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How big is a pig? Relationship between size and age of modern hyper-prolific crossbred sows

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Abstract

An animal’s physical size and the space it takes up when moving between postures are fundamental to the design of systems for housing, handling and transport. The size of sows is particularly important as they are usually kept in close confinement systems for part of their lives or are being fed in feed stations or feed stalls. In addition, design of pens for loose farrowing sows require knowledge of sow dimensions. Sows have become larger during the last 25 years in response to genetic selection, and size varies between breeds, so information on body dimensions needs to be breed specific and up to date. Danbred exports more than 150,000 gilts a year, making dimensions of Danish sows relevant to the pig industry across the world. Body dimensions of 322 Danbred crossbred (Landrace × Large White) sows between parity 1 and parity 9 from three different herds in Denmark were measured in late gestation. The measurements included weight, height (from floor to back, 30 cm in front of the tail root), width (at the shoulders), length (snout to tail root) and depth (of the body from back to belly in the middle section between front and hind legs). As expected the size of the sows increased with parity (age): Length, depth and height increased significantly up to parity 4, width and weight increased up to parity 5. A full-grown (parity 5 or older) sow had mean (95th percentile) measurements of 193 (202) cm long, 90 (96) cm high, 66 (72) cm deep, 44 (48) cm wide and a mean weight of 317 (359) kg. These measurements are among the largest reported for any breed. On the basis of these measurements, together with information on sow movements, we recommend that if a crate is to be used for farrowing, then crates for the current Danbred sows should be longer than the sow: at least 250 cm including the trough (210 cm excluding trough). The width of the farrowing crate should allow the sow as much space as possible without being able to turn around- at least 65 cm wide at the front and hinged opening to 90 cm wide at the rear. These recommendations ensure that all but the largest of sows can rise and lie down easily.

Keywords: Body dimensions, morphometry, housing design, animal welfare
1. Introduction

For captive animals, knowledge of the physical size of an animal and the space it occupies in different postures is fundamental to the design of housing and of equipment for animal handling and transport (Dawkins and Hardie, 1989; Ellerbrock and Knierim, 2002; Ceballos et al., 2004) (Petherick and Phillips, 2009). Such information needs to be updated regularly for animals undergoing genetic selection: ongoing selection for rapid growth, efficiency and leanness in finisher pigs has resulted in a concomitant increases in the mature size of breeding stock (Whittemore, 1994) as reported by McGlone et al (2004).

In most parts of the world, sows in intensive systems are closely confined in crates for farrowing and lactation and in stalls for mating and pregnancy. Confinement of sows in systems which are too small results in restriction of movement, injuries and other welfare problems. Space restriction in crates results in less time spent standing and being active (Anil et al., 2002; Anil et al., 2006; Li and Gonyou, 2007) and it takes larger sows longer to perform posture changes (Anil et al., 2002). When sows are given the opportunity to choose they prefer wider crates, especially around the time of farrowing (Phillips et al., 1992). Based on observations of sows movements, Baxter and Schwaller (1983) found that a 238 kg sow makes use of 50 cm in length and 40 cm in width in addition to her own size in order to rise and lie down freely.

Due to welfare concerns, stalls will only be allowed to be used for the first four weeks after service from January 2013 in the EU (Council Directive 2008/120/EC, 2008), and EU policy makers are keeping loose-housed farrowing systems under review (EFSA, 2007). Although close confinement is currently allowed in the EU, there are limits: Council Directive 91/630/EEC (1991) which lays down minimum housing standards stipulates that pigs must be able to ‘lie down, rest and stand up without difficulty’ (Annex Chapter 1, paragraph 8). In the farrowing unit, sows must have enough room to lie laterally and expose the udder, allowing piglets access for suckling (Council Directive 91/630/EEC, Annex Chapter 3, paragraph 2).

The objective of the present study was to measure the size of Danish crossbred sows at a range of ages and to establish the relationship between parity number and size (as sows continue to grow beyond their first lactation; O’Connell et al., 2007), in order to inform the design of housing systems. We measured crossbred Danbred (Large White × Landrace) sows, which are a hyper-prolific breed. These sows represent the most common commercial genotype for maternal lines in Denmark. There is considerable international interest in this hyper-prolific genotype which is also increasingly being exported for use outside Denmark (e.g. in 2009/10 over 150,000- 1/3 of all Danbred hybrid breeding gilts were exported; PRC, 2010). In addition, increased pressure on litter size by other breeding companies may lead to similar increases in size of their sows. Our recent
practical experience on pig farms in Denmark shows that producers are beginning to report
problems with sows being too large to fit into their gestation stalls and farrowing crates, an issue
that has also been raised recently in the Danish media following a press release by the Danish
Veterinary and Food Administration (Ministry of Food, Agriculture and Fisheries) stating that in
more than half of 50 randomly visited herds they had found sows housed in crates that were too
small (Ministeriet for Fødevarer Landbrug og Fiskeri Fødevarestyrelsen, 2011), suggesting that an
update of the recommended dimensions for sow housing is timely.

2. Materials and methods

2.1 Animals

Body dimensions of 322 Danbred sows (Landrace × Large White) from parity 1 to 9 were
measured in three herds in Denmark. The three herds were selected because they represented
typical Danish sow herds using Danish genetics, crossbred sows and not having increased herd
size significantly in the years before. Due to low numbers of animals (n=46), parity 7, 8 and 9
sows were grouped together as “>= parity 7” for statistical analysis. The number of sows in each
parity that were measured (Table 1) does not represent the age distribution in the herds. A larger
survey based on 35,726 litters from 18 typical Danish herds suggested that typical age distribution
was as follows- parity 1: 23%, parity 2: 20%, parity 3: 17%, parity 4: 14%, parity 5+: 26%.

2.2 Measurement of Body Dimensions

Length, width, height and depth were measured when sows entered the farrowing unit. All traits
were measured when the sow was in a standing position on a level surface. Measuring tape,
folding rule and a specially developed calliper were used to determine body dimensions. The
measures were taken to nearest centimetre. Length was measured with the calliper as a straight
line from snout to tail. The sows were measured standing in a weighing scale, and the position of
the head was standardized with the snout forward. Depth was measured in the middle section of
the sows between front and hind legs from the dorsal to the ventral surface and can be used as an
estimate of the width of the sow’s body when lying (McGlone et al., 2004; O’Connell et al.,
2007). Width was measured at the shoulders. Height was measured from the floor to the dorsal
surface 30 cm in front of the tail root. Sow dimensions were only measured in late gestation,
because the sows are largest at this point (Curtis et al., 1989; O’Connell et al., 2007). Each sow
was weighed twice; when entering the farrowing unit and at weaning approximately four weeks
later, to assess weight change over the farrowing and lactation period. All measurements were
carried out by agricultural engineers.

2.3 Statistical analysis
Data were analyzed using generalized linear models (SAS 9.2, 2007) using length, width, height, depth and weight in turn as response variables. The growth of sows as they get older (increase in parity) is presented as estimated means (and standard error) for each litter. Means were generated using the lsmeans statement and separated with the pdiff option. Fixed main effects in the model included herd and parity. There was an effect of herd but no interaction between herd and parity.

In the statistical analysis, means were compared by Student's t-test.

3. Results

The measurements of sows overall and by parity are shown in Table 1. There was a significant effect of age (expressed as parity) on length up to parity 4 (p<0.01). Sows became significantly larger in depth (p<0.01) with each parity from parity 1 to parity 4. The width of sows changed significantly from parity 1 to 2 (p<0.05), and again from parity 3 to 5 (p<0.05), but the width did not increase significantly from parity 2 to parity 3. Sows increased significantly in height from parity 1 to 4 (p<0.01). Sows’ weight increased significantly from parity 1 to 5 (p<0.05). The sows lost a mean of 43 kg during a farrowing and lactation period.

In our sample, sows showed no increase in length, height and depth after their fourth litter and no increase in width after their fifth litter. So parity 5 or older sows can be described as full-grown.

Mean dimensions of a full-grown sow are shown in Table 1 and illustrated in Figure 1.

4. Discussion and recommendations

Compared to older measurements, sows have become larger over recent years. Table 2 compares mean, 95th percentile or maximum sow dimensions in the present study with five other studies in the literature. There is considerable variation in breed and country, making systematic comparisons between studies to identify clear time trends difficult. However, comparing like with like by contrasting the present study to a report on Danish sow dimensions (Fisker, 1994), shows that the modern Danish sows are heavier and longer than their ancestors.

Only the O’Connell et al (2007) study gives averages for each measurement by parity, enabling mature size to be compared: Measurements of the average fifth parity sow (and expressed as a % of a 5th parity sow in the present study) in the Irish study were: Weight 246 kg (78.1%), Height 89.2 cm (98.0%); Length 183.3 cm (95.0%), Width 40.0 cm (90.9%) and Depth 60.4 cm (91.5%; O’Connell et al., 2007). McGlone et al (2004) reported per parity was depth, where the average for a fifth parity sow was 61.2 cm (92.7%). Based on these figures it is evident that all the linear dimensions of fifth parity Danish sows exceed those of the Irish sows, with width and depth being almost 10% greater, and length around 5% greater, resulting in a difference of over 20% in weight.
In our study, sows increased in size in terms of height, length and depth until parity 4 and weight and width increased until parity 5, suggesting that mature size had been reached by parity 5 (Table 1, Figure 1). This is similar to earlier reports that body dimensions increase until parity 6 (McGlone et al., 2004; O’Connell et al., 2007).

Crates for farrowing and lactating sows were introduced in the 1950’s primarily for ease of management, hygiene and stockperson safety (Robertson et al., 1966). There is also evidence that they protect piglets from crushing during the first 72 hrs of life (Marchant et al., 2000). However, crates thwart the sows natural and highly motivated nest-building behaviour pre-farrowing (Phillips et al., 1992; Arey, 1997; Jarvis et al., 2002), prevent them from turning round to nose piglets and may lead to chronic stress during lactation (Jarvis et al., 2006). These sow welfare concerns are driving the development of crate-free farrowing systems which allow for the sows needs while also protecting piglets (Wechsler and Weber, 2007; Weber et al., 2007). The present information on sow dimensions is being used for this (Moustsen et al., 2007; Moustsen and Pedersen, 2009; Baxter et al., 2011).

Despite these problems for the sow, crates are currently the most widespread farrowing system globally (BPEX, 2004; EFSA, 2007; Johnson and Marchant-Forde, 2009). Based on measurements from this study and being mindful of the EU rule that pigs should be able to ‘lie down, rest and stand up without difficulty’ (Council Directive 2001/88/EC; Annex Chapter 1, paragraph 8), we recommend that if crates are to be used, then crate length for Danish crossbred sows should not be less than 250 cm long (57 cm longer than the average full-grown sows). In Denmark, the trough is conventionally mounted at floor level, providing space above it for sow movements, so this recommended length includes the trough (210 cm excluding trough).

In terms of crate width, we recommend that an adjustable crate at least 65cm wide, hinged to allow the rear to be opened up to 90cm wide should be provided and adjusted over time to follow the changing needs of sow and piglets. Before farrowing the sows are active, performing nest-building behaviour and the width of the crate should allow the sow as much space as possible without being able to turn around. In the hours just before the first piglet is born and for the first three-four days after farrowing, the sows spend 22-23 hours a day lying down and make very few posture changes. At the same time, the piglets are vulnerable. During this period, the crates can be narrowed to reduce risk of crushing. Three to four days after farrowing, the sow and piglets could be safely moved to a loose-housed system, or if remaining in crates, the crates can be opened up again to allow the sow as much space as possible without being able to turn around. The width will at any time therefore depend on size of the sow and her stage of lactation.
Finally, crate height is normally not a problem in Denmark, because the top is open in most cases, although based on our measurements crates should be at least 95 cm high (or 105 cm to suit the very largest sows). To ensure piglet’s easy access to the udder regardless of which side the sow is lying on, the size of the farrowing pen must be taken into consideration and when the sow is lying in lateral recumbency the distance from the udder to the pen side should be the length of a four week old piglet (approx. 56 cm, required by Council Directive 91/630/EEC 1991 Annex 3 chapter 2). In addition, Danish legislation requires that there shall always be at least 20 cm from the rear end of the crate to the back end of the pen, for the piglets to move freely behind the sow.

We have used the average size of a full-grown sow (Figure 1) as basis for recommending dimensions. This is because there would be practical difficulties with basing crate dimensions for all sows on the needs of the very largest sows. Crates are meant to ensure that the sows cannot turn around in the pen, so food and water can be provided at the head end, a solid floor where the sow is lying and a slatted floor where the sow is defecating and urinating. Thus, if crates are too wide, young sows and gilts may turn around, ending up hungry and thirsty and causing an unacceptable level of hygiene. Sows attempting to turn round or slide under the bars also risk getting stuck or injured (Baxter and Schwaller, 1983). In a recent study observing sows’ movements, we have confirmed that a crate with the dimensions we recommend here (210 cm long, 65 cm wide opening to 90 cm wide at the rear) will allow Danish sows to stand up and lie down, but prevents them from turning round (Moustsen and Duus, 2006). Basing our recommendations on the average full-grown sow ensures that the very largest sows will still have enough room to stand and lie in the crate, but their space requirements for making rising and lying down movements are not respected. If we assume that 26% of sows are parity 5+ (based on our data from 18 herds), then around 13% of sows will be larger than the average full-grown sow we have used as the design criterion. Farms could install some larger crates for their very largest sows, or could consider culling them.

Although this study was designed to address a specific need from pig producers for recommendations on increased farrowing crate dimensions, accurate information on sow dimensions is essential for designing all kinds of equipment such as non-crate farrowing systems, farrowing huts for outdoor sows, electronic feeders or individual feeding stalls for use in group-housing for dry sows, weigh crates and handling races, vehicles for road transport, and equipment for lairage and slaughter.

Acknowledgements
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References


Fisker, B.N., 1994. Boske skal være 190-200cm lange - det bør være en selvfølge (Sow stalls must be 190-200cm long- it should be obvious). In: Videncenter for SvineProduktion.


<table>
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<th>Dimension</th>
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<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>&gt;=7</th>
<th>Mean 5 to &gt;=7</th>
<th>Change 1 to 5</th>
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<tr>
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<td>287 (±2.4)</td>
<td>216 (±4.5)</td>
<td>261 (±3.1)</td>
<td>279 (±4.9)</td>
<td>299 (±3.9)</td>
<td>315 (±4.3)</td>
<td>320 (±4.2)</td>
<td>315 (±4.8)</td>
<td>317 (±2.6)</td>
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<td>Height (cm)</td>
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<td>226-309</td>
<td>226-346</td>
<td>263-330</td>
<td>270-357</td>
<td>272-368</td>
<td>260-368</td>
<td>266-359</td>
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<tr>
<td>Length (cm)</td>
<td>322 31 71 52 42 42 38 46</td>
<td>126</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Depth (cm)</td>
<td>55-71 50-61 55-67 57-69 61-71 59-74 59-73 59-71 59-72</td>
<td>10</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of sows (n)</td>
<td>322 31 71 52 42 42 38 46</td>
<td>126</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 1**: Sow dimensions by parity. Weight (kg) was measured in late gestation, when sows were moved into the farrowing house. Height (cm) was measured from the floor to the dorsal surface 30 cm in front of the tail root, length (cm) was measured from snout to tail, width was measured across the shoulders, depth (cm) was measured in the middle section between front and hind legs from the dorsal to the ventral surface. Each cell contains the **mean (±s.e.)** in bold, then the 5th-95th **percentiles** in italics, and below that the range in plain type.
<table>
<thead>
<tr>
<th>Year</th>
<th>1983¹</th>
<th>1989²</th>
<th>1994³</th>
<th>2004⁴</th>
<th>2007⁵</th>
<th>Present study</th>
</tr>
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<td>Denmark</td>
<td>USA</td>
<td>Ireland</td>
<td>Denmark</td>
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<td>Mean</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>184†</td>
<td>244.8</td>
<td>263‡</td>
<td>239.9</td>
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<td>287</td>
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<td>-</td>
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<td>89.4</td>
<td>88</td>
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<tr>
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<td>160.8</td>
<td>179‡</td>
<td>171.2</td>
<td>180.7</td>
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<td>42.9</td>
<td>40‡</td>
<td>40.4</td>
<td>40.2</td>
<td>42</td>
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<tr>
<td>Depth (cm)</td>
<td>-</td>
<td>-</td>
<td>69‡</td>
<td>60.5</td>
<td>63</td>
<td></td>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>352</td>
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<td>-</td>
<td>-</td>
<td>95</td>
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<td>200</td>
</tr>
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<tr>
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<td>360</td>
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<td>51.8</td>
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</tr>
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<td>78.0</td>
<td>80.0</td>
<td>78</td>
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</table>

**Table 2:** Comparison between sow dimensions reported in the literature and the present study, showing mean, 95th percentile and maximum value of weight (kg), height (cm), length (cm), width (cm) and depth. ¹Baxter & 1983, ²Curtis et al 1989, ³Fisker 1994, ⁴McGlone et al 2004, ⁵O’Connell et al 2007. A – indicates that the value was not reported in the study. McGlone et al 2004 and O’Connell et al 2007 reported the 95% Confidence interval but not the 95th Percentile.* indicates that this value did not appear in the paper but was estimated from weight using the allometric equations given. † indicates that the value was read from a graph. ‡ data from the oldest (4th parity) sows in this study was used.
Figure 1: Mean dimensions of a full-grown (parity 5 or more) Danish crossbred sow