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The effect of the body condition of late pregnant sows on fat reserves at farrowing and weaning and on litter performance

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Abstract

The objective of this study was to determine the effect of the body condition of late pregnant sows on fat reserves at farrowing and weaning, including the scale of the relevant changes in that period, and on the reproductive performance of sows and the results of piglet rearing.

The experiment involved 97 hybrid sows (Polish Large White × Polish Landrace [PLW×PL]) divided into two groups, according to backfat thickness: I – $(P_2+P_4)/2>20$ mm (10 primiparous, 36 multiparous) and II – $(P_2+P_4)/2\leq20$ mm (19 primiparous, 32 multiparous). It was carried out between pregnancy day 104 and weaning after 21 days of lactation. During late pregnancy, at weaning and at the end of lactation, the body weight of sows, fatness (points P_1, P_2, P_3, P_4) and *longissimus* muscle depth at point P_4M were determined. Feed consumption during lactation, reproductive performance traits and the results of piglet rearing were also analyzed.

Higher backfat thickness percentages and body weight noted in group I sows vs. group II sows ($P\leq0.001$) during late pregnancy were maintained at farrowing and weaning. At weaning, the values of *longissimus* muscle depth were significantly ($P\leq0.001$) higher in group II than in group I. The level of changes in fat reserves differed between late pregnancy and farrowing for P_4 ($P\leq0.01$) and $(P_2+P_4)/2$ ($P\leq0.001$); fat reserve loss was noted in group I, while an increase in adipose tissue was observed in group II. Body weight losses (%) during late pregnancy and at weaning were non-significant in sows of both groups. Based on feed consumption levels, group I sows were characterized by a lower appetite during lactation than group II sows. A regular trend in feed intake was noted in lactating sows of both groups: feed consumption increased in week 2, compared with week 1, while a decrease was noted in week 3 in comparison with week 2. Significant differences were reported in favour of group I vs. II ($P\leq0.05$) as regards the piglets stillborn, litter weight at weaning, the average piglet weight at weaning and placental weight. Multiparous sows as compared to primiparous sows were characterized by significantly ($P\leq0.05$) larger total number of piglets born and the number of piglets born alive. The difference in the litter weight at birth was found to be highly significant ($P\leq0.01$).

Keywords: pig, sows, body condition, backfat, litter size, litter weight

Zusammenfassung

Einfluss der Körperkondition von Sauen auf die Körperfettreserven bei Abferkelung und Ferkelabsetzen sowie auf die Wurfleistungen

Es sollte der Einfluss der Körperkondition auf die Fettreserven bei der Abferkelung und beim Ferkelabsetzen sowie auf die Wurfleistungen untersucht werden. Die Beobachtungen fanden an 97 Kreuzungssauen (Polnische Large White × Polnische Landrasse) vom 104. Trächtigkeitstag bis zum Absetzen der Ferkel am 21. Tag. statt. Nach ihrer Rückenspeckdicke erfolgte die Bildung von zwei Sauengruppen nämlich I $(P_2+P_4)/2>20$mm und II $(P_2+P_4)/2\leq20$mm. Am 104. Trächtigkeitstag, zum Zeitpunkt der Abferkelung und am 21. Laktationstag wurde das Körpergewicht und mittels Ultraschall die Rückenspeckdicke (P_1, P_2, P_3, P_4) sowie der Durchmesser des *M. longissimus dorsi* (P) ermittelt. Der Futterverbrauch während der Laktation und die Wurfleistungen wurden erfasst.

Signifikant größere Körpergewichte und Rückenspeckdicken der Sauen aus Gruppe I gegenüber Gruppe II fanden sich sowohl bei Abferkelung als auch zum Absetzzeitpunkt. In den Muskeldicken wiesen die Tiere der Gruppe II zum Absetzzeitpunkt höhere Werte auf. Zwischen Hochträchtigkeit und Abferkelung verringerte sich die Rückenspeckdicke bei Gruppe I während sie bei II signifikant zunahm. Keine Unterschiede zwischen den Gruppen gab es beim prozentualen Körpergewichtsverlust zwischen Hochträchtigkeit und Absetzen. Beim Futterverbrauch während der Laktation fand sich keine einheitlich Tendenz zwischen den Gruppen. Bezüglich der Wurfleistungen waren die sowohl die Alt- als auch die Jungsauen der Gruppe I gegenüber II in allen erfassten Merkmalen signifikant überlegen.

Schlüsselwörter: Schwein, Sau, Körperkondition, Rückenspeckdicke, Wurfgröße, Wurfgewicht

Introduction

The body condition of an animal, determined by the nutritional regime, is an indicator of physiological condition and a measure of performance. Body condition is determined with the use of linear and/or ultrasound methods (REKIEL *et al.* 2007, PATIENCE *et al.* 1995, JOHNSTON 1996, TODD SEE 1999, NEARY and YAGER 2002, WIDOWSKI *et al.* 2003 as cited in REKIEL and BEYGA 2008). Research results indicate that a visual assessment of body condition and backfat thickness measured *in vivo* are weakly interrelated, and the estimated correlation is 0.19 (YOUNG *et al.* 2001). The body condition of sows, determined mostly by fat and protein reserves, directly affects their performance throughout the entire production period (WÄHNER *et al.* 2001a). Inadequate environmental conditions have an adverse impact on the body condition of sows, leading to premature culling and increasing overall production costs (DEAN BOYD *et al.* 2002, YOUNG *et al.* 2004, ANIL *et al.* 2006).

The nutritional regime affects the reproductive traits and body condition of sows, as demonstrated by their body weight and fat reserves in different phases of the reproduction cycle, as well as changes in body protein and lipid content in each phase (KÄMMERER *et al.* 1998, GUEDES and NOGUEIRA 2001, WÄHNER *et al.* 2001b, YOUNG *et al.* 2004, CECHOVA and TVRDON 2006, McNAMARA *et al.* 2008a,b). The above changes as well as metabolic processes observed during lactation are of particular significance for reproduction results (PRUNIER *et al.* 2001, QUESNEL and PRUNIER 2005). Feed restriction during lactation increases protein and fat loss in sows, while *ad libitum* feeding minimizes the scale of the relevant loss (REVELL *et al.* 1998a, EISSEN *et al.* 2003).

Fatness at farrowing affects the rate of fat reserve depletion. Higher fat percentages before farrowing contribute to increased fat reserve depletion during lactation (ESTIENNE *et al.* 2000, WÜLBERS-MINDERMANN *et al.* 2002, YOUNG *et al.* 2004, REKIEL *et al.* 2007). During lactation, sows decrease their body weight by mobilizing energy reserves that support milk production (MULLAN and WILLIAMS 1989 as cited in REKIEL 2002, BEYGA and REKIEL 2009). Sows whose fat reserves and body weight differ at farrowing and weaning show a similar degree of weight loss over this period. Changes in the fat content and body weight of sows during lactation are also strongly affected by litter size (WÜLBERS–MINDERMANN *et al.* 2002).

KYRIAZAKIS and WHITTEMORE (2006) argue that the optimal backfat thickness in sows at point P_2 should amount to 14-25 mm. Sows have to be fed *ad libitum* during lactation and in the weaning-to-mating interval (REKIEL 2002). The body condition of sows at weaning and postweaning flushing has been described by REKIEL (2002), HOFFMANN and BILKEI (2003). According to REKIEL (2002), an intensive feeding regime is justified, especially in primiparous sows in the peri-weaning period, because it has a beneficial effect on their body condition and reproductive performance.

When investigating changes in the body weight and fat reserves of sows between the first mating and the fourth weaning (WHITTEMORE and YANG 1989), and between the first mating and the third weaning (REKIEL 2002), the above authors noted a steady increase in body weight and fat loss despite an increase in fat percentages in selected individuals. Fat reserve control at weaning is a valuable measure of reproductive performance (REKIEL 2002). A low level of fat reserves at weaning (backfat thickness <14 mm) has an adverse effect on the productivity and reproduction results of sows (KOKETSU *et al.* 1996 as cited in REKIEL 2002).

The objective of this study was to determine the effect of the body condition of late pregnant sows on fat reserves at farrowing and weaning, including the scale of the relevant changes in that period, and on the reproductive performance of sows and the results of piglet rearing.

Material and methods

The studies included two groups of sows – crossbreds of breeds Polish Large White x Polish Landrace and their progeny; participation of multiparous and primiparous sows amounted to 70 and 30%, respectively. Backfat thickness was measured during late pregnancy, at farrowing and at weaning, at the following points: P_1 – over the shoulder, P_2 – over the last rib, 3 cm from the dorsal midline, P_3 – over the *gluteus medius* muscle, P_4 – over the last rib, 8 cm from the dorsal midline (ultrasound device Piglog 105) (ECKERT and SZYNDLER-NĘDZA 2004). The animals were divided into groups based on the arithmetic mean of $(P_2+P_4)/2$, calculated using backfat thickness at points P_2 and P_4. Measurements were performed on pregnancy day 104 when the sows were transferred to the farrowing section. Sows with average backfat thickness of $(P_2+P_4)/2>20$ mm were assigned to group I (10 primiparous, 36 multiparous) while sows with average backfat thickness of $(P_2+P_4)/2 \leq 20$ mm – to group II (19 primiparous, 32 multiparous) (Table 1).

Table 1
Experimental design
Versuchsdesign

Trait	Group I	Group II	SE	*P*
Number of sows, n	46	51		
Average backfat thickness $(P_2+P_4)/2$ of late pregnant sows, mm (5-point scale)	26.19 (>4)	15.24 (~2.5)	0.388	***
Average backfat thickness $(P_2+P_4)/2$ of sows at farrowing, mm (5-point scale)	24.91 (>4)	16.25 (~2.5)	0.463	***
Average backfat thickness $(P_2+P_4)/2$ of sows at weaning, mm (5-point scale)	21.60 (>3.5)	12.29 (~2.0)	0.560	***

Group I $(P_2+P_4)/2>20$ mm, late pregnant sows, Group II $(P_2+P_4)/2 \leq 20$ mm, late pregnant sows, ***$P \leq 0.001$

Table 2
Backfat thickness, *longissimus* muscle depth and body weight determined in late pregnant sows, at farrowing and at weaning
Rückenspeckdicke, Muskeldurchmesser und Körpergewicht in der Spätträchtigkeit bei Abferkelung und Absetzen

Trait	Group I	Group II	SE	*P*
Late pregnancy – day 104				
Body weight, kg	235.88	203.42	3.870	***
Backfat thickness over the shoulder, at point P_1, mm	35.22	24.90	0.600	***
Backfat thickness over the last rib, 3 cm from the dorsal midline, at point P_2, mm	24.73	14.40	0.422	***
Backfat thickness over the *gluteus medius* muscle (loin II), at point P_3, mm	30.18	18.58	0.523	***
Backfat thickness over the last rib, 8 cm from the dorsal midline, at point P_4, mm	27.65	16.08	0.454	***
Longissimus muscle depth at point P_4M, mm	44.22	43.04	0.596	ns
Farrowing day				
Backfat thickness over the shoulder, at point P_1, mm	36.86	26.45	0.613	***
Backfat thickness over the last rib, 3 cm from the dorsal midline, at point P_2, mm	23.68	14.66	0.504	***
Backfat thickness over the *gluteus medius* muscle (loin II), at point P_3, mm	29.75	19.41	0.550	***
Backfat thickness over the last rib, 8 cm from the dorsal midline, at point P_4, mm	26.14	17.84	0.537	***
Longissimus muscle depth et point P_4M, mm	41.14	42.39	0.509	ns
Weaning – day 21 of lactation				
Body weight, kg	207.04	177.43	3.513	***
Backfat thickness over the shoulder, at point P_1, mm	35.30	22.45	0.726	***
Backfat thickness over the last rib, 3 cm from the dorsal midline, at point P_2, mm	20.97	12.10	0.564	***
Backfat thickness over the gluteus medius muscle (loin II), at point P_3, mm	26.32	16.90	0.654	***
Backfat thickness over the last rib, 8 cm from the dorsal midline, at point P_4, mm	22.23	12.48	0.652	***
Longissimus muscle depth at point P_4M, mm	40.52	44.6	0.489	***

Group I $(P_2+P_4)/2>20$ mm, late pregnant sows, Group II $(P_2+P_4)/2 \leq 20$ mm, late pregnant sows, ***$P \leq 0.001$, ns not significant

The average backfat thickness in group I and II sows was 5 and 2 points on a 5-point BCS scale, respectively (PATIENCE *et al.* 1995, JOHNSTON 1996, TODD SEE 1999, FEARON 2005 as cited in REKIEL and BEYGA 2008). The body condition of sows during the experiment was also evaluated by measuring *in vivo* the *longissimus* muscle depth at point P_4M which corresponds to point P_4, and by determining their body weight (Table 2).

The experiment was conducted during the months of May and June in sow houses with controlled microclimate. The animals were kept individually in farrowing pens with standard welfare requirements in place (SOSSIDOU and SÜCS 2007).

Sows and piglets had constant access to water (nipple drinkers). The sows were fed a complete diet (12.7 MJ ME/kg, 17% protein, 1% lysine) in accordance with Polish Swine Nutrient Requirements (ANONYMOUS 1993). Feed was administered twice daily during pregnancy and three times a day during lactation. Piglets were additionally fed a prestarter diet, beginning on the fifth day after birth until weaning on the 21st day (13.5 MJ ME/kg, 19.9% protein, 1.53% lysine) (AOAC 1990). Both sows and piglets were included in a prevention program, all farrowings were supervised, and the key reproduction and piglet rearing parameters were monitored.

The results were verified statistically by a one-way or a two-way analysis of variance and the computer package SPSS 12.0 PL for Windows (2003) was used for calculations. In the tables, the least square averages and standard errors have been provided.

In the one-way factor analysis of variance the following model was applied:

$$Y_i = c_i + e_{ik} \qquad (1)$$

where Y_i is the observed value for a sow from group i, c_i is the effect of group i (i=I, II, measured as explained above), and e_{ik} is the error term.

In the two-way factor analysis of variance the following model was estimated:

$$Y_i = c_i + d_j + e_{ijk} \qquad (2)$$

where Y_{ij} is the observed value for a sow from group i and parity j, c_i is the effect of group i, (i= I, II), d_j is the effect of parity j (j= primiparous, multiparous), and e_{ijk} is the error term.

Results

The body weight, backfat thickness and *longissimus* muscle depth in sows during late pregnancy, at farrowing and weaning are presented in Table 2. The results of measurements performed in late pregnant sows showed that in comparison with group II sows, group I sows were marked by significantly higher (P≤0.001) body weight – by 32.46 kg, higher backfat thickness at points: P_1 – by 10.32 mm, P_2 – by 10.33 mm, P_3 – by 11.60 mm, P_4 – by 11.57 mm (Table 2), and higher average backfat thickness $(P_2+P_4)/2$ by 10.95 mm (Table 1). *Longissimus* muscle depth was higher in group I than in group II by 1.18 mm (not significant difference). At farrowing, highly significant (P≤0.001) differences were noted in backfat thickness which was higher in group I than in group II sows at points: P_1 – by 10.41 mm, P_2 – by 9.02 mm, P_3 – by 10.34 mm, P_4 – by 8.30 mm, while average backfat thickness $(P_2+P_4)/2$ was higher by 8.66 mm. *Longissimus* muscle depth was 1.25 lower in group I than in group II (not significant difference). The results of measurements performed at weaning showed that group I sows were characterized by significantly higher (P≤0.001) body weight than group II sows (by 29.61 kg), higher backfat thickness at points: P_1 – by 12.78 mm, P_2 – by 8.87 mm, P_3 – by 9.42 mm, P_4 – by 9.75 mm, and higher average backfat thickness $(P_2+P_4)/2$ – by 9.31 mm.

An analysis of changes in fat and lean content between the first (pregnancy day 104) and the second measurement (farrowing day) showed a greater decrease in backfat thickness at points P_2 and P_3 (not significant), P_4 (P≤0.01) in group I sows in comparison with group II sows, and a decrease in average backfat thickness $(P_2+P_4)/2$ (P≤0.001) (Figure 1). Backfat thickness at point P_1 increased in both groups, and the increase was 0.71 percentage points lower in group II than in group I. In comparison with group II, the *longissimus* muscle depth was 5.07 percentage points lower than in group I (Figure 1). An analysis of changes in the investigated parameters in the farrowing-to-weaning interval indicates that backfat reserves were further depleted in group I sows. In group II backfat reserves also decreased, but an increase was noted in the *longissimus* muscle depth. The differences between groups were non-significant, nevertheless, they were greater in group II than in group I (Figure 2). A comparison of two phases of the reproduction cycle, i.e. late pregnancy (pregnancy day 104) and end of lactation (lactation day 21, the weaning day), showed a drop in body weight in both groups with a slightly greater decrease in group I than in group II (Figure 3). In group II sows, backfat thickness at point P_2 decreased by 2.07 percentage points more than in group I, while a similar decrease was noted at point P_4. Average backfat thickness $(P_2+P_4)/2$ decreased in both groups, and the drop was higher by 0.92 percentage points in group II than in group I. The *longissimus* muscle depth (P_4M) decreased in group I, while it increased in group II (highly significant difference at P≤0.001). An increase in backfat thickness at point P_1 was noted in group I, while a decrease was observed in group II. Backfat thickness at point P_3 decreased in both groups, and the drop was 4.94 percentage points higher in group I than in group II.

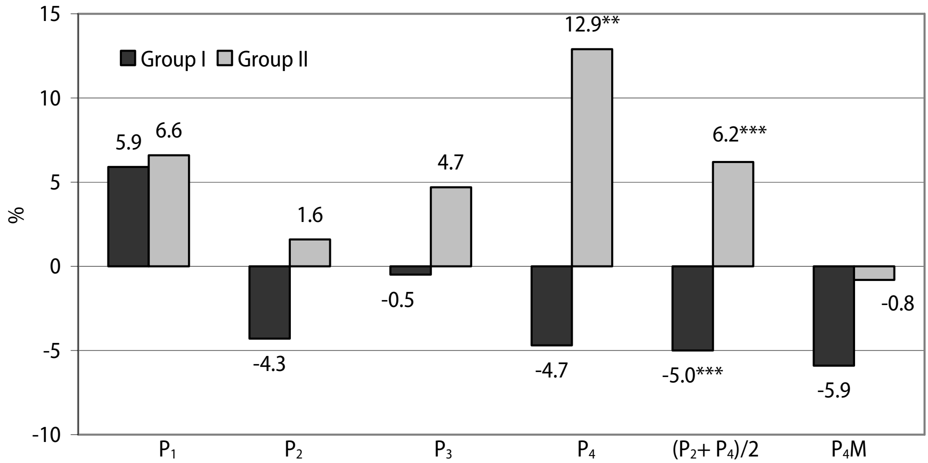


Figure 1
Changes in the values of the analyzed traits[1] in sows between day 104 of pregnancy and farrowing day, %
Veränderungen der Rückenspeck- und Muskeldicke zwischen dem 104. Trächtigkeitstag und Geburtstag,%

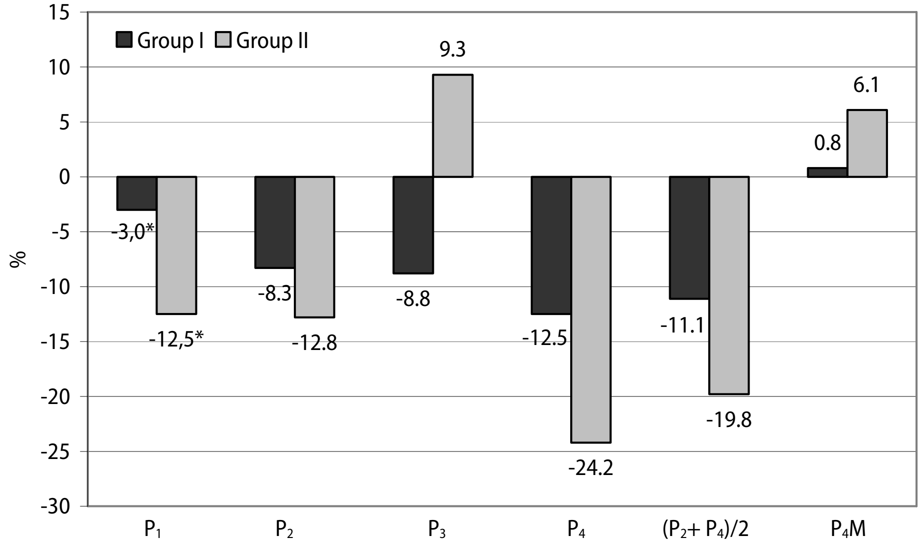
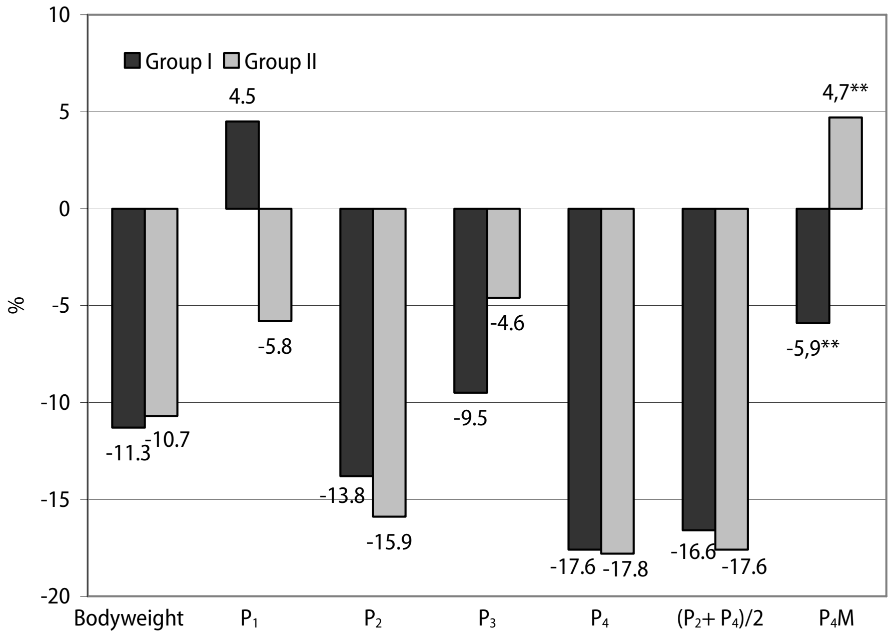


Figure 2
Changes in the values of the analyzed traits[1] in sows between farrowing day and weaning day, %
Veränderungen der Rückenspeck- und Muskeldicke zwischen dem Geburts- und Absetztag, %



[1]Traits: bodyweigth; backfat thickness at points – P_1, P_2, P_3, P_4; backfat thickness – average of two measurements – $(P_2+P_4)/2$; *longissimus* muscle depth – P_4M)

Figure 3
Changes in the values of the analyzed traits[1] in sows between day 104. of pregnancy and weaning day, %
Veränderungen der Rückenspeck- und Muskeldicke zwischen dem 104. Trächtigkeitstag und dem Absetztag, %

In the first week of lactation, the total consumption of complete diets was 0.79 kg lower in group I than in group II, and this difference reached 0.49 kg and 3.81 kg (not significant) in lactation weeks 2 and 3. Daily feed intake was also lower in group I than in group II in successive weeks of lactation (Table 3), and the resulting difference in the first, second and third week of lactation was 0.12 kg, 0.07 kg and 0.55 kg (not significant), respectively. The total average feed consumption over the period of three weeks differed by 5.09 kg between group I and group II sows (not significant), while the difference in daily consumption reached 0.11 kg (not significant). In successive weeks of lactation, feed consumption in group I vs. group II was 96.9%, 98.9% and 89.7%, respectively. The following changes were reported in three consecutive weeks of the lactation period: in week 2, feed consumption in group I increased by 75.2% compared with week 1, while a 22.7% decrease was noted in week 3 in comparison with week 2. A similar trend was reported in group II, but the relevant changes were less pronounced: in week 2, feed consumption increased by 71.1% compared with week 1, while a 14.8% drop was noted in week 3 in comparison with week 2.

Table 3
Average feed consumption per sow during 3-week lactation
Durchschnittlicher Futterverbrauch der Sauen während der 3-wöchigen Laktationszeit

Average feed consumption per sow:	Group I	Group II	SE	*P*
Week 1, kg	24.51	25.30	0.783	ns
Week 2, kg	42.95	43.44	0.955	ns
Week 3, kg	33.19	37.00	1.461	ns
Over lactation, kg	100.65	105.74	2.563	ns
Per day of lactation, kg	4.98*	5.09**	0.102	ns

Group I $(P_2+P_4)/2>20$ mm, Group II $(P_2+P_4)/2\leq20$ mm, *average lactation period for group I – 20.21 days **average lactation period for group II – 20.77 days, ns not significant

Piglets were fed supplementary solid feed, and the intake per each weaned pig was estimated at 3.73 MJ ME, 60 g protein and 4.26 lysine on average. In addition to mother‹s milk and colostrum, the feeding of a complete diet to piglets of both experimental groups contributed to satisfactory performance results. The average daily gains of suckling piglets amounted to: in group I – 220 g (228 g for piglets from primiparous sows, and 213 g from multiparous sows), in group II – 187 g (181 g and 192 g, respectively).

Selected reproductive and rearing parameters are presented in Table 4. Significant differences were reported in favour of group I vs. II ($P\leq0.05$) as regards the piglets stillborn (0.21), litter weight at weaning (5.17 kg), the average piglet weight at weaning (0.62 kg) and placental weight (0.45 kg). Multiparous sows as compared to primiparous sows were characterized by significantly ($P\leq0.05$) larger total number of piglets born (1.22) and the number of piglets born alive (1.33). The difference in the litter weight at birth (2.93 kg) was found to be highly significant ($P\leq0.01$).

The length of the weaning-to-estrus interval (WEI) did not differ statistically neither between the groups I and II, nor between the primiparous and multiparous sows.

Table 4
Selected reproductive and piglet rearing parameters in sows that differed in average backfat thickness during late pregnancy
Geburts- und Wurfleistungsmerkmale der Sauen beider Gruppen

Parameter	Sows	Group I	Group II	(I+II)/2	*P*
Piglets born in total, no. of heads	Primiparous	9.80	9.16	9.48[a]	
	Multiparous	11.11	10.28	10.70[b]	
	Total	10.46	9.72	10.09	0.249
Piglets born alive, no. of heads	Primiparous	9.80	8.84	9.32[a]	
	Multiparous	11.11	10.19	10.65[b]	
	Total	10.46	9.52	9.99	0.260
Stillborn piglets, no. of heads	Primiparous	0	0.09	0.16	
	Multiparous	0	0.32	0.05	
	Total	0[a]	0.21[b]	0.10	0.35
Piglets weaned, no. of heads	Primiparous	9.70	8.95	9.32	
	Multiparous	9.92	9.72	9.82	
	Total	9.81	9.33	9.57	0.170
Litter birth weight, kg	Primiparous	15.02	13.92	14.47[A]	
	Multiparous	18.08	16.71	17.40[B]	
	Total	16.55	15.32	15.93	0.414
Litter weaning weight, kg	Primiparous	56.56	49.98	53.27	
	Multiparous	59.68	55.91	57.80	
	Total	58.12[a]	52.95[b]	55.53	1.191
Average piglet birth weight, kg	Primiparous	1.55	1.66	1.63	
	Multiparous	1.66	1.71	1.68	
	Total	1.61	1.68	1.65	0.046
Average piglet weaning weight, kg	Primiparous	6.33	5.47	5.90	
	Multiparous	6.14	5.75	5.94	
	Total	6.23[a]	5.61[b]	5.92	0.138
Placental weight, kg	Primiparous	3.87	3.43	3.65	
	Multiparous	3.95	3.49	3.72	
	Total	3.91[a]	3.46[b]	3.69	0.057
Placental weight per piglet, kg	Primiparous	0.40	0.36	0.38	
	Multiparous	0.37	0.34	0.36	
	Total	0.38	0.35	0.37	0.010
Weaning-to-estrus interval, days	Primiparous	6.63	6.29	6.46	
	Multiparous	5.74	5.90	5.82	
	Total	6.18	6.09	6.14	0.586

Group I $(P_2+P_4)/2>20$ mm, Group II $(P_2+P_4)/2\leq 20$ mm, $^{AB}P\leq 0.01$, $^{ab}P\leq 0.05$

Discussion

The dynamics of changes in fatness differed in the analyzed periods, and the obtained results are validated by the findings of other authors (GUEDES and NOGUEIRA 2001, WÜLBERS–MINDERMANN *et al.* 2002, YOUNG *et al.* 2004, SALAK-JOHNSON *et al.* 2007). According to YOUNG *et al.* (2001), the increased demand of growing fetuses in the last four weeks of pregnancy does not seem to be fully met by daily feed intake. In this period, sows are likely to use their fat reserves to cover the steadily growing energy requirements. The above is supported by selected results of this study as well as the findings of MILLER *et al.* (2000) who argue that feed consumption levels should be increased in sows from pregnancy day 100 until farrowing. The above does not reduce feed intake during lactation, nor does it increase the frequency of agalactia in sows. Fat reserves are used up even when sows increase their body weight. In this study, backfat thickness at points P_2, P_4, and the average backfat thickness $(P_2+P_4)/2$ decreased in the last days before farrowing, and the above change was more profound in sows with a higher backfat thickness (group I). An assessment of the body condition of sows carried out by MAES *et al.* (2004) pointed to a dependency between fatness and the genotype. According to these authors, the level and course of the mentioned changes between pregnancy day 80, farrowing and weaning differs from that proposed by MILLER *et al.* (2000) and YOUNG *et al.* (2001). According to REVELL *et al.* (1998a), DEAN BOYD *et al.* (2002), REKIEL (2002), ANIL *et al.* (2006) fat reserve depletion and weight loss can be limited by introducing an adequate nutritional regime and shortening the rearing period.

Higher, although non-significant, weight loss in group I than in group II in the late pregnancy-to-weaning interval is validated by the findings of other authors (GUEDES and NOGUEIRA 2001, MULLAN and WILLIAMS 1989 as cited in REKIEL 2002). Yet according to WŰLBERS – MINDERMANN *et al.* (2002), the level of changes could differ when larger litters are reared by the sows. NEWTON and MAHAN (1993) as cited in REKIEL (2002) observed that gilts that were heavier (≥150 kg) at first farrowing lost more weight during lactation than lighter sows. The highest piglet mortality and the lowest litter weight at weaning were reported in the heaviest gilts. Throughout the second and the third lactation, higher weight loss was noted in lighter sows which consumed less feed during lactation. In this group, sows were more frequently culled due to a prolonged weaning-to-estrus interval. WELDON and BILKEI (2005) observed that weight loss in excess of 10 percentage points during lactation decreased sow fertility. REKIEL *et al.* (2007) and SALAK-JOHNSON *et al.* (2007) noted that primiparous sows characterized by greater backfat thickness and higher body weight lost more weight at farrowing and weaning than young sows with lower fat reserves and lower body weight. According to SALAK-JOHNSON *et al.* (2007), the applied housing system also affects the body condition and fat reserves of pregnant sows.

The feed consumption of lactating sows differed in the experimental groups I and II. According to other authors, sows with a higher fat content are marked by lower feed intake during lactation than sows with lower fat reserves (MULLAN and WILLIAMS 1989 as cited in REKIEL 2002, ESTIENNE *et al.* 2000, YOUNG *et al.* 2004), and the resulting differences can be as high as 30% (REVELL *et al.* 1998a). The above is also affected by the energy value of feed consumed during pregnancy. Higher energy intake decreases feed consumption during lactation (MULLAN and WILLIAMS 1989 as cited in REKIEL 2002, REVELL *et al.* 1998a, PRUNIER *et al.* 2001). *Ad libitum* access to feed affects the factors controlling hunger during lactation and it decreases the feed intake of sows over that period. KYRIAZAKIS and WHITTEMORE (2006) argue that feed intake of minimum 5 kg/day/sow is possible during lactation if the sow has accumulated adequate protein and fat reserves after farrowing. The desired body weight is 180 kg and backfat thickness at point P_2 – 18 mm.

High-performance sows have a limited appetite, and during lactation, it is inversely proportional to feeding intensity during rearing and pregnancy (LAWLOR *et al.* 2007). The correlation between feed intake and backfat thickness on farrowing day and the appetite of lactating sows is r=0.52 (MULLAN and WILLIAMS 1989 as cited in REKIEL 2002). When feed and nutrient intake is limited during lactation, catabolic processes are intensified and they dominate over anabolic processes, especially in primiparous sows. Gilts and sows with a higher fat content consume less feed during lactation (REVELL *et al.* 1998a). As a result, their feed intake may be insufficient relative to milk production levels, thus exerting an adverse effect on reproductive performance (KOKETSU *et al.* 1996 as cited in REKIEL 2002, REVELL *et al.* 1998b).

According to REVELL *et al.* (1998a), voluntary feed intake over the first two weeks of lactation is not determined by the protein content of feed or its uptake, but by fat percentages. The consumption of feed protein affects voluntary intake only in the third and fourth week of lactation, and it is probably related to continued milk production. Feed intake during lactation is also determined by successive litters: primiparous sows consume 20% less feed than multiparous sows (YOUNG *et al.* 2004). Greater nutrient mobilization from body tissues is noted in lactating sows characterized by low daily energy intake, to cover the energy demand for milk production. Feed intake by lactating sows significantly affects piglet growth rates in the final phase of the four-week lactation period (YANG *et al.* 1989 as cited in REKIEL 2002).

In this study, late pregnant sows with a higher fat content (group I) consumed less feed than leaner sows (group II) during lactation. These results were confirmed by other authors (MULLAN and WILLIAMS 1989 as cited in REKIEL 2002, ESTIENNE *et al.* 2000, YOUNG *et al.* 2004). The sows increased their feed intake in the first two weeks of lactation, after which a drop in consumption was noted. A gradual, voluntary increase in feed intake was also observed by PRUNIER *et al.* (2001) in the first and second week and by (REVELL *et al.* 1998a) in the first week of lactation. In the cited studies, all sows reached at least 60% of the maximum voluntary feed intake level after one week of feeding. In the first week of lactation, the average voluntary feed intake of sows with higher fatness reached 61% of the intake observed in leaner animals. The reported differences were reduced in successive weeks.

Selected reproductive traits of sows and piglet rearing parameters differed between groups I and II ($P \leq 0.05$, $P \leq 0.01$). According to LAWLOR *et al.* (2007), the fatness of sows affects the number and vitality of piglets as well as rearing parameters. Young gilts with a higher backfat thickness achieved higher litter performance and a higher number of litters CECHOVA and TVRDON (2006). Litter size increased from the first until the fifth parity. In an experiment performed by REVELL *et al.* (1998b), smaller litters and more stillbirths were reported in obese sows than in lean ones. YOUNG *et al.* (2004) did not observe any differences in the total number of births, live births, stillbirths, mummified fetuses and weaned piglets between fat and lean sows, but they noted that sows with a very high fat content were more likely to produce smaller litters.

No differences were reported in the body weight of piglets delivered by sows characterized by different fat levels during late pregnancy. Similar results were reported by ESTIENNE *et al.* (2000). REVELL *et al.* (1998b) showed that during four weeks of lactation, the litters of lean sows grew 16% faster than the piglets fed by sows with higher fat reserves (1.92 vs. 1.66 kg/day). In this study, litter birth weight was significantly higher in group I than in group II due to the difference in litter size. The growth rate of piglets reared by group I sows was 10.6% higher than that of piglets reared by group II sows (1.98 vs. 1.79 kg/day). An up to 20% drop in litter growth rates is noted when the mother loses 10-12% protein (CLOWES *et al.* 2003). In this study, a similar decrease in average backfat thickness $(P_2+P_4)/2$ between pregnancy day 104 and the weaning day was noted in group I and group II at −16.5% and −15.6%, respectively. Changes in *longissimus* muscle depth varied from −5.9% in group I to +4.7% in group II ($P\leq0.01$), while higher piglet growth rates were noted in group I. Piglets reared by heavier sows (group I) were characterized by 17.7% higher growth rates in comparison with the litter of lighter sows (group II) (220 vs. 187 g). Similar results were noted by CLOWES *et al.* (2003). In their study, the piglets from sows that were heavier at farrowing grew around 17% faster than the piglets from leaner sows (2.21 vs. 2.05 kg/day). WÜLBERS–MINDERMANN *et al.* (2002) demonstrated that the body weight of sows and their fat levels before farrowing did not have a significant effect on the growth rate of piglets. YANG *et al.* (1989) as cited in REKIEL (2002) argued that piglet growth rates were not determined by the fat content of sows at farrowing or litter size, but solely by sow nutrition levels in the last week of lactation. According to MULLAN and WILLIAMS (1989) as cited in REKIEL (2002) the piglets from sows that begin lactation with low fat reserves and have restricted access to feed during lactation are characterized by lower growth rates.

Nutritional levels, metabolic status and fat loss during lactation affect the length of the weaning-to-estrus and weaning-to-mating interval (JOHNSTON *et al.* 1989 as cited in REKIEL 2002). Excessive loss of body fat reserves that accompanies a very long lactation period, large litters and/or restrictive feeding contribute to longer weaning-to-estrus intervals (MULLAN and WILLIAMS 1989 as cited in REKIEL 2002, TANTASUPARUK *et al.* 2001). The absence of differences in the above ratio for groups I and II in this experiment indicates that sows were fed adequately, suggesting that a 3-week piglet rearing period is recommended in intensive production systems. The above was confirmed by the findings of KIM and EASTER (2001). Excessive weight gain and fattening after weaning disrupts the production cycle, lowers the fertilization rate and reduces the litter size (HOFFMANN and BILKEI 2003).

Researchers vary in their opinions on the effect of weight loss during lactation on the duration of the weaning-to-estrus interval (WEI) and mating efficiency TANTASUPARUK *et al.* (2001). In this study, body weight loss in both groups and weaning-to-estrus interval between groups I and II was minimal (non-significant difference between groups). According to JOHNSTON *et al.* (1989) as cited in REKIEL (2002), nutrition during lactation has a greater influence on the duration of the WEI than fat reserves. A different view is presented by MULLAN and WILLIAMS (1989) as cited in REKIEL (2002) who claim that the length of the above interval is affected by backfat thickness during mating, at farrowing and weaning. In this study, late pregnant sows in group I were marked by significantly higher ($P\leq0.001$) body weight and fat reserves than group II sows. Changes in backfat thickness at points P_2, P_4, $(P_2 + P_4)/2$ were similar in both groups between pregnancy day 104 and weaning day, while different values of *longissimus* muscle depth (P_4M) were reported for group I and group II. The duration of the weaning-to-estrus interval could be affected by nutrient intake during lactation. Restricted protein or energy intake in this phase of the reproduction cycle delays the onset of estrus (MULLAN and WILLIAMS 1989, KLOCEK *et al.* 1993 and EDWARDS 1998 as cited in REKIEL 2002). In this study, a 5.1% higher feed consumption in group II vs. I did not have a significant impact on the duration of the WEI.

The results of this study indicate that higher fat percentages and body weight noted in group I sows in comparison with group II sows ($P \leq 0.001$) during late pregnancy were maintained at farrowing and weaning. *Longissimus* muscle depth was significantly higher ($P \leq 0.001$) at weaning in group II vs. I. The dynamics of percentage changes in fat levels (late pregnancy-farrowing-weaning) varied between late pregnancy and farrowing day for P_4 ($P \leq 0.01$) and $(P_2+P_4)/2$ ($P \leq 0.001$). Fat reserves were depleted in group I, while an increase in fat content was noted in group II. In the late pregnancy-weaning interval, the percentage of weight loss was similar in group I and group II sows (not significant). Changes in feed consumption observed during lactation showed that group I sows had a lower appetite than group II sows. A regular trend in feed intake was noted in lactating sows of both groups: feed consumption increased in week 2, compared with week 1, while a decrease was noted in week 3 in comparison with week 2. Significant differences were reported in favour of group I vs. II ($P \leq 0.05$) as regards the piglets stillborn, litter weight at weaning, the average piglet weight at weaning and placental weight. Multiparous sows as compared to primiparous sows were characterized by significantly ($P \leq 0.05$) larger total number of piglets born and the number of piglets born alive. The difference in the litter weight at birth was found to be highly significant ($P \leq 0.01$).
In late pregnant sows from group I characterized by higher fat reserves vs. sows in group II significantly better litter performance and rearing of piglets was observed. The following findings indicate the importance of monitoring sow condition.

References

Anil SS, Anil L, Deen J, Baidoo SK (2006) Association of inadequate feed intake during lactation with removal of sows from the breeding herd. J Swine Health Prod 14, 296-301

Anonymous (1993) Polish Swine Nutrition Requirements, IFiŻZ PAN Omnitech-Press, Warszawa [in Polish]

Association of Official an Analytical Chemists (1990) Official Methods of Analysis of the Associated Official Analytical Chemists, 15th ed., Chapter 32, Washington DC, USA

Beyga K, Rekiel A (2009) Effect of the backfat thickness of sows in late pregnancy on the composition of colostrum and milk. Arch Tierz 52, 593-602

Cechova M, Tvrdon Z (2006) Relationship between backfat thickness and parameters of reproduction in the Czech Large White sows. Arch Tierz 49, 363-69

Clowes EJ, Aherne FX, Foxcroft GR, Baracos VE (2003) Selective protein loss in lactating sows is associated with reduced litter growth and ovarian function. J Anim Sci 81, 753-64

Dean Boyd R, Castro GC, Cabrera RA (2002) Nutrition and Management of the Sow to Maximize Lifetime Productivity. Adv Pork Prod 13, 47-59

Eckert R, Szyndler-Nędza M. (2004) Judging of live of young boars. Report on pig breeding in 2003. Instytut Zootechniki, XXIV, Kraków, Poland, 31-46 [in Polish]

Eissen JJ, Apeldoorn EJ, Kanis E, Verstegan MWA, De Greef KH. (2003) The importance of a high feed intake during lactation of primiparous sows nursing large litters. J Anim Sci 81, 594-03

Estienne MJ, Harper AF, Barb CR, Azain MJ (2000) Concentrations of leptin in serum and milk collected from lactating sows differing in body condition. Domest Anim Endocrinol 19, 275-80

Guedes RMC, Nogueira RHG (2001) The influence of parity order and body condition and serum hormones on weaning-to-estrus interval of sows. Anim Reprod Sci 67, 1, 91-9

Hoffmann CL, Bilkei G (2003) Effect of body condition of postweaning »flushed« sows and weaning-to-mating interval on sow reproductive performance. Vet Rec 152, 261-3

Kämmerer B, Müller S, Hühn U (1998) Reproductive and rearing performance of gilts with different side fat thickness before start of breeding. Arch Tierz 41, 387-96

Kim SW, Easter RA (2001) Nutrient mobilization from body tissues as influenced by litter size in lactating sows. J Anim Sci 79, 2179-86

Kyriazakis I, Whittemore CT (2006) Whittemore's science and practice of pig production. Blackwell Publishing Ltd

Lawlor PG, Lynch PB, O'Connell MK, Namara LM, Reid P, Stickland NC (2007) The influence of over feeding sows during gestation on reproductive performance and pig growth to slaughter. Arch Tierz 50 Special Issue, 82-91

Maes DGD, Janssens GPJ, Delputte *P*, Lammertyn A, De Kruif A (2004) Back fat measurements in sows from three commercial pig herds: relationship with reproductive efficiency and correlation with visual body condition scores. Liv Prod Sci 91, 57-67

McNamara LB, Stickland NC, Lynch PB, O'Connel MK Lawlor PG (2008a) The influence of increasing feed intake during gestation on litter size, piglet growth and within litter variation from birth to weaning. Arch Tierz 51 Special Issue, 23-4

McNamara LB, Stickland NC, Lynch PB, O‹Connel MK, Lawlor PG (2008b) Influence of five gestation feeding regimes for sows on lactation feed intake, lactation weight loss, subsequent farrowing rate and litter size. Arch Tierz 51 Special Issue, 25-6

Miller HM, Foxcroft GR, Aherne FX (2000) Increasing food intake in late gestation improved sow condition throughout lactation but did not affect piglet viability or growth rate. Anim Sci 71, 141-8

Prunier A, Mejia Guadarrama CA, Mourot J, Quesnel H (2001) Influence of feed intake during pregnancy and lactation on fat body reserve mobilisation, plasma leptin and reproductive function of primiparous lactating sows. Reprod Nutr Dev 41, 333-47

Quesnel H, Prunier A (2005) Dietary protein restriction lactation in primiparous sows with different live weights at farrowing: I. Consequences on sow metabolic status and litter growth. Reprod Nutr Dev 45, 39-56

Rekiel A, Beyga K (2008) Body condition scoring in sows. Przegl Hod 76, 9, 7-13 [in Polish]

Rekiel A. (2002) Effect of different drying off methods on the level of fat reserves and reproduction results in sows. Pr hab, 246. Wyd. SGGW, 1-99 [in Polish]

Rekiel A, Beyga K, Vaško V (2007) Effect of backfat in point P_2 and of body weight of primiparous sows in high pregnancy on their condition at weaning. Rocz Nauk Pol Tow Zoot 3, 89-104 [in Polish]

Revell DK, Williams IH, Mullan BP, Ranford JL, Smits RJ (1998a) Body composition at farrowing and nutrition during lactation affect the performance of primiparous sows: I. Voluntary feed intake, weight loss, and plasma metabolites. J Anim Sci 76, 1729-37

Revell DK, Williams IH, Mullan BP, Ranford JL, Smits RJ (1998b) Body composition at farrowing and nutrition during lactation affect the performance of primiparous sows: II. Milk composition, milk yield, and pig growth. J Anim Sci 76, 1738-43

Salak-Johnson JL, Niekamp SR, Rodriquez-Zas SL, Ellis M, Curtis SE (2007) Space allowance for dry, pregnant sows in pens: Body condition, skin lesions, and performance. J Anim Sci 85, 1758-69

Sossidou E, Szücs E (2007) Farm animal welfare, environment and food quality interaction studies. National Agricultural Research Foundation.

SPSS (2003). User's Guide 12.0. SPSS Inc, USA

Tantasuparuk W, Dalin A-M, Lundeheim N, Kunavongkrit A, Einarsson S (2001) Body weight loss during lactation and its influence on weaning-to service interval and ovulation rate in Landrace and Yorkshire sows in the tropical environment of Thailand. Anim Reprod Sci 65, 273-81

Wähner M, John A, Hoffmeyer C (2001a) Influence of growth and side fat thickness on reproduction and rearing performance of gilts. I. Comparison of characteristics growth, side fat thickness and reproduction performances. Arch Tierz 44, 157-66

Wähner M, Scholz H, Kämmerer B (2001b) Relationship between feed intake, side fat thickness and special parameters of rearing performance of lactating sows. Arch Tierz 44, 639-48

Weldon CMP, Bilkei G (2005) The effect of weight loss during lactation on weaning-to first-service-interval, farrowing rate to first-service, and subsequent litter size to first-service in sows. The Pig J 56, 55-65

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. Livest Prod Sci 73, 285-97

Young MG, Tokach MD, Aherne FX, Main RG, Dritz SS, Goodband RD, Nelssen JL (2004) Comparison of three methods of feeding sows in gestation and the subsequent effects on lactation performance. J Anim Sci 82, 3058-70

Young MG, Tokach MD, Goodband RD, Nelssen JL, Dritz SS (2001) The relationship between body condition score and backfat in gestating sows. Kansas State University Swine Day Report of Progress, 5-9

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