

## **ANALYSIS OF SEXUAL ACTIVITY IN GILTS IN TERMS OF THEIR REPRODUCTIVE VALUE**

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### **Abstract**

The effect of the level of sexual activity in Pulawska gilts on their reproductive performance in the first reproductive cycle was investigated. Gilts were kept in herds included in the Genetic Resources Conservation Programme for Pulawska Pigs. Females were divided into 3 groups according to their response to the back-pressure test, the riding test and the standing reflex with a boar present (group A, n = 40; group B, n = 36; group C, n = 32). The results of behavioural responses were referred to plasma leptin levels, indicators of potential and actual fertility, and chemical composition of the colostrum and milk. Gilts' sexual activity was found to have a significant effect on the duration of the standing reflex and some traits of the reproductive system and potential fertility. Gilts with high sexual activity took significantly longer (by 17.08 h) to show lordosis reflex compared to gilts with low sexual activity. These females were characterized by significantly higher uterine weight and length of uterine horns, and the highest number of corpora lutea in ovaries compared to gilts exhibiting low sexual drive. A lower proportion of leptin (3.60–3.62 ng/ml) was observed in the groups of females that were high and intermediate on the scale of sexual activity. Actual fertility, piglet rearing performance and chemical composition of milk in the first reproductive cycle were unrelated to the strength of oestrus signs in gilts.

**Key words:** gilts, oestrous behaviour, reproductive performance, leptin, Pulawska breed

The domestic pig is considered to be a polyestrous, non-seasonal and multiparous species. In healthy and correctly fed gilts, oestrus recurs periodically throughout the year. Oestrus is directly associated with specific behaviours that determine the level of sexual activity in the female. The intensity of perioestrous behaviours is an important factor of the conception rate (Pedersen, 2007). Gilts and sows in which oestrus occurs without showing any outward signs generally have a prolonged farrowing interval due to the low conception rate (McGlone and Fullwood, 2001). Signs of oestrus are directly related to the attainment of sexual maturity. First signs of oestrus

are observed in gilts older than 4 months but the behaviours displayed are usually vague. During that period, gilts are rarely willing to be in contact with boars (Stasiak et al., 2006). Premature mating of gilts, even those that show proper sexual behaviour responses, may result in a marked decrease in reproductive parameters. When detecting oestrus, rather than treating the herd as a group of gilts each female should be treated individually due to high individual variation in the sexual behaviours manifested (Brooks and Smith, 1980; Holder et al., 1995). Therefore, it is necessary to account for several factors, including the genetically determined susceptibility of the pigs to stress. It is assumed that stress-susceptible pigs (*RYR1<sup>T</sup>*) may exhibit lower reproductive value (Matoušek et al., 2003). This is why monitoring of different populations for the *RYR1* locus is helpful when choosing animals for mating (Kmieć et al., 2000). In breeding practice, the degree to which gilts and sows show oestrus signs is regarded as an important factor for attaining high reproductive performance. Sexual behaviour disorders are most often traceable to the body's hormonal metabolism, which also involves leptin (Barb et al., 2005). The Puławska breed has been recommended for this type of research on account of the status of the breed, which is recognized as a maternal component in the commercial crossbreeding of pigs.

The objective of the observations and analyses was to determine the interactions of sexual activity, leptin levels and selected traits of reproductive performance in gilts with identified genotype at the *RYR1* locus.

## Material and methods

Subjects were Puławska gilts raised in the Lublin region. Females originated from herds included in the Genetic Resources Conservation Programme for Puławska Pigs. Housing conditions conformed to animal welfare standards and nutrition complied with breeding standards. Gilts were kept in groups of 3 to 5 in pens with an area of 1.65 m<sup>2</sup> per animal. One kg of the ration contained 15.8% crude protein, 12.72 MJ/kg metabolizable energy and 4.08% crude fibre. Analysis was made of the second oestrus as the optimum time for mating gilts of maternal breeds. The experiment was conducted in two stages.

In stage 1, the breed populations were monitored for the *RYR1* locus.

The gilts' hair roots were used as the biological material. DNA was isolated using a Sherlock AX kit (A&A Biotechnology) following the manufacturer's procedure. PCR was performed in a PTC-200 Peltier thermal cycler (MJ Research). Polymorphism at the *RYR1* locus was determined using PCR-RLFP (Fujii et al., 1991). A total of 108 Puławska gilts with the *RYR1 C/C* genotype were chosen for the next stage, which follows breeding trends.

In stage 2, sexual activity, plasma leptin levels and parameters of maternal traits defined in the first reproductive cycle were subjected to comparative analysis.

Observations of sexual behaviour were initiated when the gilts reached five months of age. Gilts were divided into groups according to the intensity of oestrus signs and the response to the back-pressure test, the riding test and the standing re-

flex in front of a boar, which were evaluated on a 3-point scale: A – gilts showing very clear signs of oestrus and responding to the riding test and the boar for at least 60 seconds (40 animals) – score of 3 points; B – gilts showing clear signs of oestrus and responding to the riding test and the boar for 30 seconds (36 animals) – 2 points; C – gilts exhibiting weak signs of oestrus and responding to the riding test and the boar for up to 5 seconds (32 animals) – 1 point.

Gilts were checked for oestrus twice daily (after the morning and afternoon feeding) with a teaser boar. Plasma leptin concentrations were determined by radioimmunoassay using a Multi-Species Leptin RIA Kit (Linco Research), according to the manufacturer's protocol. Gilts were sampled during the standing reflex in their second oestrus, until 12 h after signs of oestrus were observed. To eliminate the effect of fatness on leptin levels, gilts with a backfat thickness of 13.0–15.5 mm (PIGLOG 105 measurement) were selected for the analysis.

Reproductive maturity of the gilts covered parameters such as age at second oestrus (days), body weight on the day of second oestrus (kg), and duration of the standing reflex (h). To determine the reproductive potential, 10 gilts from each of the groups (A, B and C) were slaughtered at the meat plant between 5 and 10 days after signs of oestrus were no longer apparent. The following parameters were determined: uterine weight (g), weight of ovaries (g): right ovarian weight (g) and left ovarian weight (g), length of uterine horns (cm): length of right uterine horn (cm) and length of left uterine horn (cm), and number of corpora lutea in the right ovary and in the left ovary.

Gilts intended for reproduction were mated naturally in accordance with the mating programme for the Puławska breed. Reproductive value was estimated based on the parameters determined in the first reproductive cycle: age at first farrowing (days), number of piglets born alive per litter, number of piglets reared to 21 days of age, mean piglet weight per litter at 1, 7 and 21 days of age, and chemical composition of colostrum and milk.

Colostrum and milk were collected at 1, 7 and 21 days of lactation following intravenous administration of 15 i.u. of synthetic oxytocin. The same teat pairs were always used. A MilkoScan 104 instrument was used to determine the main ingredients of sow's milk: fat, protein, lactose, and solids.

Significant differences for the level of some productive traits were analysed by multivariate analysis of variance using the least squares method, taking into account the following statistical model:

$$y_{ijk} = \mu + i(hys) + a + r + bl + e_{ijk}$$

where:

- $y_{ijkl}$  – value of the observed trait,
- $\mu$  – mean value of a trait,
- $i(hys)$  – herd  $\times$  year  $\times$  season interaction,
- $a$  – regression coefficient on age of gilt,
- $r$  – fixed effect of oestrus intensity,
- $bl$  – effect of sire of litter,
- $e_{ijkl}$  – random error.

Significance of differences for leptin level was analysed by multivariate analysis of variance using the least squares method, taking into account the following statistical model:

$$y_{ijk} = \mu + i(hys) + a + r + bl + e_{ijk}$$

where:

- $y_{ijkl}$  – value of the observed trait,
- $\mu$  – mean value of a trait,
- $l$  – fixed effect of leptin measurement number,
- $r$  – fixed effect of oestrus intensity,
- $i(hys)$  – oestrus intensity  $\times$  herd interaction,
- $h$  – fixed effect of herd,
- $e_{ijkl}$  – random error.

Calculations were made using SAS statistical package. The level of analysed traits was presented as the least square means (LSM) while providing the value of standard errors (SE) that determine the reliability of estimates.

## Results

Table 1 gives the numerical data for age and body weight parameters found in the groups of gilts with different intensity of oestrus signs. These values remained at similar levels with non-significant differences. There was a tendency whereby gilts with low sexual activity (group C) were the last to reach second oestrus at 227.35 days of age.

Table 1. Indices of reproductive maturity in gilts

Item	Group A		Group B		Group C	
	LSM	SE	LSM	SE	LSM	SE
Age of gilt at second oestrus (days)	218.11	1.48	215.48	1.77	227.35	2.63
Weight of gilt at second oestrus (kg)	121.65	1.04	123.62	1.25	126.20	1.86
Duration of standing reflex (h)	53.67 A	1.97	50.63 A	2.35	36.59 B	3.49

A, B – means in rows with different letters differ significantly: A, B –  $P \leq 0.01$ .

Sexual activity of the gilts had a significant effect on the duration of standing reflex (Table 1). Females from group A showed the lordosis reflex for 53.67 h, which was significantly longer (by 17.08 h) compared to the gilts with weak signs of oestrus ( $P \leq 0.01$ ).

The effect of intensity of oestrous activity in the gilts was also apparent in relation to morphology of the reproductive system and indicators of potential fertility (Table 2). Gilts from group A were characterized by significantly higher uterine

weight and length of uterine horns compared to gilts exhibiting low sexual drive ( $P \leq 0.01$  and  $P \leq 0.05$ ). As regards the other anatomical characteristics of the reproductive system, higher reproductive potential was observed in gilts from group A. These values decreased with decreasing sexual activity and showed the following tendency: A (highest values) – B (intermediate values) – C (lowest values). The number of corpora lutea, which is regarded as the main indicator of potential fertility in gilts and sows, proved the highest in group A (14.83), being 1.25 higher compared to gilts from group C ( $P \leq 0.05$ ).

Table 2. Traits of the reproductive system and potential fertility in gilts

Item	Group A		Group B		Group C	
	LSM	SE	LSM	SE	LSM	SE
Uterine weight (g)	640.56 a	31.96	595.91 ab	29.30	537.57 b	35.91
Length of right uterine horn (cm)	65.95	2.11	55.54	1.77	56.12	2.46
Length of left uterine horn (cm)	63.39	2.51	55.65	1.74	56.06	2.42
Length of uterine horns (cm)	128.46 A	4.87	111.24 B	5.39	112.33 B	6.73
Right ovarian weight (g)	6.80	0.52	6.37	0.40	5.87	0.24
Left ovarian weight (g)	6.17	0.36	6.47	0.34	5.96	0.38
Weight of ovaries (g)	12.98	0.77	12.75	0.61	11.78	0.54
No. of corpora lutea – right ovary	7.28	0.31	7.02	0.30	6.42	0.25
No. of corpora lutea – left ovary	7.61	0.38	7.31	0.28	7.19	0.37
No. of corpora lutea – total	14.83 a	0.35	14.31 ab	0.52	13.58 b	0.29

a, A – means in rows with different letters differ significantly; a,b –  $P \leq 0.05$ ; A,B –  $P \leq 0.01$ .

The level of sexual activity in gilts was also determined by plasma leptin concentrations (Figure 1). The lowest proportion of leptin (3.60–3.62 ng/ml) was established in the groups of females with high and intermediate sexual activity. Gilts with weak signs of oestrus were characterized by the highest plasma leptin concentration of 4.31 ng/ml.

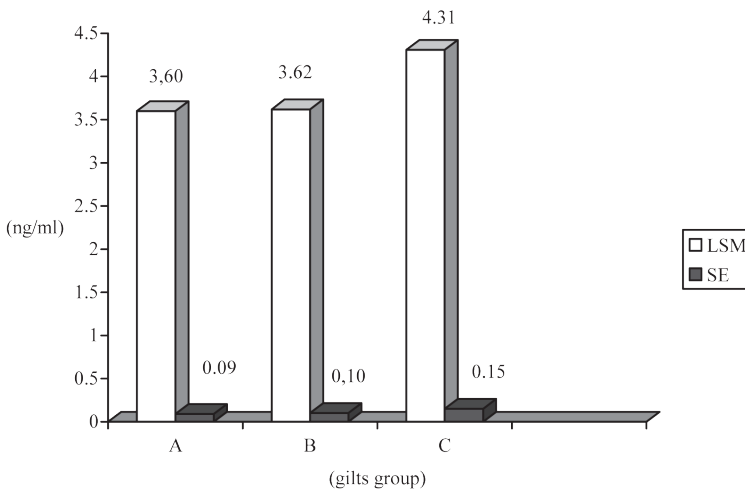


Figure 1. Plasma leptin concentration in gilts with different degrees of sexual activity

Sexual activity of the gilts was found to be related to the conception rate. In the group of gilts showing very clear signs of oestrus, conception rate (96.9%) was higher by 9.2% in relation to group C (Figure 2).

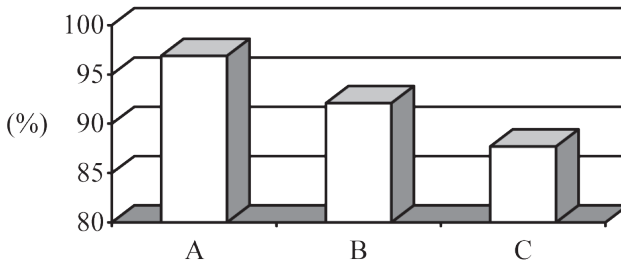


Figure 2. Conception rate in gilts

The results presented in Table 3 indicate that the level of sexual activity in the gilts had no significant effect on litter size at 1 and 21 days of age. The number of piglets born and reared per litter to 21 days of age was slightly lower in group C compared to groups A and B. Also the body weights of piglets in successive stages of rearing were unrelated to the intensity of oestrus signs in the sows.

Table 3. Indices of reproductive value in gilts showing different degrees of sexual activity

Parameter	Group A		Group B		Group C	
	LSM	SE	LSM	SE	LSM	SE
No. of piglets born alive per litter (head)	10.38	0.36	10.68	0.26	10.18	0.22
No. of piglets born (head)	5.60	0.26	5.76	0.30	6.41	0.41
No. of gilts born (head)	4.78	0.21	3.92	0.24	3.77	0.32
No. of piglets reared per litter to 21 days age (head)	9.52	0.21	9.73	0.24	9.38	0.34
Piglet weight on day 1 of age (g)	1173.60	23.93	1205.86	27.47	1224.10	38.56
Piglet weight on day 7 of age (g)	1975.40	23.61	2001.14	27.10	2019.07	38.04
Piglet weight on day 21 of age (g)	5025.09	102.59	4993.59	117.78	5272.60	165.30

Table 4 shows percentage chemical composition of gilts' colostrum and milk. With regard to different sampling periods, slightly higher parameters were found among gilts with the highest sexual activity (group A).

As regards the actual fertility noted in the subgroups of gilts with different durations of the standing reflex, it was high in the gilts in which oestrus lasted for 36 to 48 h (Table 5). An analogous distribution of values was noted for litter size at 21 days of age.

Table 4. Chemical composition of colostrum and milk from gilts showing different degrees of sexual activity

Proportion of ingredient (%) – day of lactation	Group A		Group B		Group C	
	LSM	SE	LSM	SE	LSM	SE
Solids – 1	22.01	0.41	21.57	0.29	21.55	0.25
Protein – 1	10.57	0.29	10.21	0.21	10.19	0.18
Fat – 1	7.84	0.30	7.86	0.21	7.58	0.18
Lactose – 1	3.55	0.14	3.48	0.10	3.53	0.09
Solids – 7	18.19	0.34	17.88	0.24	17.71	0.21
Protein – 7	6.23	0.17	6.02	0.12	6.01	0.11
Fat – 7	7.02	0.27	7.04	0.19	6.79	0.17
Lactose – 7	4.88	0.19	4.79	0.14	4.85	0.12
Solids – 21	17.21	0.33	17.21	0.24	17.14	0.21
Protein – 21	5.31	0.13	5.16	0.09	5.04	0.08
Fat – 21	6.54	0.26	6.78	0.19	6.76	0.16
Lactose – 21	5.35	0.21	5.25	0.15	5.31	0.13

Table 5. Actual fertility and number of piglets reared in relation to duration of standing reflex in gilts at second oestrus

Trait	Duration of oestrus									
	24 h		36 h		48 h		60 h		72 h	
	LSM	SE	LSM	SE	LSM	SE	LSM	SE	LSM	SE
No. of piglets born alive per litter (head)	10.39	0.41	10.59	0.27	10.64	0.36	9.89	0.28	10.04	0.44
No. of piglets per litter at 21 days of age (head)	9.94	0.29	10.20	0.28	10.22	0.33	9.29	0.31	9.44	0.30

## Discussion

The onset of sexual maturity in gilts is marked by a number of external symptoms and physiological changes known as oestrus (Cronin et al., 1982; Hixon et al., 1987). According to Stasiak et al. (2006), the first, spontaneous oestrus in gilts is closely correlated to the breed. An earlier oestrus is observed in gilts of maternal breeds (including the Landrace type), and a later oestrus in high-lean animals used as male parents (including Pietrain and Hampshire). When analysing Large White and Landrace gilts, Knauer (2009) found that the most favourable age at mating for these genetic groups is 211 days, with a body weight exceeding 130 kg.

Our study (Table 1) showed that second oestrus in Puławska gilts occurred between 215.48 and 227.35 of age with a body weight of 123.62–126.20 kg, which complies with farming standards. Puławska gilts were housed in a litter system and were allowed free movement in the pen, which could have a positive effect on sexual activity. McGlone and Fullwood (2001) observed that locomotor activity of gilts has a beneficial effect on their behaviour during both oestrus and pregnancy.

The observed Puławska gilts showed significantly different durations of the standing reflex, determined by the degree of sexual activity (Table 1, Figure 2). Most gilts were found to show characteristic signs of oestrus for 36 to 48 h, and the longest duration of the standing reflex was characteristic of females exhibiting distinct sexual behaviour (group A). When studying duration of the standing reflex, Weitze et al. (1992) showed that the largest proportion (60.4%) in the analysed group of 483 sows was formed by animals in which oestrus lasted between 48 and 64 h, with 14.3% of the sows showing shorter duration and 25.3% showing longer duration.

Gilts and sows have a very high reproductive potential, as evidenced by the number of oocytes, which ranges between 100,000 and 140,000 at the end of gametogenesis (Kauffold et al., 2004). The group of factors associated with reproductive potential also includes the size of reproductive organs. Uterine size and volume are even used as selection factors for improving actual fertility (Rillo et al., 2001; Viana et al., 2004). These parameters are influenced by gilt feeding, breed and housing system among others (Stasiak et al., 2006). Data shown in Table 2 suggest that traits of the reproductive system and potential fertility indices can also be differentiated by the level of sexual activity in females. This state of affairs may result from different intensities of the body's neurohormone metabolism (Jana et al., 2003). The sexual behaviour of gilts is controlled by oestrogens, the metabolism of which also involves leptin (Kędzierski, 2009). This hormone takes part in activating the hypothalamic-pituitary axis during synthesis of gonadotropins responsible for the normal course of sexual maturation processes (Schneider et al., 2000).

In our study, we did not show significant differences in the amount of leptin in relation to the scale of sexual activity in Puławska gilts, although gilts exhibiting low sexual drive had higher plasma leptin levels (Figure 1). Therefore, leptin can be ascribed a limited role in neurohormone metabolism as a factor affecting the sexual behaviour of females during the reproductive cycle. This type of research should be repeated using a greater number of test animals.

An important factor affecting the economic performance of breeding is the size of litters obtained from sows. Research shows that first-farrowing gilts have 5 to 10% lower fertility compared to multiparous sows (Koketsu, 2003). Reproductive efficiency is also definitely influenced by the duration of oestrus and thus the possibility of repeated mating or reinsemination in one sexual cycle. However, prolonged oestrous activity may cause ovarian dysfunction, resulting in decreased fertility (Koczanowski et al., 2004). In our study (Table 3), the largest litter size at 1 and 21 days of age was characteristic of gilts with clear signs of standing reflex (group B). Also the gilts whose oestrus signs lasted for 36 to 48 h showed higher reproductive parameters (Table 5).

An interesting tendency was observed for the main ingredients of colostrum and milk (Table 4). Gilts exhibiting higher sexual activity produced colostrum and milk with a higher concentration of nutrients compared to the other groups of gilts. This state of affairs may result from the role of prolactin, which not only stimulates the development of mammary glands and milk formation, but also shapes the sexual behaviour of females (Goncikowska, 2001).



The present study revealed important relationships for some of the traits studied. Gilts with very clear signs of oestrus were characterized by significantly longer duration of lordosis reflex, higher uterine weight and greater number of corpora lutea in ovaries. The intensity of sexual activity in gilts tended to be related to plasma leptin concentration and the level of potential and actual fertility indices. Gilts with the weakest signs of oestrus were characterized by higher plasma leptin levels and lower litter size at 1 and 21 days of age. The evidence obtained in this study could be used in breeding and production practice.

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### **Analiza aktywności płciowej loszek w aspekcie ich wartości rozrodczej**

#### STRESZCZENIE

Wykonano badania i analizy w kierunku ustalenia oddziaływania poziomu aktywności płciowej loszek rasy puławskiej na ich wartość rozrodczą w pierwszym cyklu reprodukcyjnym. Loszki utrzymywane były w stadach uczestniczących w Programie Ochrony Zasobów Genetycznych Świń Rasy Puławskiej. Samice uszeregowano w 3 grupy w zależności od reakcji na próbę dotyku, dosiadu i toleracji w odniesieniu do knura (grupa A n = 40, grupa B n = 36, grupa C n = 32). Wyniki reakcji behawioralnych odniesiono do poziomu leptyny w osoczu krwi, wskaźników płodności potencjalnej, rzeczywistej oraz składu chemicznego siary i mleka. Wskazano istotny wpływ aktywności płciowej loszek na czas trwania odruchu tolerancji oraz wybrane cechy układu rozrodczego i płodności potencjalnej. Loszki o wysokiej aktywności płciowej przejawiały odruch lordozy w czasie istotnie dłuższym o 17,08 godz. w porównaniu do loszek niskiej aktywności płciowej. Samice te charakteryzowały się istotnie wyższą masą macicy, długością rogów macicy oraz najwyższą liczbą ciałek żółtych zlokalizowanych na jajnikach w porównaniu do loszek o niskim libido. Niższy układ leptyny (3,60–3,62 ng/ml) zanotowano w grupach samic o wysokiej oraz średniej skali aktywności płciowej. Płodność rzeczywista, wyniki odchovu prosiąt oraz skład chemiczny mleka w pierwszym cyklu reprodukcyjnym nie wykazywały zależności od skali nasilenia objawów rujowych loszek.