The Sow Body Condition Caliper

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THE SOW BODY CONDITION CALIPER

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ABSTRACT. *Sows throughout the world are commonly fed to a subjective body condition target. Therefore, the objective of the study was to develop a fast and accurate, objective tool to measure sow body condition. A prototype caliper was developed to quantify the angularity from the spinous process to the transverse process of a sow's back. The sow caliper technology is based on the premise that as a sow loses weight, fat and muscle her back becomes more angular. The arms of the caliper were 3.8 cm tall and could be adjusted to 16.5, 21.6, 26.7, or 31.8 cm wide. Landrace × Large White gilts and multiparous sows (n = 315) were utilized to associate the caliper with weight, backfat, muscling, and visual body condition at commercial sow farms in eastern North Carolina. The caliper was evaluated at locations on the sow's back: behind the shoulder, middle of the back, and at the last rib. Sow weight was estimated and parity recorded. Backfat (BF) and loin depth (LD) were measured using an Aloka 500V SSD ultrasound machine. Visual body condition (BCS) was scored using a scale of 1 (thin) to 5 (over conditioned). Weight, BF, LD, and BCS explained 51% to 71% of the variation in caliper measures. Results suggest the optimal sow caliper width was 26.7 cm and measurements should be taken at the last rib. The sow body condition caliper is an objective tool that can be used by farmers to standardize sow body condition.*

Keywords. *Backfat, Body condition, Caliper, Sow, Weight.*

Sows are commonly fed during gestation based on a subjective body condition target (Young et al., 2004). Yet, visual sow body condition scores typically have low associations with sow backfat (Esbenshade et al., 1986; Young et al., 2001; Maes et al., 2004). Both training subjective scorers and collecting multiple sow body condition measurements increase the association between visual condition scores with estimated body composition (Fitzgerald et al., 2009). However, the extra labor cost needed to collect additional subjective measures would be better spent on a fast and accurate objective measurement of sow body condition.

The perceived "ideal" target for sow body condition varies between individuals (Charette et al., 1996; Fitzgerald et al., 2009). These differences in opinion cause across herd variation in sow body condition. In other words, what is deemed as proper sow body condition in one herd may be viewed as under or over conditioned by another individual. This can increase both feed costs and animal well-being issues. Therefore, a cost effective, objective measure of sow body condition would allow for needed standardization across farms.

Sows that are not in proper body condition are more likely to have an animal well-being concern. Knauer et al. (2007a) reported multiple well-being traits related to feet, disease, and shoulder lesions were associated with poor sow body condition. Other authors have also reported associations between sow body condition and well-being traits. Davies et al. (1997), Ritter et al. (1999), Bonde et al. (2004), and Zurbrigg (2006) reported poor body condition was associated with increased shoulder lesions. Sows that are too thin have been associated with increased lameness (Bonde et al., 2004; Knauer et al., 2012) which reduces sow longevity (Knauer et al., 2007b). Overly conditioned sows have been reported to experience an increase in stepping behavior when lying down (Bonde et al., 2004). Knauer et al. (2007a) reported greater body condition was associated with increased rear heel lesions. The creation of cost-effective, objective body condition tools would enable producers to optimize feed costs and maximize sow well-being. Therefore, the objective of the study was to develop an objective tool to quantify sow body condition.

MATERIALS AND METHODS

Two studies were conducted to identify the caliper width and location that best describes sow weight, backfat, muscling, and visual body condition. Landrace × Large White (Smithfield Premium Genetics, Rose Hill, N.C.) gilts and multiparous sows (n=315) were measured within five weeks of breeding at two commercial sow farms in eastern North Carolina. A prototype caliper (fig. 1) was developed by the authors to quantify the angularity of a sow's topline from the spinous process to the transverse process. The tool is based on the concept that as an animal's back loses fat and muscle it becomes more angular (Edmonson et al., 1989). The arms of the caliper were 3.8 cm tall and could

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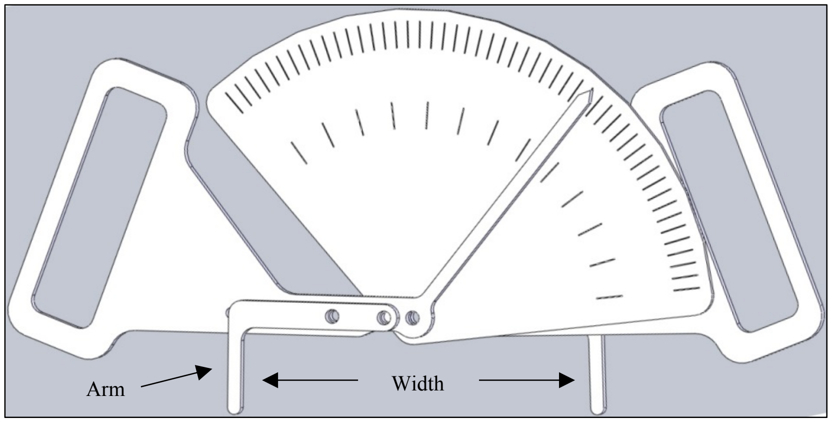

Figure 1. A prototype sow body condition caliper developed to quantify the angularity of a sow's topline from the spinous process to the transverse process. The arms of the caliper were 3.8 cm tall and could be adjusted to 16.5, 21.6, 26.7, or 31.8 cm width.

be adjusted to 16.5, 21.6, 26.7, or 31.8 cm width. The caliper was tested on three locations of the sow's back: behind the shoulder, middle of the back, and at the last rib. Due to labor restrictions, not all combinations of caliper widths and back locations were determined. However, all caliper widths were measured at the last rib. Measurements were captured: behind the shoulder at the 21.6 cm caliper width (SHOULDER21.6), in the middle of the back at the 26.7 cm width (MIDDLE26.7) and across the last rib at the 16.5, 21.6, 26.7, and 31.8 cm widths (LASTRIB16.5, LASTRIB21.6, LASTRIB26.7, and LASTRIB31.8, respectively).

STUDY 1

Commercial females (n=242) were used to associate caliper measures: SHOULDER21.6, MIDDLE26.7, LASTRIB16.5, LASTRIB21.6, and LASTRIB26.7 with estimates of sow body weight and composition. Sow weight was estimated from heart girth circumference using the equation by Iwasawa et al. (2004). Sow ear tag number and parity were recorded. Backfat (BF) and loin depth (LD) were measured from a cross sectional 10th rib image using an Aloka 500V SSD ultrasound machine (Corometrics Medical Systems Inc., Wallingford, Conn.). Evaluation of visual body condition score (BCS) was determined using a scale of 1 (thin) to 5 (over conditioned) by a trained technician.

STUDY 2

Commercial females (n=73) were used to associate caliper measures LASTRIB26.7 and LASTRIB31.8 with estimates of sow body weight and composition. Sow weight was recorded. As in Study 1, sow ear tag and parity were recorded and BF, LD, and BCS were measured. Descriptive statistics for Study 1 and Study 2 are shown in table 1.

STATISTICAL ANALYSIS

Data were analyzed in SAS (SAS Institute, Cary, N.C.). To identify the optimal caliper width and location, an analysis of variance procedure (PROC GLM) was used to estimate the percentage of variation (R^2) that weight, BF, LD, and BCS explained in the caliper. To identify associations between individual traits, Pearson correlations were calculated using the PROC CORR procedure. A value of P<0.05 was considered statistically significant in all tests.

Table 1. Descriptive statistics for Landrace × Large White females (n=315) from commercial sow farms.

	Study 1 (n = 242)		Study 2 (n = 73)	
Trait[a]	Mean	SD	Mean	SD
Weight (kg)	239	34.9	233	22.4
Backfat (cm)	2.7	0.73	2.3	0.57
Loin Depth (cm)	5.2	0.56	5.9	0.61
BCS	3.2	0.72	3.2	0.50
Parity	3.5	2.60	5.0	1.64
Caliper Measure (degrees)				
LASTRIB16.5	172	6.2		
SHOULDER21.6	149	6.9		
LASTRIB21.6	148	8.5		
MIDDLE26.7	137	7.1		
LASTRIB26.7	133	8.0	133	5.3
LASTRIB31.8			110	6.1

[a] BCS = body condition score 1 to 5 (1 = thin, 5 = over conditioned), LASTRIB16.5 = caliper measure across the last rib at the 16.5 cm width, SHOULDER21.6 = caliper measure behind the shoulder at the 21.6 cm width, LASTRIB21.6 = caliper measure across the last rib at the 21.6 cm width, MIDDLE26.7 = caliper measure across the middle of the back at the 26.7 cm width, LASTRIB26.7 = caliper measure across the last rib at the 26.7 cm width, LASTRIB31.8 = caliper measure across the last rib at the 31.8 cm width.

RESULTS

STUDY 1

The percentage of variation explained by weight, BF, LD, and BCS for LASTRIB16.5, SHOULDER21.6, LASTRIB21.6, MIDDLE26.7, and LASTRIB26.7 was 51%, 52%, 62%, 57%, and 71%, respectively. Correlations between sow body condition measures are shown in table 2. Sow weight was correlated (P<0.05) with LASTRIB16.5, SHOULDER21.6, LASTRIB21.6, MIDDLE26.7, and LASTRIB26.7 (0.15, 0.21, 0.34, 0.33, and 0.43, respectively). Yet, parity was not associated (P>0.05) with LASTRIB21.6, MIDDLE26.7, and LASTRIB26.7 (r=-0.03, -0.05, and -0.05, respectively). Backfat, LD, and BCS were correlated (P<0.05) with caliper measurements (r=0.50 to 0.60, 0.40 to 0.47, and 0.60 to 0.77, respectively).

Table 2. Correlations ±SE between sow body condition measures for Landrace × Large White females (n=242) from a commercial farm – Study 1.

	Backfat	Loin Depth	BCS	Parity	Caliper Measure[a]				
					LASTRIB16.5	SHOULDER21.6	LASTRIB21.6	MIDDLE26.7	LASTRIB26.7
Weight	0.33±.06	0.44±0.06	0.30±0.06	0.62±0.05	0.15±0.06	0.21±0.06	0.34±0.06	0.33±0.06	0.43±0.06
Backfat		0.08[b]±0.06	0.65±0.05	-0.02[b]±0.06	0.50±0.06	0.50±0.06	0.55±0.05	0.57±0.05	0.60±0.05
Loin Depth			0.25±0.06	0.32±0.06	0.40±0.06	0.41±0.06	0.45±0.06	0.43±0.06	0.47±0.06
BCS[c]				-0.04[b]±0.06	0.60±0.05	0.64±0.05	0.75±0.04	0.68±0.05	0.77±0.04
Parity					-0.20±0.06	-0.16±0.06	-0.03[b]±0.06	-0.05[b]±0.06	0.05[b]±0.06
LASTRIB16.5						0.72±0.04	0.85±0.03	0.83±0.04	0.82±0.04
SHOULDER21.6							0.70±0.05	0.76±0.04	0.73±0.04
LASTRIB21.6								0.85±0.03	0.91±0.03
MIDDLE26.7									0.92±0.03

[a] Caliper measures quantified the angularity from the spinous process to the transverse process of a sow's back; LASTRIB16.5 = measured across the last rib at the 16.5 cm caliper width, SHOULDER21.6 = measured behind the shoulder at the 21.6 cm caliper width, LASTRIB21.6 = measured across the last rib at the 21.6 cm caliper width, MIDDLE26.7 = measured across the middle of the back at the 26.7 cm caliper width, LASTRIB26.7 = measured across the last rib at the 26.7 cm caliper width.
[b] P>0.05.
[c] BCS = body condition score 1 to 5 (1 = thin, 5 = over conditioned).

Correlations between caliper measures ranged from 0.70 to 0.92. Among the caliper traits, LASTRIB26.7 was associated ($P<0.05$) with LASTRIB16.5, SHOULDER21.6, LASTRIB21.6, MIDDLE26.7, and MIDDLE26.7 (r=0.82, 0.73, 0.91, and 0.92, respectively).

STUDY 2

Weight, BF, LD, and BCS explained variation ($P<0.05$) in LASTRIB26.7 and LASTRIB31.8 (R^2=0.70 and 0.65, respectively). Correlations between sow body condition measures for Study 2 are shown in table 3. The caliper traits LASTRIB26.7 and LASTRIB31.8 were correlated ($P<0.05$) with sow weight (0.66 and 0.68, respectively), BF (0.62 and 0.59, respectively), LD (0.51 and 0.49, respectively), and BCS (0.76 and 0.72, respectively). Yet LASTRIB26.7 and LASTRIB31.8 were not associated ($P>0.05$) with parity (r=0.17 and 0.17, respectively). The correlation between LASTRIB26.7 and LASTRIB31.8 was 0.90.

DISCUSSION

The present study develops a novel, objective technology to quantify sow body condition. Since gestating gilts and sows are regularly fed based on a subjective body condition target, there is a need for fast and accurate technology to measure sow body condition. Farmers that implement objective body condition tools would reduce known BCS variation between individuals (Charette et al., 1996; Fitzgerald et al., 2009), optimize feed costs and ensure animal well-being. Thus, the sow body condition caliper (fig. 2) is an objective tool that can be readily utilized in the swine industry. Yet, the proposed sow caliper design may only work on modern genetic lines with similar skeletal size to those used in the current study. Perhaps genetic lines with a much smaller mature skeletal size would require a sow caliper with different dimensions, particularly width.

The current analysis used weight, BF, LD, and BCS to determine optimal caliper width and location. These traits were referenced because body condition is a composite trait

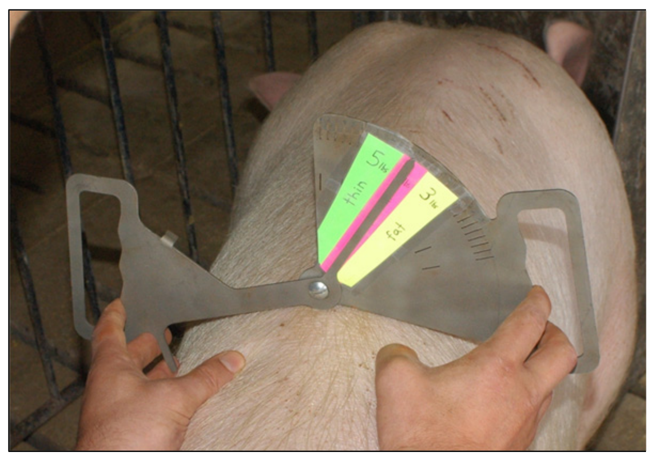

Figure 2. The sow body condition caliper quantifying the angularity from the spinous process to the transverse process at the last rib.

Table 3. Correlations ±SE between sow body condition measures for Landrace × Large White females (n=73) from a commercial farm – Study 2.

Trait	Backfat	Loin Depth	BCS	Parity	Caliper Measure[a]	
					LASTRIB26.7	LASTRIB31.8
Weight	0.57±0.10	0.44±0.11	0.64±0.09	0.47±0.10	0.66±0.09	0.68±0.09
Backfat		0.28±0.11	0.52±0.19	0.23[b]±0.12	0.62±0.09	0.59±0.10
Loin Depth			0.39±0.11	0.09[b]±0.12	0.51±0.10	0.49±0.10
BCS[c]				0.21[b]±0.12	0.76±0.08	0.72±0.08
Parity					0.17[b]±0.12	0.17[b]±0.12
LASTRIB26.7						0.90±0.05

[a] Caliper measures quantified the angularity from the spinous process to the transverse process of a sow's back; LASTRIB26.7 = measured across the last rib at the 26.7 cm caliper width; LASTRIB31.8 = measured across the last rib at the 31.8 cm caliper width.
[b] P>0.05.
[b] BCS = body condition score 1 to 5 (1 = thin, 5 = over conditioned).

of weight, backfat, and muscling (Wright and Russel, 1984). This is supported by results from the present study that show both BCS and caliper measures were correlated with weight, BF, and LD. Similar correlations between BCS with weight, backfat, and muscling were reported by Fitzgerald et al. (2009). In contrast to the methodology applied in the current study, several authors (Maes et al., 2004; Young et al., 2004; Fitzgerald et al., 2009) have used backfat as an objective measure of body condition. However in the current study and others (Knauer et al., 2007a; Schenkel et al., 2011) backfat is poorly correlated with muscling, an important component trait of body condition. Collectively, these results suggest body condition evaluation should account for both backfat and muscling.

Results from the current study showed the optimal caliper measure in relation to weight, BF, LD, and BCS was LASTRIB26.7. Yet, multiple caliper widths at the last rib (LASTRIB21.6 and LASTRIB31.8) produced results similar to LASTRIB26.7. Hence, the last rib was deemed the optimal caliper location. Perhaps the last rib was superior to behind the shoulder or the middle of the back because a more consistent anatomical location was available to locate the point of measurement. The authors acknowledge not all combinations of caliper width and caliper location were tested. Yet, assuming no interactions between caliper width and caliper location with body condition measures, sufficient combinations of caliper width and location were evaluated. Although results found LASTRIB26.7 to have the greatest association with body condition, high correlations between LASTRIB26.7 with LASTRIB21.6, MIDDLE26.7, and LASTRIB31.8 suggest multiple caliper widths and locations could successfully be used.

SUMMARY

The present study describes the development of a novel technology, the sow body condition caliper. The sow caliper describes substantial variation in sow weight, BF, LD, and BCS. The optimal sow caliper width was 26.7 cm and measurements should be taken at the last rib. Farmers should consider implementing the sow body condition caliper as an objective tool to standardize body condition for modern genetic lines. Future research with the sow body condition caliper should identify the "ideal" caliper angle in relation to reproductive performance.

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