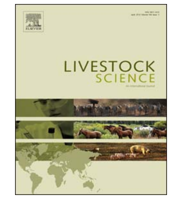
Livestock Science 209 (2018) 73–76

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci



Short communication

Litter size of Danish crossbred sows increased without changes in sow body dimensions over a thirteen year period

S.E. Nielsen[a], A.R. Kristensen[a], V.Aa. Moustsen[b,*]

[a] Department of Veterinary and Animal Sciences, University of Copenhagen, Grønnegårdsvej 2, DK-1870 Frederiksberg C, Denmark
[b] SEGES, Danish Pig Research Centre, Axeltorv 3, DK-1609 Kbh. V., Denmark

ARTICLE INFO

Keywords:
Sow body dimension
Sow welfare
Litter size

ABSTRACT

The purpose of this study was to investigate if body dimensions of Danish crossbred sows (Yorkshire x Landrace) had increased compared to a previous Danish study from 2004. In addition, and as an expected potential benefit of increased body dimensions, a potential correlation between body dimensions and litter size was also investigated. Depth, width, length and height were measured from 405 Danish crossbred sows in 10 different herds, classified in groups of parity 1, 2, 3, 4, 5, 6 and ≥ 7. By Linear Mixed-Effects Models with depth, width, length and height in turn as response variable and parity and herd as explanatory variables, estimated means, 5th and 95th percentiles, minimum and maximum observation were recorded. Furthermore, a weighted index for litter size (denoted as the "litter size potential") was used as response variable with depth, width, length, height and parity as explanatory variables in an additive linear model. The factors were removed individually and in combination to test the effect. Mean depth, width, length and height were estimated to 66, 43, 192 and 90 cm, respectively, for full grown sows (parity ≥ 5). Sows' body dimensions were not found to have increased since 2004. The result of this study did not find significant ($P < .05$) effect of sow dimensions on litter size.

1. Introduction

A general perception that sow body dimensions have increased over time (Miljø- og Fødevareministeriet, 2017; Pedersen et al., 2013) has been expressed by The Danish Veterinary and Food Administration by a campaign launched in May 2017 (Fødevarestyrelsen, 2017). The campaign is focusing on welfare consequences of undersized crates due to increased body dimensions of Danish sows. The Danish quality program, DANISH Product Standard, did report 0.5% of the inspected herds in 2016 had one or more sows that were too long to fit in the crate (Nielsen, 2017).

Dimensions of sows are not only relevant to keep a good standard of welfare; it is also relevant in the aspect of developing new crates and reconsidering recommendations of crate, stall and pen dimensions.

Whereas it seems to be perceived that sow dimensions have increased since 2004, it is a well-known fact that litter size has increased considerably over the same years. Thus, in 2004 the average litter size (total born), registered for 1934 crossbred Danish sows (Yorkshire x Landrace) in parity 1–10 was 14.6 (The National Committee for Pig Production, 2004). In 2016, the litter size had increased to 18.0 on average (Helverskov, 2017). In other words, litter sizes had increased with 3.4 piglets' pr. litter over a period of 12 years.

The increase in litter size is a result of systematic breeding and if there is any correlation between body dimensions and litter size, a side effect of breeding for litter size would be larger sows. Therefore, a potential correlation between body dimensions and litter size was also investigated in this study.

Bono et al. (2012) developed a litter size model where a sow effect (in the following denoted as the "litter size potential") is estimated relative to the parity specific herd average. It summarizes all observed litter sizes of a sow as a single index. Thus, a hypothesis of this study is that there is a positive correlation between the litter size potential and body dimensions. Use of the litter size potential ensures that it is a comparison within herd and also that the random variation in individual litter size results is, to some extent, filtered away. In general the litter size potential denotes the relative, within herd, ability for the sow to produce piglets.

The objective of this study was to determine whether the dimensions of Danish crossbred sows have increased since 2004 (Moustsen et al., 2011) in order to evaluate need for adjusted feeding regimes, avoid welfare problems due to undersized crates and to test the hypothesis that litter size is correlated to body dimensions.

* Corresponding author.
E-mail address: vam@seges.dk (V.A. Moustsen).

https://doi.org/10.1016/j.livsci.2018.01.015
Received 26 July 2017; Received in revised form 21 January 2018; Accepted 22 January 2018

Table 1
Overview of the herds included in the study.

	Herd										
	Overall	1[a]	2[a]	3[a]	4[a]	5[a]	6[a]	7[a]	8[a]	9[a]	10
Sows included, no	405	40	37	40	49	40	40	40	39	40	40
Average days between farrowing and measuring	8.8	9.5	8.2	8.8	10.5	7.7	8.1	7.2	8.9	9	9.9
Average piglets when measured	12.8	12.3	12	11.9	14.1	15.2	12.9	13.2	12.0	12.2	11.4
Average parity	3.1	2.4	3.4	3.1	2.9	3.2	2.2	3.5	3.6	3.3	4.1
Parity 1	114	13	9	9	18	10	22	9	10	7	7
Parity 2	72	11	6	6	8	9	5	7	7	9	4
Parity 3	58	8	5	7	4	3	5	7	3	10	6
Parity 4	59	4	7	10	7	8	3	5	3	4	7
Parity 5	41	4	5	7	6	4	2	2	6	2	3
Parity 6	32	–	2	–	3	4	3	6	6	4	4
Parity ≥ 7	30	–	3	1	3	2	–	4	4	4	9

[a] Herds included in the litter size potential study.

2. Materials and methods

2.1. Sows and herds

Body dimensions of 405 crossbred Danbred sows in 10 different herds were measured (Table 1). The sows were from 1 to 10th parity and were measured approximately one week after farrowing. All sows were crossbred Yorkshire × Landrace. Production databases from herds with notation "a" in Table 1 were used to calculate the litter size profile individually for each sow in the respective herd.

Depth, width and height were measured with the same vernier caliper gauge as in 2004 (Moustsen et al., 2011), whereas length was measured using a carpenter ruler. All sows were measured standing in crates on a level surface. Additional to these measurements, the parity was registered for each sow. Depth was measured midway between front and hind legs in a vertical line from the back to under the udder at the ventral side of the body. Width was measured in a horizontal line from sinister to dexter, right over the shoulder. Height was measured in a vertical line from the floor to dorsal part of the body where the sow seemed to be highest. Length was measured in a horizontal line from snout to behind the sow. Measuring of length was repeated three times, and the average was recorded. All measurements were taken to nearest half centimeters and were carried out by agricultural engineers at SEGES.

All 10 herds were asked to send databases; 9 databases were received. By use of the software system known as SoLiv (PigIT, 2016) and production databases from herds, the litter size potential defined by (Bono et al., 2012) was calculated to estimate the potential of each sow individually. The litter size potential was estimated for 364 sows.

2.2. Statistical analysis

Data were analyzed using R statistics (R Core Team, 2016). Depth, length, width and height were by turn used as response variable. Herd and parity were used as explanatory variables. Herd and parity were unbalanced factors with 10 and 7 levels (1, 2, 3, 4, 5, 6, ≥ 7), respectively. In order to compare the present study with a previous study (Moustsen et al., 2011) a group of parity equal to or larger than 5 was constructed to compare dimensions of full grown sows. Parity was therefore also included as an unbalanced factor with 5 levels (1, 2, 3, 4, ≥ 5). Levels of the individual herds were not of interest in this study, and herd was therefore included in the model as a random effect. By use of the function `anova` a two-way mixed effects model and a two-way analysis of variance were compared to analyze whether an interaction between herd and parity was significant ($P < .05$). If interaction was non-significant ($P > .05$), a one-way analysis of variance and a two-way analysis of variance were compared to test the effect of herd. Model control by QQ-plot and residual plot were carried out for each of 8 final models.

The final mixed effects model when interaction between parity and herd was found to be significant ($P < .05$) was

$$Y_{ijk} = \mu + \alpha_j + B_k + C_{j\times k} + e_{ijk}$$

where

$$i = 1, ..., 405, j = 1, ..., 7, k = 1, ..., 10$$

- Y_{ijk} was the response variable for observation of sow i in parity j and herd k.
- μ is a general intercept.
- α_j is a systematic effect of parity j.
- $B_k \sim N(0, \sigma_B^2)$ is a random effect of herd k.
- $C_{j\times k} \sim N(0, \sigma_C^2)$ is a random interaction between parity j and herd k.
- $e_{ijk} \sim N(0, \sigma^2)$ is a random residual.

Final models were fitted as Linear Mixed-Effects Models from the package `nlme`(Pinheiro et al., 2017) used to estimate mean with related standard error. The 5th and 95th percentiles were found by use of the function `quantile` (R Core Team, 2016). The minimum and maximum observation for each group of parity was found by using the function `summaryBy`(Højsgaard and Halekoh, 2016) with e.g. depth as response and parity as explanatory variable. By use of the function `contrast` (Kuhn et al., 2016) comparison between groups were made.

The litter size potential was based on the entire litter size history of the sow, and it is expressed relative to the herd average. A herd specific litter size model suggested by Bono et al. (2012) was used to estimate the litter size potential, M_{ij}, of sow i in parity j:

$$\Gamma_{ij} = \mu_j + M_{ij} + e_{ij},$$

where:

- Γ_{ij} denotes the observed litter size for sow i at parity j in the herd.
- μ_j is the herd specific average litter size at parity j.
- $M_{ij} \sim N(0, \sigma_M^2)$ is the litter size potential of sow i at parity j. It is modeled as a first order autoregressive time series so that $M_{ij} = \rho M_{i,j-1} + \epsilon_{ij}, where \epsilon_{ij} \sim N(0, (1-\rho^2)\sigma_M^2)$ and the autoregressive coefficient ρ is a number close to, but less than, 1.
- $e_{ij} \sim N(0, \sigma^2)$ is a random term.

The herd averages, μ_j, as well as the litter size potential of each sow, M_{ij}, were estimated from the litter size records in the production databases of the herds. All values were estimated by use of the Kalman filter technique developed by Bono et al. (2012). The technique has been implemented in a software system known as SoLiv (PigIT, 2016). Analysis of litter size potential was carried out with litter size potential as response variable and depth, width, length, height and/or parity as