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RELATIONSHIPS BETWEEN GROWTH, FATNESS AND MEATINESS TRAITS IN GILTS AND THEIR SUBSEQUENT REPRODUCTIVE PERFORMANCE

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Abstract

The study was carried out on 79 gilts of the Polish synthetic line 990, which were derived from the litters of dams that gave birth to 12 piglets and more per litter and were kept under the same environmental conditions. Their weight gains were evaluated during the growth period and their fatness and meatiness at 180 days of age. No significant correlations were found between the body weight of gilts in different periods of their life (days 21, 30, 63 and 180), their growth rate to 180 days of age and their subsequent reproductive traits. Positive relationships were found between backfat thickness on day 180 of age and number of total born and live-born piglets in the first three litters altogether (0.18 and 0.19, respectively), and significant negative relationships ($P \leq 0.01$) between the meatiness of performance-tested gilts and their subsequent reproductive performance (from –0.34 to –0.43). This would indicate that the increase of meatiness in gilts is a significant parameter that determines the further course of their reproductive functions.

Key words: gilts, weight gain, backfat thickness, meatiness, reproduction

For many years, most breeding programmes for pigs have been mostly focused on evaluation and improvement of meatiness traits, for which significant progress has been made as a result. The proportion of fat in the body decreased from 27–35% to 20–25%, while the proportion of muscle tissue increased from about 45% to 55–60%. If this is a favourable phenomenon in growing animals intended for fattening and slaughter, a decrease in the body fat content of animals used for breeding impairs their reproductive performance (Rekiel, 2002).

It is evident from many studies that successful improvement of meatiness results in many negative consequences such as deterioration of meat quality, inferior reproductive performance of sows, increased mortality during piglet rearing, less developed gastrointestinal tract, and more frequent cardiovascular insufficiency and susceptibil-

ity to stress (Johansson and Kennedy, 1983; Kersey DeNise et al., 1983; Herpin et al., 1993; McKay, 1993; Rydhmer, 1993; Gaughan et al., 1995; Łyczyński et al., 2000, Čechová and Tvrdoň, 2006; Imboonta et al., 2007). Also a decrease in breeding efficiency of boars was observed (Kawęcka et al., 1997).

Unfavourable relationships were also established between productive and reproductive traits (Johansson and Kennedy, 1983; Rydhmer, 1993; Webb et al., 1998). Special attention is paid to unfavourable genetic correlations between reproductive traits in sows and meatiness (Čechová and Buchta, 1995; Kerr and Cameron, 1996; Holm et al., 2004). Bečkova et al. (2005) report after Čeřovský (2001) that total lean meat content is a more critical parameter for reproductive traits in sows than a decreased content of required fat reserve. According to Falkenberg et al. (1989), an extreme increase of performance with breeding methods may lead to disturbances in the homeostasis of genetic relationships between complexes of performance traits. Thus, reproductive success requires a continuous, clear-sighted analysis and identification of many factors that can determine reproductive results. This is because the whole reproduction process is a basis for maximum utilization of pig performance traits and reduction of piglet production costs.

This study was aimed at determining phenotypic correlations between growth, fatness and meatiness traits in gilts of the Polish synthetic line 990, which were evaluated in the rearing period and during performance tests, and their subsequent reproductive performance.

Material and methods

The study was carried out at the Experimental Station in Pawłowice, belonging to the National Research Institute of Animal Production. Subjects were 79 gilts of the Polish synthetic line 990 derived from litters of the dams which gave birth to 12 piglets and more per litter. The piglets were weaned at 30 days of age. After separation from the sows, piglets were still kept in farrowing pens until day 63 of age. On day 63, routine selection of gilts for performance test carried out to the age of 180 days was made in line with the methods used in the Experimental Station. During the evaluation period, gilts were individually kept and fed complete diets adjusted to age. The body weight of gilts was evaluated on days 21, 30, 63 and 180, as were daily gain during the test period (from days 63 to 180) and feed conversion (kg feed/kg gain) during the same period.

On day 180 of age, gilts were subjected to evaluation using a PIGLOG 105 ultrasound apparatus (according to the methods of the National Research Institute of Animal Production from 2003). The values of the examined traits, i.e. carcass meat percentage calculated from two measurements of backfat thickness at points P_2 and P_4 (3 and 8 cm, respectively, away from the back midline behind the last rib) and a measurement of loin eye height at point P_4M (8 cm away from the back midline behind the last rib) as well as body weight gain from birth until evaluation day, were a basis for calculating selection indices. After carrying out the performance test, gilts were selected for mating, with the first mating at the age of 242 days ($\overline{x}$) and body weight

of about 140 kg. Gilts were mated to Polish synthetic line 990 boars and evaluated in 3 consecutive reproduction cycles. The age at first farrowing was 350 days ($\bar{x}$), the interval between first and second parity was 159.6 days and that between second and third parity was 157.2 days. The following breeding performance traits were examined: number of total born piglets, number of live and stillborn piglets, litter weight, piglet weight on day 21 of age and during rearing (day 30 of age) as well as piglet mortality from birth to day 21 of age and to weaning. During the evaluation period, all animals were fed alike, kept under the same environmental conditions and handled by the same persons.

The results obtained during the study were analysed using standard statistical methods and Statistica PL computer software. Mean values from three consecutive litters were compared by means of one-factor analysis of variance and phenotypic correlations between production and reproductive traits were calculated.

Results

The results for the growth of gilts to 180 days of age and their fatness and meatiness as well as the selection index values are presented in Table 1. Mean growth rate of the gilts from birth to 180 days of age was 572 g, whereas body meat content was 58.7%.

Table 1. Characteristics of growth rate, backfat thickness and meatiness of herd replacement gilts during the rearing period to 180 days of age (n = 79)

Traits	$\bar{x}$±s
Body weight (kg):	
at 21 days of age	5.8±0.9
at 30 days of age	8.0±1.3
at 63 days of age	21.1± 3.3
at 180 days of age	102.5±4.5
Average daily gain from birth to 180 days of age (g)	572.0±25.0
Average daily gain in test from 63 to 180 days of age (g)	701.0±36.0
Feed conversion per kg gain (kg)	2.9±0.2
Backfat thickness at P_2 (mm)	11.0±2.3
Backfat thickness at P_4 (mm)	9.6±1.9
Average backfat thickness at P_2 and P_4 (mm)	10.5±2.1
Height of *longissimus* muscle P_4M (mm)	51.8±4.8
Lean meat in performance test (%)	58.7±2.0
Selection index (pts)	124.5±8.3

In the first litter, sows delivered a total of 9.6 piglets on average, including 8.6 live-born piglets, and reared 8.1 piglets per litter until day 21 (Table 2). The weight of litter at 21 days of age was 41.9 kg, with piglet weight of 5.2 kg. In subsequent litters of the sows, a significant increase ($P \leq 0.05$ and $P \leq 0.01$) was observed in the number of piglets born and reared as well as in litter and piglet weight. In three consecutive

reproduction cycles, the sows gave birth to an average of 10.4 piglets per litter, including 9.3 live-born piglets, and reared 8.7 piglets until day 21.

Table 2. Characteristics of reproductive performance in successive reproduction cycles and together

Traits	Parity			Total
	1st	2nd	3rd	
	$\bar{x}$±s	$\bar{x}$±s	$\bar{x}$±s	$\bar{x}$±s
Number of piglets:				
total born	9.6 A±2.3	10.3 a±2.7	11.4 Bb±2.9	10.4±1.9
born alive	8.6 A±2.3	9.1 a±2.2	10.1 Bb±2.9	9.3±1.5
born dead	1.0 ±1.5	1.1±1.4	1.3±1.7	1.2±1.0
at 21 days of age	8.1 A±2.3	8.6±2.4	9.3 B±3.1	8.7±1.5
at weaning	8.0 a ±2.3	8.4±2.5	9.2 b±3.2	8.5±1.5
Litter weight (kg):				
at 21 days of age	41.9 Aa±12.3	48.1 b±13.3	51.0 B±17.5	47.0±8.8
at weaning	54.1 Aa±16.3	62.1 b±17.9	64.7 B±23.0	60.3±11.9
Body weight of piglet (kg):				
at 21 days of age	5.2 a±0.7	5.5 b±0.7	5.5 b±0.9	5.4±0.6
at weaning	6.8 a±0.9	7.2 b±0.9	7.1 b±1.0	7.1±0.7
Piglet mortality from birth (%):				
to 21 days of age	5.4±8.7	6.9±15.7	8.4±14.3	6.9±7.9
to weaning	6.9±10.6	8.6±16.9	10.4±16.8	8.6±8.7

A, B – means marked with different capital letters differ significantly at $P \leq 0.01$.
a, b – as above for $P \leq 0.05$.

The next tables show coefficients of phenotypic correlations between the growth traits of gilts until day 180 of age, their fatness and meatiness, the selection index value and the traits of their first litter (Table 3) and three litters altogether (Table 4). Statistically significant ($P \leq 0.05$ and $P \leq 0.01$) negative relationships were found between the meatiness (determined by loin eye height and body meat percentage), selection index and the number of total born and live-born piglets and the number of piglets at 21 days of age and at weaning. These relationships were demonstrated when considering mean values from three consecutive litters of the sows (Table 4). No significant correlations were found when analysing the above relationships with the first litter of sows only.

Table 3. Correlation coefficients between growth rate, backfat thickness and meatiness of gilts and their subsequent reproductive performance (first parity)

Traits	No. of piglets born	No. of piglets born alive	No. of piglets born dead	No. of piglets at 21 days	Piglet mortality to 21 days	No. of weaned piglets	Piglet mortality to weaning	Litter weight at 21 days	Body weight of piglet at 21 days	Litter weight at weaning
Body weight of gilts:										
at 21 days of age	0.11	0.08	0.04	0.10	–0.12	0.13	–0.19	0.18	0.25	0.18
at 30 days of age	0.11	0.13	–0.03	0.17	–0.18	0.20	–0.26*	0.23	0.23	0.19
at 63 days of age	–0.08	–0.13	0.07	–0.90	–0.14	–0.08	–0.16	–0.13	–0.19	0.68
at 180 days of age	0.04	0.08	–0.06	0.08	–0.02	0.11	–0.14	0.06	0.09	0.11
Daily weight gain to 180 days of age	0.04	0.10	–0.09	0.10	–0.01	0.14	–0.14	0.09	0.09	0.11
Daily weight gain in test	0.06	0.15	–0.14	0.10	0.11	0.13	0.00	0.09	0.07	0.02
Feed intake per kg gain in test	–0.05	0.01	–0.09	0.09	–0.28*	0.07	–0.20	0.17	0.18	0.21
Backfat thickness at P_2	0.16	0.15	0.03	0.12	0.07	0.11	0.06	0.11	–0.14	0.04
Backfat thickness at P_4	–0.04	–0.09	0.07	–0.12	0.19	–0.09	0.10	–0.24	–0.21	–0.17
Average backfat thickness (P_2 and P_4)	0.15	0.15	–0.11	0.10	0.15	0.11	0.09	0.03	–0.13	–0.09
Height of *longissimus* muscle	–0.20	–0.13	–0.11	–0.10	–0.13	–0.08	–0.17	–0.15	–0.12	–0.03
Lean meat (%)	–0.17	–0.11	–0.11	–0.07	–0.19	–0.06	–0.17	–0.04	0.03	0.03
Selection index	–0.13	–0.04	–0.14	–0.05	–0.18	0.02	–0.22	0.01	0.07	0.08

* – $P \leq 0.05$.

Table 4. Correlation coefficients between growth rate, backfat thickness and meatiness of gilts and their subsequent reproductive performance (three parities)

Traits	No. of piglets born	No. of piglets born alive	No. of piglets born dead	No. of piglets at 21 days	Piglet mortality to 21 days	No. of weaned piglets	Piglet mortality to weaning	Litter weight at 21 days	Body weight of piglet at 21 days	Litter weight at weaning
Body weight of gilts:										
at 21 days of age	0.03	–0.02	0.05	–0.01	0.01	0.02	–0.06	0.11	0.20	0.19
at 30 days of age	0.05	0.06	–0.05	0.08	–0.04	0.10	–0.10	0.21	0.23	0.22
at 63 days of age	–0.17	–0.21	–0.00	–0.15	–0.13	–0.14	–0.15	–0.18	–0.05	–0.00
at 180 days of age	–0.09	–0.07	–0.06	–0.11	0.11	–0.06	–0.02	–0.07	0.09	0.14
Daily weight gain to 180 days of age	–0.08	–0.07	–0.04	–0.09	0.08	–0.04	–0.05	–0.04	0.10	0.16
Daily weight gain in test	–0.02	0.02	–0.08	–0.7	0.23	–0.01	0.08	–0.01	0.13	0.14
Feed intake per kg gain in test	–0.12	–0.08	–0.12	0.02	–0.23	–0.02	–0.11	0.09	0.12	0.10
Backfat thickness at P_2	0.24	0.17	0.19	0.09	0.14	0.07	0.14	–0.09	–0.24	–0.12
Backfat thickness at P_4	0.18	0.17	0.07	0.16	–0.00	0.17	–0.04	0.02	–0.17	–0.13
Average backfat thickness (P_2 and P_4)	0.18	0.19	0.04	0.15	0.04	0.15	0.00	–0.00	–0.17	–0.09
Height of l*ongissimus* muscle	–0.43**	–0.37**	–0.25	–0.35**	0.03	–0.34**	0.04	–0.32**	–0.08	–0.05
Lean meat (%)	–0.43**	–0.36**	–0.26	–0.31*	–0.05	–0.30*	–0.03	–0.15	0.13	0.08
Selection index	–0.44**	–0.37**	–0.26	–0.34**	0.00	–0.30*	–0.04	–0.17	0.01	0.15

* – $P \leq 0.05$; ** – $P \leq 0.01$.

Discussion

Mean values of the traits analysed in the Polish synthetic line 990 gilts do not differ from the results presented in the Report on pig breeding in Poland (2004). During the period of three consecutive reproduction cycles, the sows were characterized by good parameters. The Polish synthetic line 990 is a sire component, while sows of this line are usually characterized by slightly lower reproductiveness. A clear increase in litter size between the first and subsequent farrowings in sows is a regularity because of the known relationships between litter number and breeding performance indices (Kapelański et al., 2000).

Reproductive problems have been observed in sows for many years, both in Poland and abroad. In the opinion of many authors, the introduction of gilts into a breeding herd is associated with mating problems, smaller number of piglets born in the first litter, long weaning-to-oestrus interval as well as high culling rate before mating and after first farrowing (Bečkova et al., 2005; Everaert et al., 2007). At present, gilts are characterized by high body weight gains, as a result of which increasingly young gilts are being bred (Walkiewicz et al., 2004). Attention has been called to the necessity of reaching minimum levels of body weight and fatness in gilts at a given age. It is believed that fatness is a necessary, though not the only, condition for high breeding performance in the future (Rozeboom et al., 1996).

It has been found in some studies that the rate of growth from birth to 100 kg body weight affects many reproductive traits. Body weight in the early period of animal life can be one of the criteria for preliminary classification of gilts for reproduction (Kapelański et al., 1985). According to King (1989), body weight of gilts on day 165 of age affects more ovulation level than backfat thickness. Gilts with a higher growth rate had a subsequent larger litter size, shorter weaning-to-first service interval and sometimes higher farrowing rate as sows compared to gilts with a lower growth rate (Tummaruk et al., 2001). Bečkova et al. (2005) showed that gilts with a body weight gain of 675.6 g and more (from birth to the end of performance test) delivered more live-born piglets per litter (12.2) when compared with those with a gain of 553.1 g and less (9.8 piglets). On the other hand, Ruitz-Flores and Johnson (2001) reported a strong positive direct genetic correlation between birth weight and ovulation rate at puberty (0.44).

In the present study, no significant correlations were found between the body weight of gilts in respective ages (on day 21, 30, 63 and 180) or the growth rate to day 180 of age and the traits of their further reproductive performance. This was perhaps caused by small differences between gilts selected for reproduction. However, it should be emphasized that positive relationships were found between the backfat thickness during that time period and the number of total born and live-born piglets in the first three litters altogether (0.18 and 0.19, respectively). At the same time, significant ($P \leq 0.01$) negative relationships were found between the meatiness of gilts in performance test and their further breeding performance (from –0.34 to –0.43). This would indicate that the increase of meatiness in gilts is a significant parameter that determines the further course of their reproductive functions.

For many years, attention has been paid to genetic antagonisms occurring between reproductive traits and meatiness. In some studies, relatively high (from 0.13 to 0.25) positive genetic correlations were found between backfat thickness and litter size (Johansson and Kennedy, 1983; Čechová and Buchta, 1995; Karsten et al., 2000; Chen et al., 2003). However, the results are not consistent. The relationships found by Bereskin (1984) and Peškovičova et al. (2002) between backfat thickness and reproductive traits were low with a variable sign. Such different results can be caused by differences in the level of sow performance resulting from genetic variabilities, metabolic efficiencies and various maintenance conditions and evaluation methods.

Johansson and Kennedy (1983) and Kersey DeNise et al. (1983) suggested that an increase in carcass leanness results in deterioration of reproductive performance due to deterioration in the body's ability for lipid mobilization during gestation or the suckling period. These sows with a high predisposition for mobilization of body fat realized significantly highest rearing performance (Wähner et al., 2001). In an earlier work, Wähner et al. (1995) observed that gilts with high backfat show higher ovarian activity (higher concentration of 17β-estradiol) with more follicles compared with those having low backfat.

Bečkova et al. (2005) showed that gilts with higher meatiness before mating delivered less total born and live-born piglets in litters and had lower litter weight on day 21. On the other hand, no relationships were found between meatiness measured in performance test and reproductive performance. According to these authors, it is necessary to provide a sufficient source of energy in the feeding for the growth of fat tissue since gilts, after completing the performance test, are not fully mature and their growth is not completed either; meatiness, however, should be maintained at the same level.

Viewing backfat thickness as a source of energy for the sow, one could expect that backfat thickness would play a role in the sow's rebreeding capacity (Holm et al., 2004). Pig selection towards high lean meat gain in carcass may be a reason for poorer breeding performance results in sows and their premature culling (Young et al., 1991; Łyczyński et al., 2000). Therefore, the ongoing selection must be paralleled by accurate balancing of the nutritional needs of sows such that fat reserves and animal condition are optimal (Jarczyk et al., 2003).

In conclusion, it can be stated that meatiness level in gilts is a significant parameter that determines the further course of their reproductive functions.

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Zależności między cechami wzrostu, otłuszczenia i mięsności loszek a ich późniejszą użytkowością rozpłodową

STRESZCZENIE

Badania przeprowadzono na 79 loszkach linii 990, pochodzących z miotów matek, które rodziły 12 i więcej prosiąt w miotach oraz utrzymywanych w tych samych warunkach środowiska i w tym samym okresie. Oceniono ich przyrosty w okresie wzrostu oraz otłuszczenie i mięsność w 180. dniu życia. Nie stwierdzono istotnych korelacji pomiędzy masą ciała loszek w poszczególnych okresach życia (w 21., 30., 63. i 180. dniu) i tempem wzrostu do 180. dnia życia a cechami ich późniejszej użytkowości rozpłodowej. Wykazano natomiast dodatnie zależności pomiędzy grubością słoniny w 180. dniu ich życia a liczbą prosiąt urodzonych ogółem i żywych, łącznie w trzech pierwszych miotach (odpowiednio: 0,18, 0,19) oraz statystycznie istotne ($P \leq 0,01$) ujemne zależności pomiędzy mięsnością loszek w ocenie przyżyciowej a ich późniejszą użytkowością rozpłodową (od –0,34 do –0,43). Wskazywałoby to, iż wzrost mięsności u loszek jest parametrem istotnym, decydującym o dalszym przebiegu ich funkcji reprodukcyjnych.