth. *Journal of Animal Science*, *80*, 33–40.

Guy, J. H., & Edwards, S. A. (2002). Consequences for meat quality of producing pork under organic standards. *Pig News and Information*, *23*, 75N–80N.

Han, I. K., Bosi, P., Hyan, Y., Kim, J. D., Sohn, K. S., & Kim, S. W. (2000). Recent advances in sow nutrition to improve reproductive performance. Asian-Australas. *Journal of Animal Science*, *13*, 335–355.

Heyer, A., Andersson, K., Leufven, S., Rydhmer, L., & Lundström, K. (2005). The effects of breed cross on performance and meat quality of once-bred gilts in a seasonal outdoor rearing system. Archiv Tierzucht. *Dummerstorf*, *48*, 359–371.

Hughes, P. E. (1998). Effects of parity, season and boar contact on the reproductive performance of weaned sows. *Livestock Production Science*, 54, 151–157.

Hulten, F., Wallenbeck, A., & Rydhmer, L. (2006). Ovarian activity and oestrous signs among group-housed, lactating sows: Influence of behaviour, environment and production. *Reproduction in Domestic Animals*, *41*, 448–454.

Jultved, C. R. (2006). *Rapport over P-rapporternes resultater oktober 2006*. (Report of results from P-reports October 2006). Dansk Svineproduktion, notat nr. 0627.

Koketsu, Y., Dial, G. D., & King, V. L. (1997). Returns to service after mating and removal of sows for reproductive reasons from commercial swine farms. *Theriogenology*, *47*, 1347–1363.

Kongsted, A. G. (2006). Relation between reproduction performance and indicators of feed intake, fear and social stress in commercial herds with group-housed non-lactating sows. *Livestock Science*, *101*, 46–56.

Kongsted, A. G., Hermansen, J. E., & Kristensen, T. (2007). Relation between parity and feed intake, fear of humans and social behaviour in non-lactating sows group-housed under various on-farm conditions. *Animal Welfare*, *16*, 263–266.

KRAV (2008). Available at: http://www.krav.se/Documents/Regler/englishEditions/Standards_July_2008.pdf (Accessed 12 December 2009).

Larsen, V. A., & Jørgensen, E. (2002). Reproductive performance of outdoor sow herds. *Livestock Production Science*, *78*, 233–243.

Lauritsen, H. B., Sørensen, G. S., & Larsen, V. A. (2000). Organic pig production in Denmark. In J. E. Hermansen, V. Lund and E. Thuen (eds.) *Ecological Animal Husbandry in the Nordic Countries*, Section I: Soil, Water and Environment, Swedish University of Agricultural Sciences, DARCOF Report 2, Nordic Association of Agricultural Scientists (NJF), Denmark. pp. 113–118.

Littell, R. C., Milliken, G. A., Stroup, W. E., & Wolfinger, R. D. (1996). *SAS® System for Mixed Models* (p. 633). Cary, NC: SAS Institute.

Love, R. J., Klupiec, C., Thornton, E. J., & Evans, G. (1995). An interaction between feeding rate and season affects fertility of sows. *Animal Reproduction Science*, *39*, 275–284.

Maes, D. G. D., Janssens, G. P. J., Delputte, P., Lammertyn, A., & de Kruif, A. (2004). Backfat measurements in sows from three commercial pig herds: Relationship with reproductive efficiency and correlation with visual body condition scores. *Livestock Production Science*, *91*, 57–67.

Meynhardt, H. (1990). *Schwarzwild-Report. Mein Leben Unter Wildschweinen*. (Leipzig, Radebeul, Germany: Neumann Verlag), p. 221.

Oldigs, V. B., Link, M., Baulain, U., & Kallweit, E. (1995). Untersuchungen zur Tiergerechtheit der Ferkelproduktion in einer Aussenhaltung. 1. Mitteilung: Bewertungen nach Leistungen, Technopathien und physiologischen Reaktionen. *Züchtungskunde*, *67*, 230–244.

Pajor, E. A., Weary, D. M., Fraser, D., & Kramer, D. L. (1999). Alternative housing for sows and litters. 1. Effects of sow-controlled housing on responses to weaning. *Applied Animal Behaviour Science*, *65*, 105–121.

Pedersen, P. N., & Thorup, F. (1995). *Analyse af besætningens reproduktionsresultater I bedriftsløsningens rapportgenerator* (Dansk Svineproduktion: Faglig publikation), Notat 9524, p. 21.

Peltoniemi, O. (1999). Seasonal manifestations in reproduction in gilts and sows: Experimental and epidemiological studies. Report, pp. 1–48.

Peltoniemi, O. A. T., Love, R. J., Heionen, M., Tuovinen, V., & Saloiemi, H. (1999). Seasonal and management effects on fertility of the sow: A descriptive study. *Animal Reproduction Science*, *55*, 47–61.

Reilly, J. D., & Roberts, A. J. (1992). An investigation into summer infertility in a commercial pig unit. *Pig Veterinary Journal*, *27*, 157–168.

Rydhmer, L., Wallenbeck, A., & Hultén, F. (2005). Reproduction and maternal behaviour in organic piglet production. *NJF Seminar 369*, 15–17 June 2005 (Alnarp, Sweden), pp. 207–210.

SAS Institute Inc (1990). *SAS/STAT® User's Guide*, SAS Institute, (Gary, NC).

Stern, S., Heyer, A., Anderson, H. K., Rydhmer, L., & Lundström, K. (2003). Production results and technological meat quality for pigs in indoor and outdoor rearing system. *Acta Agriculturae Scandinavica – Section A, Animal Science*, *53*, 166–174.

Tummaruk, P., Lundeheim, N., Einarsson, S., & Dalin, A-M. (2000). Reproductive performance of purebred Swedish landrace and Swedish Yorkshire sows: I. Seasonal variation and parity influence. *Acta Agriculturae Scandinavica – Section A, Animal Science*, *50*, 205–216.

Walker, B., & Young, B. A. (1992). Modelling milk yield, milk components and body composition changes in the lactating sow. *Livestock Production Science*, *30*, 347–360.

Wallenbeck, A., Rydhmer, L., & Thodberg, K. (2008). Maternal behaviour and performance in first-parity outdoor sows. *Livestock Production Science*, *116*, 216–222.

Whittemore, C. T. (1996). Nutrition reproduction interactions in primiparous sows. Review. *Livestock Production Science*, *46*, 65–83.

Whittemore, C. T., & Morgan, C. A. (1990). Model components for the determination of energy and protein requirements for breeding sows: A review. *Livestock Production Science*, *26*, 1–37.

Wülbers-Mindermann, M., Algers, B., Berg, C., Lundeheim, N., & Sigvardsson, J. (2002). Primiparous and multiparous maternal ability in sows in relation to indoor and outdoor farrowing systems. *Livestock Production Science*, *73*, 285–297.

Young, L. G., King, G. J., Shaw, J., Quinton, M., Walton, J. S., & McMillan, I. (1991). Interrelationships among age, body weight, backfat and lactation feed intake with reproductive performance and longevity of sows. *Canadian Journal of Animal Science*, *71*, 567–575.

Young, L. G., King, G. J., Walton, S., McMillan, I., Klevorick, M., & Shaw, J. (1990) Gestation energy and reproduction in sows over four parities. *Canadian Journal of Animal Science*, *70*, 493–506.