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Association among Serum Insulin–like Growth Factor–I, Backfat Thickness, and Age at First Observed Estrus in Gilts

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Original Article

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Abstract

The present study investigated the association among serum insulin-like growth factor-I (IGF-I), backfat thickness, and age at first observed estrus in replacement gilts. In total, 80 replacement gilt, Landrace (L, n = 48) and Yorkshire (Y, n = 32), were included. The gilts were determined for age at first observed estrus between 167 to 212 days of age. They were categorized according to age at first observed estrus into ≤ 200 days (n = 41) and > 200 days (n = 36) groups. Backfat thickness, body weight, and serum IGF–I concentration were measured before mating. Age at first mating, interval from boar exposure to first observed estrus, and interval from entry-to-first-mating were recorded. It was found that the level of serum IGF–I negatively correlated with age at first observed estrus (r = -0.26, p = 0.022), as well as with interval from boar exposure to first observed estrus (r = -0.28, p = 0.015), but it positively correlated with backfat thickness (r = 0.37, p < 0.001). The gilts exhibiting first observed estrus at ≤ 200 days of age had higher serum IGF–I level (30.2±1.2 and 25.4±1.1 nmol/l, p = 0.002) and tended to have a shorter interval from entry-to-first-mating (106.7±2.8 and 113.2±2.7 days, p = 0.082) than those exhibiting first estrus at > 200 days of age. The gilts with backfat ≥ 17.0 mm had higher level of serum IGF–I (31.1±1.1 nmol/l) than those with a backfat of 14.5-16.5 mm (26.2±1.3nmol/l, p = 0.009) and ≤ 14.0 mm (26.0±1.4 nmol/l, p = 0.008).

Keywords: backfat thickness, IGF–I, pig, puberty, reproduction

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บทคัดย่อ

ความสัมพันธ์ระหว่างอินซูลินไลค์โกรทแฟคเตอร์วันในซีรั่ม ความหนาไขมันสันหลัง และอายุเมื่อพบการเป็นสัดครั้งแรกในสุกรสาว

อตถพร รุ่งสิทธิชัย [1] เสรี กุญแจนาค [2] เผด็จ ธรรมรักษ์ [1]*

การศึกษาครั้งนี้ศึกษาความสัมพันธ์ระหว่างอินซูลินไลค์โกรทแฟคเตอร์วัน (IGF-I) ในซีรั่ม ความหนาไขมันสันหลัง และอายุที่แสดงการเป็นสัดครั้งแรกในสุกรสาวทดแทน โดยใช้สุกรสาวทั้งหมด 80 ตัว (พันธุ์แลนด์เรซ 48 ตัว และพันธุ์ยอร์กเชีย 32 ตัว) อายุที่แสดงการเป็นสัดครั้งแรกในสุกรสาวถูกตรวจระหว่างอายุ 167-212 วัน สุกรสาวถูกแบ่งตามอายุที่แสดงการเป็นสัดครั้งแรกออกเป็น กลุ่มที่แสดงการเป็นสัดที่อายุ ≤ 200 วัน (41 ตัว) และ กลุ่มที่แสดงการเป็นสัดที่อายุ >200 วัน (36 ตัว) ทำการตรวจวัดความหนาไขมันสันหลัง น้ำหนักตัว และปริมาณไอจีเอฟวันในซีรั่มก่อนทำการผสมพันธุ์ในสุกรสาวทุกตัว บันทึกอายุที่ผสมพันธุ์ครั้งแรก ช่วงเวลาตั้งแต่สุกรสาวสัมผัสพ่อสุกรจนถึงแสดงการเป็นสัดครั้งแรก และช่วงเวลาตั้งแต่สุกรสาวเข้าฝูงจนถึงผสมพันธุ์ครั้งแรก ผลการศึกษาพบว่าปริมาณของไอจีเอฟวันในซีรั่มแปรผกผันกับอายุที่พบการเป็นสัดครั้งแรก (r = -0.26, p = 0.022) และ ช่วงเวลาตั้งแต่สัมผัสพ่อสุกรถึงแสดงการเป็นสัดครั้งแรก (r = -0.28 p = 0.015) แต่แปรผันตรงกับความหนาไขมันสันหลัง (r = 0.37 p < 0.001) สุกรสาวที่แสดงการเป็นสัดครั้งแรกที่อายุ ≤200 วัน มีปริมาณไอจีเอฟวันในซีรั่มสูงกว่า (30.2±1.2 และ 25.4±1.1 นาโนโมล/ลิตร p = 0.002) และมีแนวโน้มที่จะมีระยะเวลาตั้งแต่เข้าฝูงถึงผสมพันธุ์ครั้งแรก (106.7±2.8 และ 113.2±2.7 วัน p= 0.082) สั้นกว่าสุกรสาวที่แสดงการเป็นสัดครั้งแรกที่อายุมากกว่า 200 วัน สุกรสาวที่มีความหนาไขมันสันหลังมากกว่า 17 มิลลิเมตร มีปริมาณไอจีเอฟวันในซีรั่ม (31.1±1.1 นาโนโมล/ลิตร) สูงกว่าสุกรสาวที่มีความหนาไขมันสันหลัง 14.5-16.5 มิลลิเมตร (26.2±1.3 นาโนโมล/ลิตร p = 0.009) และ สุกรสาวที่มีความหนาไขมันสันหลัง <14.0 มิลลิเมตร (26.0±1.4 นาโนโมล/ลิตร p = 0.008)

คำสำคัญ: ความหนาไขมันสันหลัง ไอจีเอฟวัน สุกร วัยเจริญพันธุ์ ระบบสืบพันธุ์

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Introduction

Gilts are considered the largest proportion of commercial swine breeding unit due to the fact that substitution of removed sows by replacement gilts accounts for 50% per annum (Engblom et al., 2007). Therefore, reproductive performance of the gilts extensively affects herd productivity. A number of studies reveal that numerous variables such as age at first observed estrus, age at first mating, and age at first farrowing, affect subsequent reproductive performance in further parity numbers, including longevity of female pigs (Koketsu et al., 1999; Tummaruk et al., 2007).

Puberty in the female pigs is a phenomenon of the first estrus and the onset of reproductive capability (Evans and O'Doherty, 2001). In general, the period which the gilts express the first standing estrus, together with an ovulation is considered as completely reaching puberty attainment (Tummaruk et al., 2007). Due to the fact that exact age at puberty cannot be identified, age at first observed estrus is generally used to define puberty in gilts (Tummaruk et al., 2009). Gilts in Thailand attain puberty at 195 days of age (Tummaruk et al., 2007). In general, age at puberty in gilts is controlled by both internal (e.g. breed, body weight, and backfat thickness) and management (e.g. nutrition, boar contact, and housing) factors which are mediated via endocrine-reproductive axis (Evans and O'Doherty, 2001). In addition, age at puberty affects age at first mating and weaning-to-service interval; gilts attaining puberty early (~185 days) are introduced to the breeding houses faster and have a shorter weaning-to-service interval than those reaching puberty late (~226 days) (Sterning et al., 1998). Furthermore, a previous study demonstrates that gilts reaching puberty faster have higher backfat than those attaining puberty late (Nelson et al., 1990). Backfat thickness measurement is one of the most objective methods used to quantify fat content in the animal's body than body condition score since a body score of 3 indicates backfat ranging from 9 to 28 mm (Young et al., 1991). Reproductive

performance and backfat are proven to have a close association, for example, gilts with higher backfat are younger at first insemination, have a larger litter size at birth, and a higher farrowing rate than those inseminated with low backfat (Tummaruk et al., 2001; Tummaruk et al., 2009). Our previous study demonstrated that gilts with backfat ≥ 17 mm at first mating gained a significantly larger total number of piglets born per litter than those with a lower backfat at first mating (Roongsitthichai et al., 2010).

According to the findings of Koketsu et al. (1999), age at puberty determines lifetime performance of the female. Besides, Rozeboom et al. (1995) suggested that puberty attainment might be relevant to a metabolic state at a critical period of pig's development. An alteration in metabolic status affects reproductive functions of the gilts through the changes in some circulating hormones such as leptin, insulin, and insulin–like growth factor–I (IGF–I) (Booth et al., 1994). In many domestic species, leptin and IGF–I are perceived to be regulators of cellular growth and differentiation, body composition, and pubertal onset (Bidanel et al., 1996). The relationships among serum IGF–I, backfat thickness, and age at first observed estrus have not been comprehensively investigated. The objective of the present study was to investigate the association among serum IGF–I, backfat thickness and age at first observed estrus in replacement gilts.

Materials and Methods

Animals and managements: This study was undertaken between November 2010 and June 2011 in a commercial swine breeding herd in northeastern Thailand. In total, 80 replacement gilt, Landrace (L, n = 48) and Yorkshire (Y, n = 32), were included. They were introduced into gilt pools at age 145.9±11.8 days (mean±SD). In the gilt pools, the gilts were accommodated in evaporative cooling houses in a group of 10 heads per pen (2.0 m^2 per head). The pens were equipped with water nipples for *ad libitum* water access. The replacement gilts were fed about 3.0 kg/day/head. All the replacement gilts were produced within the breeding herd by its own grandparent stock. The vaccination performed in gilts was for prevention of foot-and-mouth disease, classical swine fever, porcine parvovirus, Aujeszky's disease, atrophic rhinitis, and porcine reproductive and respiratory syndrome. Gilts with ≥ 32 weeks of age with ≥ 130 kg of body weight, and expressing at least once standing estrus were inseminated. All of the gilts were inseminated by means of intrauterine artificial insemination (Sumransap et al., 2007) with diluted fresh semen containing 3 billion sperm in 100 ml semen solution.

Detection of estrus: Estrus detection in the gilts was routinely conducted in the gilt pools by experienced technicians twice a day by means of back pressure test, together with an existence of mature boars. The estrus stimulation by the exposure of mature boar with high libido was performed at 167.2±11.9 days of age onwards. The estrus characteristics included the expression of standing reflex in front of the mature boar, together with the presence of vulvar symptoms (reddening, swelling and sometimes with a presence of transparent vulvar discharge). The first day the pigs showed standing reflex in response to boar exposure was recorded as the day of first observed estrus. The interval from boar exposure to first observed estrus was recorded.

Blood collection and measurements of body weight and backfat thickness: The replacement gilts were weighed before being sent to the breeding houses (212.5±2.1 days of age). Body weight was used to calculate the lifetime growth rate by Growth rate (g/day) = {[(body weight (kg)–1.5) x 1000]/age at body weight measurement} (Tummaruk et al., 2009). Body weight measurement and jugular venipuncture of the gilts was individually performed on the same day. Blood samples were centrifuged at 2,200 x g for 10 min to acquire the serum samples. All the sera were kept at -20^{0}C until assay. The measurement of backfat thickness was individually performed on mating day by A–mode ultrasonography (Renco lean meter®, Minneapolis, MN, USA) at the P2 position: approximately 6-8 cm off the dorsal midline (Tummaruk et al., 2009). An average value of backfat measured from both sides of P2 position was used in an analysis. After entering the breeding houses, the gilts were checked for standing estrus and were inseminated. The interval from entering the gilt pools to first insemination was also recorded.

Serum insulin–like growth factor–I assay: Serum IGF–I concentration was determined via enzyme immunoassay, using IGF–I–ELISA test kit (Mediagnost®, Reutlingen, Germany) according to the manufacturer's instructions. Briefly, 10 µl of serum sample were initially diluted with sample buffer (1:21) before starting the assay. First, 80 µl of antibody conjugate were added into microtiter plates, and followed immediately by 20 µl of recombinant IGF–I standard (2, 5, 15, 30, and 50 ng/ml), control, and diluted serum samples. Plates were incubated at room temperature for 1 hour, then they were washed by washing buffer for five times. Thereafter, 100 µl of the enzyme conjugate were added and incubated at room temperature for 30 min, and followed by washing for five times. Then, 100 µl of substrate solution were added and incubated for 15 min in the darkness at room temperature prior to addition of 100 µl of stopping solution in the last step. Finally, the microtiter plates were interpreted at A450 nm (ELISA reader, TECAN SUNRISE, Austria). The conversion factor of ng/ml into nmol/l is 0.13074. The intra-assay CV for low and high concentrations was 3.22% and 9.75%, respectively. The interassay CV for low and high concentrations was 16.36% and 14.38%, respectively. An average sensitivity of the assay was 0.01 nmol/l. All the serum samples were duplicately examined.

Statistical analysis: All the data were manipulated and analyzed by Statistical Analysis System (SAS) software version 9.0 (SAS Inst., Cary, NC, USA). All continuous data were presented as mean±SD.

Pearson's correlation was conducted to analyze the association among body weight, growth rate, age at entering the gilt pools, age at first observed estrus, the interval from boar exposure to first observed estrus, backfat thickness, and serum IGF–I concentration. Analysis of variance was used to analyze continuous variables under general linear model procedure (GLM) of SAS. The dependent variables included serum IGF–I concentration, age at first mating, body weight, growth rate, and entry-to-first-mating interval. The statistical models included the effects of breed (Landrace versus Yorkshire), age at first observed estrus (≤ 200 days versus > 200 days) and backfat thickness (≤ 14.0 mm, 14.5-16.5 mm and ≥ 17.0 mm). Least–squares means and SEM were acquired and compared by Tukey-Kramer adjustment for multiple comparisons. Additionally, student's t-test was used to compare serum IGF–I concentration in gilts with different response to the boar exposure [< 24 days (good response) versus > 24 days (poor response)] and to compare age at first mating, body weight, growth rate, and entry-to-first-mating interval among different categories of age at first observed estrus and backfat thickness. Values with $p < 0.05$ were considered statistically significant

Results

Descriptive statistics

Due to 3 (2 Landrace and 1 Yorkshire) out of 80 gilts did not show standing estrus prior to being introduced into the breeding units, they were excluded from the analyses. Therefore, 77 (46 Landrace and 41 Yorkshire) replacement gilts were included. The gilts (n = 77), on average, expressed first estrus at age 201.5±28.9 days, and were first mated at age 253.6±19.6 days. After an exposure to the boar, the gilts showed first estrus at 34.6±28.0 days. On average, the gilts weighed 136.6±12.3 kg and had growth rate of 642.9±58.0 gram/day before entering the breeding houses. Of these gilts, 27.9% and 79.4% were mated within 3 and 6 weeks after entering the breeding units, respectively. On average, entry-to-first-mating interval was 107.4±15.9 days. At first mating, backfat thickness of the gilts was 17.0±3.5 mm. Descriptive statistics of the gilts prior to mating are shown in Table 1.

Breed difference

According to breed difference, Landrace gilts expressed first observed estrus earlier (196.9±2.6 vs 204.7±3.1 days, $p = 0.049$) and tended to have greater growth rate (654.1±9.2 vs. 624.5±11.7 gram/day, $p = 0.062$) than Yorkshire gilts (Table 2). Moreover, Landrace gilts could be inseminated earlier than Yorkshire gilts (251.2±3.0 vs. 261.4±3.6, $p = 0.026$). However, body weight, backfat thickness, serum IGF–I concentration, and entry-to-first-mating interval were not different between the two breeds (Table 2).

Serum insulin–like growth factor–I

The serum concentration of IGF–I of the gilts in this study was, averagely, 28.2±0.8 nmol/l. The level of serum IGF–I negatively correlated with age at first observed estrus ($r = -0.26$, $p = 0.022$), as well as with interval from boar exposure to first observed estrus ($r = -0.28$, $p = 0.015$), but it positively correlated with backfat thickness ($r = 0.37$, $p < 0.001$). However, serum concentration of IGF–I did not correlate with body weight ($p = 0.246$) and growth rate ($p = 0.244$) of the gilts. The concentration of serum IGF–I differed significantly between gilts that attained puberty at ≤ 200 days of age and those that attained puberty after 200 days of age (Table 3). The concentration of serum IGF–I in gilts with backfat thickness ≥ 17 mm was higher than those with a lower backfat thickness (Table 4). In addition, the gilts with a good response to the boar tended to have higher serum IGF–I concentration than those with a poor response (29.7±1.02 vs. 27.0±1.05 nmol/l, $p = 0.078$).

Table 1 Descriptive statistics of serum insulin-like growth factor I (IGF-I) concentration, age at first observed estrus, backfat thickness, body weight, growth rate, entry-to-mating interval, and boar exposure-to-first-estrus interval of gilts (n = 77)

Parameters	Mean±SD	Range
IGF–I (nmol/l)	28.2±6.6	10.1-44.4
Age at first observed estrus (day)	201.5±28.9	146.0-273.0
Backfat thickness (mm)	17.0±3.5	10.5-26.0
Body weight (kg)	136.6±12.3	111.0-174.0
Growth rate (g/day)	642.9±58.0	521.1-828.6
Entry-to-first-mating interval (day)	107.4±15.9	87.0-149.0
Boar exposure-to-first-estrus interval (day)	34.6±28.0	0.0-97.0

Table 2 Least-squares means (±SEM) of serum insulin–like growth factor I (IGF–I) concentration, age at first observed estrus, backfat thickness, body weight, growth rate, entry-to-first mating interval, and age at first mating in Landrace and Yorkshire replacement gilts

Parameters	Landrace (n=46)	Yorkshire (n=31)	Significance
IGF–I (nmol/l)	27.4±1.0	28.2±1.2	$P = 0.580$
Age at first observed estrus (day)	196.9±2.6	204.7±3.1	$P = 0.049$
Backfat thickness (mm)	17.3±0.6	16.6±0.7	$P = 0.477$
Body weight (kg)	138.9±2.0	132.9±2.5	$P = 0.075$
Growth rate (gram/day)	654.1±9.2	624.5±11.7	$P = 0.062$
Entry-to-first-mating interval (day)	108.1±2.5	111.7±3.1	$P = 0.346$
Age at first mating (day)	251.2±3.0	261.4±3.6	$P = 0.026$

Age at first observed estrus, age at first mating and entry-to-first-mating interval

Positive correlation was found between age at first observed estrus and age at entering the gilt pools (r = 0.23, p = 0.040), as well as between age at first observed estrus and the interval from boar exposure to first observed estrus (r = 0.91, p < 0.001). Age at first mating strongly correlated with entry-to-first-mating interval (r = 0.79, p < 0.001) and age at entering the gilt pool (r = 0.58, p < 0.001). Entry-to-first-mating interval positively correlated with the interval from boar exposure to first observed estrus (r = 0.26, p = 0.024) but negatively correlated with growth rate (r = -0.25, p = 0.043). The gilts with growth rate ≥ 600 gram/day were younger at first mating (248.9±2.6 vs. 263.6±4.2 g/day, p = 0.004) and had a shorter entry-to-first-mating interval (104.2±2.2 vs. 115.6±3.6 day, p = 0.008) than those with growth rate < 600 gram/day. Neither body weight at entering the breeding houses nor backfat thickness influenced age at first mating and entry-to-first-mating interval (p > 0.05).

Discussion

The replacement gilts in this study expressed first observed estrus at 201.5 days of age which was considered as normal range according to the findings of Tummaruk et al. (2007), conducted in the gilts raised in Thailand. Moreover, the sexual maturation of the gilts reared in tropical regions, such as Thailand experienced a delay of 1-2 weeks, more than those accommodated in Europe and North America (Bidanel et al., 1996; Patterson et al., 2010). According to difference in breed, Landrace gilts expressed first observed estrus faster, could be inseminated earlier, and tended to have higher growth rate than Yorkshire gilts in this study, which is in accordance with the findings of previous studies (Bidanel et al., 1996; Tummaruk et al., 2001). Furthermore, across the breeds, gilts with a high growth rate were younger at first insemination and had a shorter entry-to-first-mating interval than those with a low growth rate, which corresponded to the previous studies (Rydhmer, 2000; Tummaruk et al., 2000). Earlier studies have demonstrated that gilts with high growth rate would perform better reproductive performance in higher parities than those with low growth rate (Koketsu et al., 1999; Roongsitthichai et al., 2013), especially in terms of litter size in the first parity (Kummer et al., 2006; Young et al., 2008). For instance, Tummaruk et al. (2007) discovered that the greater growth rate the gilts had, the bigger the litter size in the first three parities was produced. Not only the faster growth, but the higher backfat was also found in the gilts with high growth rate (Nelson et al., 1990). This signified that the high backfat gilts would have a decent reproductive performance, especially in aspect of litter size at birth and weaning-to-service interval (Tummaruk et al., 2001).

Considering IGF–I, which was recognized as one of the important hormones in female reproduction (Silva et al., 2009), the gilts, in the current study, with high backfat at first insemination possessed the highest level of serum IGF-I. This suggested that those with high concentration of serum IGF-I might tenant the decent reproductive performance, especially in terms of litter size at birth and weaning-to-first-service interval, as primiparous sows. An apparent impact of backfat at the first estrus on the litter size at birth in the first parity sows (Tummaruk et al., 2001) and on total number of piglets born per litter over three parities (Williams et al., 2005) was discovered. A previous study found

Table 3 Least-squares means (±SEM)of serum insulin–like growth factor I (IGF–I) concentration, age at first observed estrus, backfat thickness, body weight, growth rate, entry-to-first-mating interval, and age at first mating in gilts with age at first observed estrus ≤ 200 and > 200 days

Parameters	Age at first observed estrus		Significance
	≤ 200 days (n = 41)	> 200 days (n = 36)	
IGF–I (nmol/l)	30.2±1.2	25.4±1.1	P = 0.002
Age at first observed estrus (day)	181.3±2.6	226.2±2.6	P < 0.001
Backfat thickness (mm)	17.1±0.6	16.8±0.6	P = 0.712
Body weight (kg)	136.3±2.3	135.4±2.2	P = 0.412
Growth rate (gram/day)	640.4±10.6	638.2±10.2	P = 0.607
Entry-to-first-mating interval (day)	106.7±2.8	113.2±2.7	P = 0.082
Age at first mating (day)	253.5±3.3	259.0±3.2	P = 0.209

Table 4 Least-squares means (±SEM) of serum insulin–like growth factor I (IGF–I) concentration, age at first observed estrus, backfat thickness, body weight, growth rate, entry-to-first-mating interval, and age at first mating in gilts with backfat thickness ≤ 14.0 mm, 14.5-16.5 mm and ≥ 17.0 mm

Parameters	Backfat thickness		
	≤ 14.0 mm (n = 20)	14.5-16.5 mm (n = 22)	≥ 17.0 mm (n = 35)
IGF–I (nmol/l)	26.0±1.4[a]	26.2±1.3[a]	31.1±1.1[b]
Age at first observed estrus (day)	195.1±3.5[a]	202.8±3.4[a]	204.5±2.8[a]
Backfat thickness (mm)	13.2±0.4[a]	15.8±0.4[b]	20.3±0.3[c]
Body weight (kg)	136.2±1.4[a]	133.1±1.7[a]	135.5±1.1[a]
Growth rate (gram/day)	638.0±6.8[a]	625.7±8.5[a]	637.5±5.4[a]
Entry-to-first-mating interval (day)	111.8±3.5[a]	109.0±3.4[a]	109.0±2.8[a]
Age at first mating (day)	252.8±4.1[a]	255.3±4.0[a]	260.7±3.3[a]

[a,b,c] Different superscripts within row were considered statistically significant (P<0.05)

that gilts first inseminated with backfat of ≥ 17.0 mm significantly farrowed one more piglet than those first inseminated with backfat of < 17.0 mm (Roongsitthichai et al., 2010). Moreover, Filha et al. (2010) pointed out that it would not be advantageous, in aspect of farrowing rate and the number of piglets born alive per litter, if gilts were first inseminated with backfat from 17.0 mm onwards. That was because farrowing rate and the number of piglets born alive per litter were not different among these pigs. As a result, the age at first observed estrus of the gilts and different backfat thickness, in this study, were not statistically different. The replacement gilts were suggested to have backfat of at least 17.0 mm before the first mating time. Apart from these, the gilts attaining early puberty had lesser entry-to-first-mating interval than those attaining late puberty. These were the advantageous results in an economical aspect of the commercial herds since the lower the entry-to-first-mating interval, the lower the non-productive days occurred from the production line.

IGF-I has been considered one of the regulators for growth, body composition, and puberty onset (te Pas et al., 2004). Correspondingly, the gilts, in the present study, showing earlier first observed estrus had a higher level of serum IGF-I than those showing late first observed estrus. This was in accordance with the findings of Patterson et al. (2010), who discovered that 100-day-old pigs with high level of plasma IGF-I reached pubertal onset earlier than those with low plasma IGF-I level. In addition, female mice with IGF-I null mutation was unable to ovulate, even though gonadotropin administration was performed (Baker et al., 1996). Besides, it was reported in heifers that IGF-I might act at the hypothalamic–pituitary level to modulate the release of gonadotropins, entailing the pubertal onset. The expressions of IGF-I gene and its receptors took place at ovaries (Adashi, 1998), even in the corpus luteum of the primates (Wandji et al., 1998). The expression of IGF-I receptors, in cows, proliferated in the meantime of the follicle development from primary to early antral follicles (Wandji et al., 1992). In pigs, messenger RNA expression of IGF–I and its receptors in the ovarian follicles were detected from the stage of growing antral follicles to preovulatory follicles (Silva et al., 2009). Apart from these, IGF-I could promote the proliferation of granulosa cells, steroidogenesis, and development of oocyte growth in most mammalian species (Silva et al., 2009). These implied that IGF-I was one of the crucial indices which were considerably relevant to the puberty attainment in mammals, including the female pigs, since it was substantially related to folliculogenesis and follicle development.

Boar exposure was considered one of the indispensible factors in stimulating onset of puberty in the female pigs (Evans and O'Doherty, 2001), contributing to declined age at puberty (Paterson et al., 1991). Correspondingly, the gilts well responding to the boar exposure had lower age at first observed estrus and shorter entry-to-first-mating interval than those poorly responding to the boar exposure. Moreover, the gilts having shorter interval from boar exposure to first observed estrus tended to have higher level of serum IGF-I than those having such longer interval. This might be due to the fact that the effect of boar exposure to the gilts in the gilt pools was able to enhance the IGF-I level in the female bloodstream, together with modulating the tone of luteinizing hormone from adenohypophysis (Kingsbury and Rawlings, 1993). Thus, serum IGF–I concentration was high in the gilts with a good response against the boar exposure, contributing to ensuing puberty attainment. On the other hand, the gilts with a poor response to the boar exposure had a low level of serum IGF-I and tended to have a delayed puberty. Moreover, Whitley et al. (1995) revealed that boar-stimulated IGF-I entailed an increase in the release of adenohypophyseal luteinizing hormone which was an important hormone for ovulation. Consequently, boar contact contributed to the rise of circulating IGF-I level, which aroused the luteinizing hormone release from the anterior pituitary gland, then sensitized the ovaries of the gilts to first ovulate. They, subsequently, showed first estrus.

In summary, the serum IGF–I level should be one of the significant managerial factors in the preparation of the replacement gilts since it influenced the puberty attainment in terms of regulating folliculogenesis and steroidogenesis, together with modulating an increase in luteinizing hormone release. Apart from appropriate age, body weight, standing estrus, and backfat thickness at first mating, boar exposure needed to acquire more attention in the replacement gilts. It was because those well responding to the boar exposure tended to have higher IGF-I level than those poorly responding to the boar. Therefore, a manipulation of IGF-I level was recommended to be monitored so that the removal of the replacement gilts from reproductive failure, especially anestrus, would be considerably dwindled. These would contribute to the magnificent reproductive performance of the pigs since the starting point of the production cycle. The lucrativeness of the commercial swine breeding herds would follow.

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