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Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

# Relationship of backfat thickness with growth and development of the reproductive tract in Polish white gilts

**Hanna Jankowiak*, Wojciech Kapelański, Maria Bocian**

UTP University of Science and Technology, Department of Animal Breeding,
Mazowiecka 28, 85-084 Bydgoszcz, Poland

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**The aim of the study was to examine how the morphometric characteristics of the reproductive tract are related to backfat thickness in growing gilts. Our research involved 100 Polish Large White and 100 Polish Landrace gilts tested at a pig testing station. After slaughter, the reproductive tract was dissected and each element was measured and weighed. All gilts of both breeds were partitioned into three groups according to average backfat thickness of 5 measurements along the spine: ≤12.5 mm (I), from 12.6 to 15.0 mm (II), and >15.0 mm (III). Gilts with thicker backfat had slightly higher age at slaughter (I vs. II; p≤0.05), and significantly less meat in carcasses (I vs. II, vs. III p≤0.01). The gilts with the thinnest backfat had less favourable morphometric characteristics of the uterus compared to gilts of thicker backfat. The cervix was longer (p≤0.01) in more fatty gilts. The characteristics of the ovaries were clearly more advantageous in gilts with thicker fat in terms of the volume of both ovaries (p≤0.01). Highly significant positive correlations were found between backfat thickness and the weight of the uterus (with and without ligament), and the length of the cervix. The correlations between fatness and ovarian parameters did not reach statistical significance. The results indicate favourable correlations between the processes that create the energy balance and the reproductive tract of growing gilts.**

**KEY WORDS: gilts / backfat thickness classes / reproductive tract / morphometrics**

Improving the efficiency of breeding sows involves various aspects of research on their ability to deliver multiple births and produce numerous offspring. Some researches show that both the achieved genetic improvement of the slaughter value and

*Corresponding author: jankowiak@utp.edu.pl

the increase of meatiness of currently bred pigs reduce the reproductive performance of sows [Eliasson *et al.* 1991, Rydhmer *et al.* 1994]. This would suggest that reducing the fatness of the carcass is not beneficial for creating highly fertile sows. The importance of backfat thickness in gilts allotted to breeding is indicated in the research discussed by Roonsgitthichai and Tummaruk [2014] and Kim *et al.* [2015]. Animals with thicker backfat reached sexual maturity earlier, delivered more and bigger litters, and were removed from the herd later than sows with thinner backfat. Also, results obtained by Vallet et al. [2015, 2016] suggest that key components of litter environment in which gilts are grown, affect the subsequent performance and reproductive traits. Backfat accretion in gilts during growth was significantly associated with their preweaning growth rate [Vallet *et al.* 2016].

Many researchers agree that the most important factor predicting high reproductive performance of sows is a properly formed and functional reproductive tract [Wu *et al.* 1987, Chen and Dziuk 1993, Vallet 2000]. The work of Kapelański *et al.* [2013b] on the morphometric characteristics of the reproductive tracts of gilts before puberty in relation to their age and growth rate are significant for the prediction of potential fertility and possible usage in selection.

To reach our goal of examining how the reduction of fat cover in modern pig breeds affects their reproductive tract development we evaluated the relationships between anatomical characteristics of the reproductive tract of the gilts sampled from full-sib gilt families to be tested at a pig testing station and carcass backfat thickness.

## Material and methods

The study included 200 Polish white gilts from the two main maternal breeds: 100 Polish Large White (PLW) and 100 Polish Landrace (PL). The sampled animals were progeny of 50 sows and 25 boars (4 gilts from 1 boar and 2 sows); all were tested at a pig testing station. The feeding diets and maintenance were the same for all animals and consistent with the methodology developed for the testing stations [Różycki and Tyra 2010]. The growth rate of the pigs was routinely monitored from 30 to 100 kg of body weight.

The animals were slaughtered at an average body weight of 100 kg. The fattening traits evaluated were age at slaughter, average daily weight gain and feed consumption per 1 kg of weight gain. The slaughter traits considered were average backfat thickness of five measurements along the spine and the percentage of meat in the carcass.

Complete reproductive organs for the morphometric examinations were gained immediately after slaughter. They covered the weight of the uterus with and without broad ligament and measurements of cervical length, lengths of the uterine horns and lengths of the oviducts.

In order to obtain a more comprehensive description of the uterus, the ratio of the weight of uterus without ligament to the length of the horns, which characterizes uterus wall thickness, was calculated (g/cm). Volumetric capacity of the uterus was measured by filling it with physiological saline, then determining its volume according to the methodology described by Kapelański *et al.* [2013a]. The weights of the ovaries were determined, too. The volume of the ovaries was measured by immersion in a calibrated measuring cylinder with a defined volume of the physiological liquid. The gilts were considered a single population as no difference due to breed in backfat thickness was stated.

In order to estimate the relationship between fatness of gilts and morphometric characteristics of the reproductive tract, they were divided into three groups. The criterion for the division of the gilts was the average backfat thickness as a series of interval distributors: group I – ≤12.5 (mm), group II – 12.6-15.0 (mm), group III – >15.0 (mm).

The results were statistically analysed using one-way ANOVA according to the following model:

$$y_{ij} = \mu + M_i + e_{ij}$$

where:

$y_{ij}$ – trait of ij-this sow;

$\mu$ – overall mean;

$M_i$ – fixed effect of i-th fatness interval (i = I – ≤12.5 mm, II – 12.6-15.0 mm, III –>15.0 mm);

$e_{ij}$ – random error.

For the three groups created as a result of partitioning the animal material between the levels of the backfat thickness effect the least significant difference test was conducted for comparison of pairs of means. The Pearson's correlations between the overall backfat thickness of gilts and the morphometric parameters of the reproductive tract were estimated, as well. All calculations were conducted using Statistica PL.8.0 data analysis software [StatSoft Inc. STATISTICA 2008].

## Results and discussion

The characteristics of the fattening and slaughter value of the gilts are shown in Table 1. The age at which the gilts reached weight of 100 kg was lowest in the group of the thinnest backfat. The average daily gains during the tests were directly proportional to backfat thickness. The meat content in the carcass, naturally, was inversely proportional to the degree of fatness – gilts with the thinnest backfat had the leanest carcasses. The average backfat thickness in particular thickness classes differed significantly from 10.92 mm to 13.70 mm and to 17.36 mm ($p \leq 0.01$), which supports the correctness of the division into backfat thickness groups. As the backfat thickness increased meat content dropped parallel from 62.11% to 60.06% and to 57.76% ($p \leq 0.01$).

Backfat thickness affects several reproductive traits, especially at first oestrus and gestation [Tummaruk *et al*. 2007, Kim *et al*. 2015, Roonsgitthichai and Tummaruk

**Table 1**. Characteristics of fattening and slaughter value of gilts in relation to their fatness

| Trait | Average backfat thickness of 5 measurements (mm) | | | | | |
|---|---|---|---|---|---|---|
| | ≤12.5 (n=65) | | 12.6-15.0 (n=75) | | >15.0 (n=60) | |
| | mean | SD | mean | SD | mean | SD |
| Age at slaughter (days) | 164.81[a] | 19.80 | 171.61[b] | 15.38 | 169.00 | 19.17 |
| Daily gains (g/day) | 919[a] | 139 | 923 | 116 | 964[b] | 117 |
| Feed efficiency (kg/kg) | 2.51 | 0.38 | 2.62 | 0.35 | 2.61 | 0.40 |
| Av. backfat thickness (mm) | 10.92[A] | 1.42 | 13.70[B] | 0.67 | 17.36[C] | 2.87 |
| Meat in carcass (%) | 62.11[A] | 2.58 | 60.06[B] | 2.47 | 57.76[C] | 2.76 |

[aA...] Within rows means bearing different superscripts differ significantly at: small letters – $p \leq 0.05$; capitals – $p \leq 0.01$.

2014], but also important is the well developed reproductive tract in growing gilts [Chen and Dziuk 1993, Vallet 2000, Wu *et al*. 1987].

Table 2 shows the weight and dimensions of the uterus across the three backfat thickness classes of gilts. Significant differences in the studied traits of the reproductive tract were found in relation to the mean values for gilts from group I compared to group II. Animals with thicker fat cover had more advantageous parameters of particular sections of the reproductive tract, including increased uterus weight (with and without ligaments) and significantly longer cervix ($p \leq 0.01$). The length of the uterine horns of gilts was not correlated to backfat thickness due to large individual variation of this trait in the gilts.

**Table 2**. Weight and dimensions of the uterus

| Trait | Average backfat thickness of 5 measurements (mm) | | | | | |
|---|---|---|---|---|---|---|
| | ≤12.5 | | 12.6-15.0 | | >15.0 | |
| | mean | SD | mean | SD | mean | SD |
| Uterine weight with ligament (g) | 142.25[a] | 49.23 | 165.15[b] | 75.72 | 160.31 | 63.93 |
| Uterine weight without ligament (g) | 124.95[a] | 46.00 | 146.96[b] | 69.64 | 141.04 | 60.01 |
| Cervical length (cm) | 11.67[Aa] | 1.85 | 13.08[B] | 2.60 | 12.59[b] | 2.09 |
| Length of uterine horns* (cm) | 95.84 | 14.04 | 99.33 | 17.80 | 100.52 | 21.44 |
| Weight/length of horns (g/cm) | 1.30[a] | 0.39 | 1.51[b] | 0.61 | 1.41 | 0.55 |
| Uterine capacity ($cm^3$) | 134.62 | 58.35 | 151.39 | 72.29 | 145.83 | 66.88 |

[aA...] Within rows means bearing different superscripts differ significantly at: small letters – $p \leq 0.05$; capitals – $p \leq 0.01$.
*/ – Sum of both horns.

It is worth noting that the ratio between uterus weight without the ligament to the length of its horns indirectly determines the thickness of the wall of the uterus. This value represented favourable physiological uterus development of gilts with moderate and thicker fat cover ($p \leq 0.01$). The results may help predict the reproductive efficiency based on morphometric indices of the reproductive tract of gilts before puberty in relation to their backfat thickness.

The results concerning the oviducts and ovaries of gilts that differ in backfat thickness are shown in Table 3. The observed differences in measurements of ovaries

**Table 3**. Characteristics of oviducts and ovaries

| Trait | Average backfat thickness of 5 measurements (mm) | | | | | |
|---|---|---|---|---|---|---|
| | I | | II | | III | |
| | ≤12.5 | | 12.6-15.0 | | >15.0 | |
| | mean | SD | mean | SD | mean | SD |
| Length of the right oviduct (cm) | 19.15 | 3.12 | 19.76 | 4.30 | 19.64 | 3.47 |
| Length of the left oviduct (cm) | 20.04 | 2.94 | 20.81 | 3.79 | 20.84 | 3.32 |
| Weight of the right ovary (g) | 3.37 | 0.91 | 3.27 | 0.95 | 3.57 | 1.03 |
| Weight of the left ovary (g) | 3.89 | 1.09 | 3.64 | 1.13 | 3.90 | 1.09 |
| Weight of both ovaries (g) | 7.27 | 1.81 | 6.92 | 1.97 | 7.46 | 2.01 |
| Right ovary volume ($cm^3$) | 2.56 | 0.92 | $2.28^{a}$ | 0.95 | $2.66^{b}$ | 1.21 |
| Left ovary volume ($cm^3$) | $2.87^{a}$ | 1.20 | $2.45^{Ab}$ | 1.18 | $3.03^{B}$ | 1.12 |
| Both ovaries' volume ($cm^3$) | 5.43 | 1.98 | $4.74^{A}$ | 2.05 | $5.70^{B}$ | 2.22 |

$^{aA...}$ Within rows means bearing different superscripts differ significantly at: small letters – p≤0.05; capitals – p≤0.01.

were related to gilts of medium fatness from group II and the fattest gilts from group III. In gilts from group III the ovaries were more voluminous (p≤0.01). It may indicate correlation between fat metabolism and the reproductive tract growth in the fattest gilts [Dufour *et al.* 1985].

The correlations between the average backfat thickness in gilts and the traits of their reproductive tract are presented in Table 4. Significant relationship concerned the uterine weight with ligament (p≤0.01), without ligament (p≤0.01), cervical length (p≤0.01) and the proportion of the uterus mass to the length of its horns (p≤0.01) – the fatter the gilts the bigger the reproductive tract. The weight and volume of the ovaries, however, were not univocally related to backfat thickness.

**Table 4**. Correlation coefficients between backfat thickness and reproductive tract morphometric traits of gilts'

| Morphometric traits | Average backfat thickness of 5 measurements (mm) |
|---|---|
| Uterine weight with ligament (g) | $0.214^{xx}$ |
| Uterine weight without ligament (g) | $0.218^{xx}$ |
| Cervical length (cm) | $0.220^{xx}$ |
| Length of uterine horns* (cm) | 0.119 |
| Weight/length of horns (g/cm) | $0.277^{xx}$ |
| Uterine capacity ($cm^3$) | 0.081 |
| Length of the right oviduct (cm) | 0.037 |
| Length of the left oviduct (cm) | 0.070 |
| Length of both oviducts (cm) | 0.055 |
| Weight of the right ovary (g) | $0.147^{x}$ |
| Weight of the left ovary (g) | 0.093 |
| Weight of both ovaries (g) | 0.126 |
| Right ovary volume ($cm^3$) | 0.114 |
| Left ovary volume ($cm^3$) | 0.128 |
| Both ovaries' volume ($cm^3$) | 0.128 |

$^{x}$p≤0.05; $^{xx}$p≤0.01. */ – Sum of both horns.

The results of our research concerning the relationship between backfat thickness and the growth and development of the reproductive tract in growing gilts indicate favourable relation between metabolism leading to the deposition of fat and the processes that form the reproductive tract. Opinions on the beneficial influence of fatty tissue storage on the reproductive usefulness of sows are justified by the fact that the expenditure of energy needed to produce a large foetal mass in late pregnancy and sufficient quantity and quality of milk for piglets during lactation far exceeds the energy capacity of feed. It is for this reason that gilts start using the reserves of energy contained in fatty tissue [Kapelanska *et al*. 2012, Tummaruk *et al*. 2007].

As suggested by some authors the gilt's performance and reproductive competence is associated a great deal with conditions of prenatal development, uterine capacity, birth weight, preweaning growth rate, and with backfat accretion [Freking *et al.* 2016, Lents *et al.* 2014, Vallet *et al.* 2015, 2016]. It is assumed that the dynamic metabolism of various tissues and organs, including the reproductive tract of gilts, requires interaction with important regulators of fat metabolism. This is indicated by the studies of many authors [Houseknecht and Portocerrero 1998, Bogacki and Kotwica 2002, Madeja *et al.* 2002].

The results of this research concerning the relationship between average backfat thickness and the growth and development of the reproductive tract show a meaningful correlation between the process of forming the body energy balance and the reproductive tract in growing gilts.

**REFERENCES**

1. BOGACKI M., KOTWICA J., 2002 – Leptyna w procesach metabolizmu i rozrodu (Leptin in metabolic and reproductive processes). In Polish with English summary. ***Medycyna Weterynaryjna*** 58(9), 666-669.
2. CHEN Z.Y., DZIUK P.J., 1993 – Influence of initial length of uterus per embryo and gestation stage on prenatal survival, development, and sex ratio in the pig. ***Journal of Animal Science*** 71(7), 1895-1901.
3. DUFOUR J., FAHMY J., FILPOT P.M., 1985 – Follicular development during the prepubertal period of different morphological types of ovaries in Hampshire and Yorkshire gilts fed two planes of nutrition. ***Journal of Animal Science*** 61, 1201-1210.
4. ELIASSON L., RYDHMER L., EINARSSON S., ANDERSSON K., 1991 – Relationships between puberty and production traits in the gilt. 1. Age at puberty. ***Animal Reproduction Science*** 25, 143-154.
5. FREKING B.A., LENTS C.A., VALLET J.L., 2016 – Selection for uterine capacity improves lifetime productivity of sows. ***Animal Reproduction Science*** 167, 16-21.
6. HOUSEKNECHT K.L., PORTOCARRERO C.P., 1998 – Leptin and its receptors: Regulators of whole-body energy homeostasis. ***Domestic Animal Endocrinology*** 15, 457-475.
7. KAPELANSKA J., GRAJEWSKA S., BOCIAN M., JANKOWIAK H., KAPELANSKI W., 2012 – Carcass and meat quality of primiparous sows as related to the lactation period of 21 or 28 days and to body weight loss. ***Acta Veterinaria Brno*** 81, 255-260.
8. KAPELAŃSKI W., JANKOWIAK H., BOCIAN M., GRAJEWSKA S., DYBAŁA J., CEBULSKA A., 2013a – The effect of the growth rate and meatiness of young gilts during rearing on the growth and development of the reproductive system. ***Acta Veterinaria Brno*** 82(1), 19-24.

9. KAPELAŃSKI W., JANKOWIAK H., BOCIAN M., GRAJEWSKA S., DYBAŁA J., ZMUDZIŃSKA A., 2013b – Morphometric characteristics of the reproductive system in Polish Large White and Polish Landrace gilts at 100 kg body weight. ***Annals of Animal Science*** 13(1), 45-53.
10. KIM J.S., YANG X., PANGENI D., BAIDOO S.K., 2015 – Relationship between backfat thickness of sows during late gestation and reproductive efficiency at different parities. ***Acta Agiculturae Scandinavica*** Section A. 65(1), 1-8.
11. LENTS C.A., CUSHMAN R.A., FREKING B.A., 2014 – Measures of the ovaries and uterus during development of gilts selected for differences in uterine capacity. ***Journal of Animal Science*** 92, 2433-2439.
12. MADEJA Z., PIASECKA A., LECHNIAK D., ŚWITOŃSKI M., 2002 – Leptyna-polimorfizm genetyczny i rola w rozrodzie (Leptin and its role in reproduction and gene polymorphism). In Polish with English summary. ***Medycyna Weterynaryjna*** 58(8), 572-576.
13. ROONGITTHICHAI A., TUMMARUK P., 2014 – Importance of backfat thickness to reproductive performance in female pigs**. *Thai Journal of Veterinary Medicine*** 44(2), 171-178.
14. ROSENDO A., CANARIO L., DRUET T., GOGUE J., BIDANEL J.P., 2007 – Correlated responses of pre- and postweaning growth and backfat thickness to six generations of selection for ovulation rate or prenatal survival in French Large White pigs. ***Journal of Animal Science*** 85, 3209-3217.
15. RYDHMER L., ELIASSON-SELLING L., JOHANSSON K., STERN S., ANDERSSON K., 1994 – A genetic study of estrus symptoms at puberty and their relationship to growth and leanness in gilts. ***Journal of Animal Science*** 72(8), 1964-1970.
16. RÓŻYCKI M., TYRA M., 2010 – Metodyka oceny wartości tucznej i rzeźnej świń przeprowadzana w Stacjach Kontroli Użytkowości Rzeźnej Trzody Chlewnej (SKURTCh) **(**Methodology for tested fattening and slaughter value at Pig Testing Station SKURTCh). In Polish. IZ PIB, Kraków, XXVIII, 93-117.
17. STATISTICA 2008. StatSoft, Inc. (data analysis software system), version 8.0.
18. TUMMARUK P., TANTASUPARUK W., TECHAKUMPHU M., KUNAVONGKRIT A., 2007 – Age, body weight and backfat thickness at first observed oestrus in crossbred Landrace x Yorkshire gilts, seasonal variations and their influence on subsequence reproductive performance. ***Animal Reproduction Science*** 99, 167-181.
19. VALLET J.L., 2000 – Fetal erythropoiesis and other factors which influence uterine capacity in swine. ***Journal of Applied Animal Research*** 17, 1-26.
20. VALLET J.L., CALDERÓN-DÍAZ J.A., STALDER K.J., PHILLIPS C., CUSHMAN R.A., MILES J.R., REMPEL L.A., ROHRER G.A., LENTS C.A., FREKING B.A., NONNEMAN D.J., 2016 – Litter-of-origin trait effects on gilt development. ***Journal of Animal Science*** 94, 2015-9644.
21. VALLET J.L., MILES J.R., REMPEL L.A., NONNEMAN D.J., LENTS C.A., 2015 – Relationship between day one piglet serum immunoglobulin immunocrit and subsequent growth, puberty attainment, litter size, and lactation performance. ***Journal of Animal Science*** 93, 2722-2729.
22. WU M.C., HENTZEL M.D., DZIUK P.J., 1987 – Relationships between uterine length and number of foetuses and prenatal mortality in pigs. ***Journal of Animal Science*** 65(3), 762-770.