Uterine size in replacement gilts associated with age, body weight, growth rate, and reproductive status

P. Tummaruk[1], S. Kesdangsakonwut[2]

[1]Department of Obstetrics, Gynaecology and Reproduction, Faculty of Veterinary Science, Chulalongkorn University, Bangkok, Thailand
[2]Department of Pathology, Faculty of Veterinary Science, Chulalongkorn University, Bangkok, Thailand

ABSTRACT: The objective of the present study was to determine the association between the uterine size and age, body weight, growth rate, and reproductive status in Landrace × Yorkshire crossbred gilts. Genital organs from 310 gilts (302.6 ± 2.9 days of age, 145.2 ± 1.2 kg body weight) were examined. The gilts were classified into two groups according to reproductive status: non-cyclic (n = 86) and cyclic (n = 224). The uterine weight in non-cyclic gilts was lower than that in cyclic ones (128 ± 8.1 and 694 ± 17.9 g, $P < 0.001$). Likewise, the length of the uterus in non-cyclic gilts was shorter than that in cyclic gilts (123 ± 2.9 and 252 ± 4.6 cm, $P < 0.001$). The weight of the uteri correlated with the body weight ($r = 0.48$, $P < 0.001$) and growth rate ($r = 0.33$, $P < 0.001$) of the gilts but not with their age ($P > 0.05$). For every 10 kg increase in the body weight of the gilts, an increase of 67 g in uterine weight ($P < 0.001$) and 21 cm in uterine length ($P < 0.001$) was observed.

Keywords: pig; reproduction; puberty; uterus

INTRODUCTION

Age at first mating in gilts influences their subsequent reproductive performance as sows and their longevity (Koketsu et al. 1999; Tummaruk et al. 2001; Patterson et al. 2010). Under field conditions, the reported age at first mating in gilts varies considerably from 150 up to 348 days (Tummaruk et al. 2000), while the mean age at first mating in gilts varies among populations from 198 (Kummer et al. 2006) to 268 days (Tummaruk et al. 2009a). Based on economic evaluation, Schukken et al. (1994) found that gilts in North America should be mated before 220 days of age. In Japan, Koketsu et al. (1999) found that gilts mated later than 230 days of age display inferior subsequent reproductive performances and longevity. Gilts mated at an older age have a shorter herd life and a higher risk of being culled due to infertility problems (Young et al. 2008). In addition, Tummaruk et al. (2007) found that gilts exhibiting first standing oestrus between 180–200 days of age have a litter size in the first three parities larger than those expressing first oestrus between 201–220 days. These findings indicate the importance of gilt management as well as the first mating decision to their subsequent reproductive performance as sows. In practice, 40–50% of sows in herds are culled annually and they are replaced by gilts, therefore the reproductive performance of gilts largely influences the overall reproductive performance of a swine herd. Unfortunately, a number of replacement gilts in Thai swine breeding herds are culled before their first litter has been accomplished; the major reason for this culling is reproductive failure (Roongsitthichai et al. 2013).

In practice, replacement gilts are usually mated at a second or later observed oestrus, at about 210–270 days of age. The delay in age at first mating in gilts increases the non-productive days (NPD) from entry to conception and influences their subsequent reproductive performance (Tummaruk et al. 2007). Our previous study found

Supported by the National Research Council of Thailand.

that reproductive problems contribute to 47% of the reasons for the removal of gilts from swine breeding herds (Tummaruk et al. 2006). Common reproductive problems include anoestrus, repeated breeding, not being pregnant, abnormal vaginal discharge, abortion, and birth problems at first farrowing (Tummaruk et al. 2009a).

In practice, the management of replacement gilts needs special emphasis. The selection criteria for replacement gilts include age, body weight, backfat thickness, number of oestrus cycles, and the number of teats. Replacement gilts must have at least six pairs of teats and it is recommended that they should be mated at 240 days of age, at 130 kg body weight, with 17 mm backfat thickness, and at the second or later observed oestrus (Tummaruk et al. 2009b). These parameters are carefully determined in some herds in order to ensure a high prolificacy at first farrowing. However, no comprehensive data on the relationship between these parameters and size of the uterus in replacement gilts raised in tropical climates has been published. In general, litter size at birth depends on ovulation rate, fertilization, and embryonic/fetal loss (van der Lende and Schoenmarker 1990). The uterine size is an important limiting factor influencing fetal survival and the litter size at birth of gilts and sows. Nevertheless, excessive ovulation (> 18 ovulation) may lead to low embryo survival due to overcrowding of the uterus (Wu et al. 1987; Wu and Dziuk 1995). Thus, to increase litter size at birth in gilts, the size of the uterus should be carefully determined. The objective of the present study was to determine the uterine size (weight and length) of Landrace × Yorkshire (LY) crossbred gilts in Thailand and their association with age, body weight, and growth rate.

MATERIAL AND METHODS

Animal and tissue samples. In total, genital organs from 310 LY crossbred gilts were collected from six commercial swine herds in Thailand between May 2005 and September 2008. The organs were examined for gross abnormalities by a pathologist and those with normal uteri (n = 256) were included in the analyses. The organs, including ovaries, oviducts, uteri, cervixes, and vaginas-vestibules-vulvas were collected, placed on ice, and transported to the laboratory within 24 h after slaughter. Historical data including the herd of origin, the gilt's identity, breed, birth date, the date that the gilt entered the herd, first observed oestrus date, culling date, body weight at culling, and culling reasons were collected. Age at first observed oestrus, age at culling, NPD, and growth rate of the culled gilts were calculated (Tummaruk et al. 2009b):

$$\text{growth rate (g/day) from birth to culling} = ((\text{body weight (kg) at culling} - 1.5)/\text{age at culling}) \times 1000$$

NPD of the culled gilts was defined as the interval from entry into the herd to culling. In general, the criteria required to move the gilts from the gilt pool to the breeding house included age (≥ 224 days), body weight (≥ 130 kg), and completed herd monitoring program. The reasons for culling the gilts were classified into 6 groups: anoestrus, abnormal vaginal discharge, repeated service, abortion, not being pregnant, and miscellaneous (non-reproductive) causes. "Anoestrus" was defined as gilts that were culled due to no behavioural oestrus could be observed. "Abnormal vaginal discharge" was defined as the gilts that were culled because purulent vaginal discharge was observed. "Repeated service" was defined as gilts that were culled because they returned to oestrus after insemination had been repeated for ≥ 2 consecutive oestrous cycles. "Abortion" was defined as the gilts that were culled due to abortion. "Not being pregnant" included gilts that were culled due to negative pregnancy detection and gilts that were found to be non-pregnant when they were sent to the farrowing barn (not-in-pig). "Miscellaneous" included gilts that were culled due to non-reproductive causes, i.e. inverted nipple, leg problems, and poor conformation.

Historical data, herds location, climatic data, and general management. The genital organs were collected from six commercial swine herds in Thailand. The herds were located between latitude 13° and 17°N and between longitude 100° and 104°E. The average outdoor minimum and maximum daily temperature and humidity in the study area in the hot (15 February–14 June), rainy (15 June–14 October), and cool (15 October–14 February) seasons were 24.6–34.9°C (71.7%), 24.8–33.0°C (78.1%), and 21.4–32.1°C (68.1%), respectively. All were breeding herds with the number of sows on production being 900–4000 sows/herd. The gilts entered the gilt pool at a body weight of 80–100 kg (i.e. 150–160 days of age). All the gilts were housed in an open housing system. The gilts were kept in a pen with a group size of

6–15 gilts/pen and a density of 1.5–2.0 m^2/gilt. Oestrus detection was performed daily by a back pressure test together with the observation of the reddening and swelling of the vulva with a fence line boar contact. The boar exposure was initiated within 1–2 weeks of the gilts entering the gilt pools. Gilts expressing a standing response in front of the boar were defined as standing oestrus. In general, it was recommended to use breed replacement gilts at about 32 weeks of age onwards with at least 130 kg of body weight at the second or later observed oestrus. The mating technique for all herds was conventional artificial insemination (AI). Herd health was monitored by the herd veterinarian. In general, the veterinarian gave the recommendation to vaccinate the gilts against foot-and-mouth disease, classical swine fever, Aujeszky's disease, and porcine parvovirus between 22 and 30 weeks of age. In general, replacement gilts entered the herd (gilt pool) every 1–2 weeks. About one week after the gilts entered the herd, the weaned sows selected for culling were taken to acclimatize them for about 4–6 weeks with a ratio of one sow per 6–10 gilts. In general, the sows for acclimatization were rotated on a weekly basis. Feed was provided twice a day (about 3 kg/day/head) and water was provided *ad libitum*. The feed was corn-soybean-fish based containing 16–18% crude protein, 3000–3400 kcal/kg metabolizable energy, and 0.85–1.0% lysine. Oestrus detection was carried out by the observation of vulva symptoms and a back pressure test in the presence of a mature boar once or twice a day.

Post-mortem examination. The genital tract including ovaries, uteri, and cervixes was dissected from the mesometrium and examined macroscopically. The stages of the reproductive cycle were defined according to the appearance of the ovaries and their structure, i.e. corpora lutea (CL) and follicles (Tummaruk et al. 2009a). Gilts with ovaries having only small follicles (≤ 5 mm) were defined as "non-cyclic". Gilts with ovaries having CL (luteal phase) and/or follicles of 7–12 mm in diameter accompanied by old CL (follicular phase) were defined as "cyclic". The number of CL was counted. Ovulation rate was defined as the total number of CL from both ovaries.

The uterus, from the utero-tubal junction to the uterine body, was dissected and weighed using an electronic balance KD300 (Tanita Corporation, Tokyo, Japan) (capacity 5 kg, in increments of 1 g). The length of the uterine horns was measured using a metrical scale plastic tape. The measurement was done by placing one end of the plastic tape at the junction of the uterine horn and uterine body and threading the tape along the horn between the thumb and fingers. The measurement was performed on both sides of the uterine horn and the uterine body. The sum of the length of the two parts was regarded as the total length of the uterus. Endometritis was assumed if signs of inflammation were visible, i.e. severe oedema and congestion, dark red colour, and, in most cases, purulent exudates in the uterine lumen (Tummaruk et al. 2010a). Uteri containing pus exudates and/or having endometritis as well as other uterine abnormalities (n = 54) were excluded from the analyses. The cervix, vagina, and vestibule were dissected longitudinally. The length of each part of the organs and the number of cervical folds were measured.

Statistical analyses. The statistical analyses were carried out using the SAS software (Statistical Analysis System, Version 9.0, 2002). All continuous data of reproductive parameters and gross morphology is presented as mean ± SEM and proportional data is presented as a percentage. The gilts were classified into 2 groups according to reproductive status: non-cyclic (n = 86) and cyclic gilts (n = 224). Continuous data, including age and body weight at culling, NPD from entry to culling, weight and length of the uteri (both uterine horns and body), length of the cervix, vagina, and vestibule, and the number of cervical folds were compared between non-cyclic and cyclic gilts by multiple analysis of variance (ANOVA) using the General Linear Models (GLM) procedures of SAS. The statistical models included the effects of herd, season (hot, rainy, and cool), and group of the gilts (non-cyclic and cyclic). Least Squares Means were obtained from the models and were compared by Tukey-Kramer adjustment for multiple comparison. Pearson's correlation and multiple regression analyses were used to analyze the association among the weight and length of the uteri, body weight, age, and growth rate of the gilts. The multiple regression model included the effects of body weight, age at culling, and growth rate. In addition, multiple ANOVA models were also conducted. The cyclic gilts were classified according to their body weight at culling (≤ 130, 131–140, 141–150, 151–160, and ≥ 161 kg), age at culling (8 (209–269 days), 9 (270–299 days), 10 (300–330 days), and 11 (≥ 331 days) months), growth rate from birth to culling (< 400, 400–499,

Table 1. Descriptive statistics on reproductive data for Landrace × Yorkshire gilts

Parameters	*n*	Means ± SD	Range
Age at culling (days)	302	303 ± 50.0	209–504
Body weight at culling (kg)	301	145 ± 20.5	92–206
Average daily gain (g/day)	298	484 ± 88.7	150–693
Interval from entry to culling (days)	265	89.7 ± 54.7	6–273
Age at first observed oestrus (days)	164	234 ± 33.5	152–374
Age at first mating (days)	116	264 ± 28.8	204–374

500–599, and ≥ 600 g/day), reproductive cycle (follicular phase and luteal phase), and culling reason. The effects of body weight, age at culling, and growth rate on the weight and length of the uteri were analyzed by the GLM procedure. The statistical model included the effects of body weight class, age at culling class, growth rate class, reproductive cycle, and culling reason. Least Squares Means were obtained from each class of variables and were compared by a least significant difference test with Tukey-Kramer adjustment for multiple comparison. The proportion of cyclic gilts was a binomial trait (0 = non-cyclic, 1 = cyclic) and was assumed to have a binomial distribution. Logistic regression was used to analyze the proportion of cyclic gilts in each category of the factors by the Generalized Linear Model (GENMOD) procedure. The statistical models included the effects of herd and body weight, age at culling, and growth rate classes. Estimated values of Least Squares Means were compared by a least significant difference test. $P < 0.05$ was considered statistically significant.

RESULTS

Descriptive statistics. Descriptive statistics on the reproductive data of the gilts are presented in Table 1. On average, the gilts showed the first observed oestrus at 234 ± 33.5 days of age and they were culled at 303 ± 2.9 days of age with a body weight of 145 ± 1.2 kg. Table 2 shows comparison of the reproductive data and gross morphology of the genital organs between non-cyclic and cyclic gilts. Most parts of the genital organs, including the weight and length of the uterus and the length of the cervix and vagina, were higher in cyclic than non-cyclic gilts (Table 2). However, the age at culling, growth rate, and length of the vestibule did not differ significantly between non-cyclic and cyclic gilts ($P > 0.05$). Based on the herd recorded data, the culling reasons included anoestrus ($n = 148$, 46.8%), abnormal vaginal discharge ($n = 58$, 18.3%), repeated service ($n = 38$, 12.0%), not being pregnant ($n = 25$, 7.9%), abortion ($n = 24$, 7.6), and miscellaneous causes (i.e. poor conformation, leg problems, abnormal teats, and health problems) ($n = 23$, 7.3%).

Uterus size. Of the 310 gilts' uteri, 35 gilts (11.3%) had endometritis, 15 gilts (4.8%) had congenital abnormalities, and 4 gilts (1.3%) had miscellaneous abnormalities. Gilts with an abnormal uterus were excluded from the analysis ($n = 54$); therefore, 256 gilts remained for further analyses. Of these

Table 2. Reproductive data and gross morphological data (Least Squares Means ± SEM) on genital organs of non-cyclic and cyclic Landrace × Yorkshire gilts

Parameters	Non-cyclic gilts ($n = 86$)	Cyclic gilts ($n = 224$)	*P*-value
Age at culling (days)	295 ± 6.5	309 ± 5.4	0.078
Body weight (kg)	145 ± 2.5	155 ± 2.1	< 0.001
Average daily gain (g/day)	489 ± 9.2	500 ± 7.8	0.365
Ovulation rate[1]	0	15.9 ± 0.3	< 0.001
Weight of ovary (g)	3.1 ± 0.1	6.6 ± 0.2	< 0.001
Weight of uteri (g)[2]	128 ± 8.1	694 ± 17.9	< 0.001
Length of uteri (cm)[2]	123 ± 2.9	252 ± 4.6	< 0.001
Length of cervix (cm)	17.2 ± 0.6	19.1 ± 0.5	< 0.001
Number of cervical fold	18.2 ± 0.5	16.8 ± 0.4	0.112
Length of vagina (cm)	9.5 ± 0.5	12.3 ± 0.4	< 0.001
Length of vestibule (cm)	9.1 ± 0.2	9.3 ± 0.1	0.828

[1]abnormal ovaries were excluded ($n = 49$)

[2]abnormal uteri were excluded ($n = 54$)

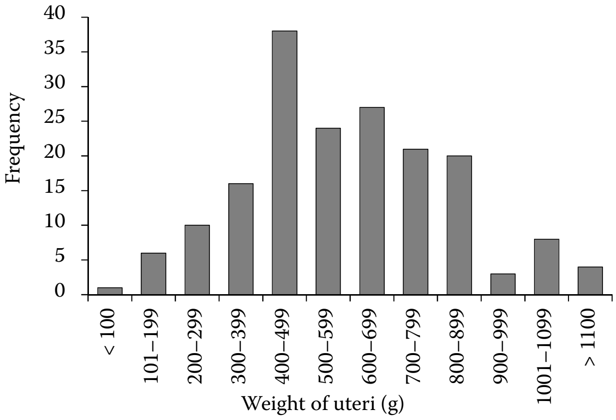

Figure 1. Frequency distribution of weight of uteri in Landrace × Yorkshire cyclic gilts

gilts, 179 were cyclic (148 in the luteal phase and 31 in the follicular phase) and 77 were non-cyclic. The frequency distribution of uterine weight in cyclic gilts is shown in Figure 1. The correlation between uterine weight and length and body weight and age and growth rate are presented in Table 3. Uterine weight correlated with the body weight ($r = 0.48$, $P < 0.001$) and growth rate ($r = 0.33$, $P < 0.001$) but not with the age ($P > 0.05$) of the gilts. Likewise, uterine length correlated with the body weight ($r = 0.34$, $P < 0.001$) and growth rate ($r = 0.20$, $P = 0.007$) but not with the age ($P > 0.05$) of the gilts. The regression coefficient of the effect of body weight on uterine weight and length revealed that for every 10 kg increase in body weight, an increase of 67 g ($P < 0.001$) in uterine weight and 21 cm ($P < 0.001$) in uterine length was observed.

Of the cyclic gilts ($n = 179$), multiple regression analyses revealed that the weight of the uteri was influenced by the reason for culling ($P = 0.012$) and growth rate ($P = 0.011$) but not by age ($P = 0.123$) and body weight ($P = 0.097$). The length of the uteri was influenced by the reason for culling ($P = 0.003$), body weight ($P = 0.002$), and reproductive cycle ($P < 0.001$) but not by age ($P = 0.356$) and growth rate ($P = 0.382$). Table 4 displays the weight and length of the uterus in each category of growth rate. The uterine weight and length in the gilts by body weight class, age class, and reasons for culling are presented in Tables 5, 6, and 7, respectively.

Proportion of cyclic gilts. The uterine weight in non-cyclic gilts was lower than that in cyclic gilts (128 ± 8.1 and 694 ± 17.9 g, $P < 0.001$). Likewise, the length of the uterus in non-cyclic gilts was shorter than that in cyclic gilts (123 ± 2.9 and 252 ± 4.6 cm, $P < 0.001$). The proportion of cyclic gilts in association with body weight and age at culling is presented in Tables 5 and 6, respectively. The proportion of non-cyclic gilts tended to be more common among those culled at ≤ 8 months of age than those culled at 10 ($P = 0.142$) and ≥ 11 ($P = 0.090$) months of age (Table 6).

DISCUSSION

It is known that gilts raised in tropical climates have a poorer litter size at birth than the same

Table 3. Pearson's correlation among weight and length of uterus and body weight, age, and growth rate of gilts

Variables	Ovulation rate	Uterine weight	Uterine length
Body weight	$r = 0.310$ ($P < 0.001$)	$r = 0.478$ ($P < 0.001$)	$r = 0.341$ ($P < 0.001$)
Age	$r = 0.027$ (ns)	$r = 0.051$ (ns)	$r = 0.014$ (ns)
Growth rate	$r = 0.200$ ($P = 0.015$)	$r = 0.329$ ($P < 0.001$)	$r = 0.204$ ($P = 0.007$)

ns = not significant ($P > 0.05$)

Table 4. Weight and length of uterus (Least Squares Means ± SEM) in Landrace × Yorkshire cyclic gilts in relation to growth rate

Growth rate (g/day)	Ovulation rate	Uterus		
		n	uterine weight	uterine length
< 400	15.1 ± 0.7[a]	19	490 ± 72.0[a]	255 ± 19.1[a]
400–499	15.6 ± 0.5[a]	61	705 ± 35.1[b]	246 ± 9.3[a]
500–599	16.5 ± 0.5[a]	75	792 ± 39.7[b]	223 ± 10.5[a]
≥ 600	16.8 ± 1.2[a]	12	823 ± 85.4[b]	210 ± 22.6[a]

[a,b]means with one letter in common are not significantly different ($P < 0.05$)

Table 5. Proportion of cyclic gilts and weight and length of uterus (Least Squares Means ± SEM) in Landrace × Yorkshire gilts in relation to body weight at culling

Body weight (kg)	Gilts (*n*)	Cyclic gilts (*n* and %)	Cyclic gilts		
			ovulation rate	uterine weight (g)	uterine length (cm)
≤ 130	59	27 (45.8)[a]	13.5 ± 0.7[a]	730 ± 62.4[a]	192 ± 16.5[a]
131–140	39	30 (76.9)[ab]	14.9 ± 0.7[ab]	671 ± 52.3[a]	217 ± 13.7[a]
141–150	52	38 (73.1)[ab]	16.7 ± 0.6[b]	681 ± 45.6[a]	235 ± 12.1[a]
151–160	46	35 (76.1)[ab]	16.6 ± 0.7[b]	651 ± 50.0[a]	243 ± 13.2[a]
≥ 161	52	41 (78.8)[b]	16.9 ± 0.6[b]	779 ± 47.1[a]	280 ± 12.5[b]

[a,b]means with one letter in common are not significantly different ($P < 0.05$)

Table 6. Proportion of cyclic gilts and weight and length of uterus (Least Squares Means ± SEM) in Landrace × Yorkshire gilts in relation to age at culling

Age (months)	Gilts (*n*)	Cyclic gilts (*n* and %)	Cyclic gilts		
			ovulation rate	uterine weight (g)	uterine length (cm)
8	73	40 (54.8)[a]	14.4 ± 0.6[a]	627 ± 50.2[a]	246 ± 13.3[a]
9	77	58 (75.3)[a]	16.7 ± 0.5[b]	755 ± 41.5[a]	241 ± 11.0[a]
10	53	43 (81.1)[a]	16.2 ± 0.6[b]	704 ± 47.5[a]	235 ± 12.5[a]
11	45	31 (68.9)[a]	16.0 ± 0.6[ab]	723 ± 54.9[a]	212 ± 14.5[a]

[a,b]means with one letter in common are not significantly different ($P < 0.05$)

Table 7. Weight and length of uterus (Least Squares Means ± SEM) in Landrace × Yorkshire cyclic gilts in relation to culling reasons

Reason for culling	Uterus (*n*)	Uterine weight (g)	Uterine length (cm)
Anoestrus	65	655 ± 34[a]	218 ± 9[a]
Abnormal vaginal discharge	42	633 ± 39[a]	216 ± 10[a]
Repeat service	24	775 ± 47[ab]	247 ± 12[ab]
Abortion	15	831 ± 58[b]	247 ± 15[ab]
Not being pregnant	6	742 ± 94[ab]	200 ± 25[ab]
Miscellaneous	15	577 ± 68[a]	274 ± 18[b]

[a,b]means with one letter in common are not significantly different ($P < 0.05$)

breeds in temperate areas (Tummaruk et al. 2010b). It is well established that the size of the uterus influences the litter size at birth in gilts (Wu et al. 1987; van der Lende and Schoenmarker 1990; Wu and Dziuk 1995). In practice, mating decisions on the replacement gilt are made based on the gilt's age and body weight. In general, the farmers breed their replacement gilts at about 224 days of age onwards with at least 130 kg of body weight. Therefore, to obtain a high prolificacy in gilts, the size of the uterus in relation to their age, body weight, and growth rate should be carefully determined. Our previous study found that LY gilts in Thailand attained puberty at 196 days of age (Tummaruk et al. 2007), which is about 2–4 weeks later than those in Europe and North America (Karlbom 1982; Patterson et al. 2010). Mating decisions for gilts should therefore be made with caution because mating gilts at suboptimal time may result in inferior reproductive performance and longevity (Schukken et al. 1994; Koketsu et al. 1999; Tummaruk et al. 2001). Under field conditions, the record of the first standing oestrus in replacement gilts is often missed and sometimes it is not recorded. This makes difficulties for the mating decision. The body weight of the gilt is one of the most practical indicators for selecting the optimal time of the first insemination. The size of the uterine horn is associated with foetal survival in pregnant gilts (Wu et al. 1987; Wu and Dziuk 1995). The present study found that the maximum size of the uterus in LY gilts in Thailand is observed at a body weight of ≥ 161 kg. Thus, breeding gilts at a body weight ≥ 61 kg may increase the number of piglets born per litter. In the present study, the weight of the uteri did not correlate with the age of the gilts. This indicates that body weight rather than age influences the size of the uterus.

The weight and length of the gilts' uteri observed in the present study is in agreement with earlier findings (Wu et al. 1987; Wu and Dziuk 1995). On average, uterine weight increases 5.5 times and uterine length increases twice following the attainment of puberty. It has been demonstrated that the length of one uterine horn increased from 71 cm at 150 days of age to 141 cm after the first oestrus (Wu and Dziuk 1995) and the weight of one uterine horn at 10 days after the first oestrus was 354 g (Wu et al. 1987). In our study, the sum of the length of two uterine horns in cyclic gilts was on average 252 cm and the uterine weight was 694 g. However, a large variation in both the length and the weight of the uteri was noticed. This might be due to the different genetics, nutritional status, and managements. An earlier study has demonstrated that the length of the uterine horn of cyclic gilts positively correlates with the length of the uterine horn before puberty and the number of live foetuses at 30 days of gestation (Wu and Dziuk 1995). In the present study, bodyweight significantly correlated with the uterine size. Thus, a careful measurement of body weight before insemination might be used to predict the size of the uterus and the total number of piglets born per litter in gilts.

A number of studies have shown that lifetime growth rate influences the reproductive performance of the gilts. Tarres et al. (2006) demonstrated that the culling of Duroc sows due to fertility problems increased when the growth rate from birth to 167 days of age was below 585 g/day. Age at the first farrowing also increased in gilts with a low growth rate compared to those with a high growth rate (Stalder et al. 2005). Our previous study has demonstrated that replacement LY gilts with a growth rate > 560 g/day attained puberty earlier than those with a growth rate < 530 g/day (Tummaruk et al. 2009b). These findings indicate the importance of lifetime growth rate on the reproductive performance of gilts, hence, in the present study, uterine sizes were compared between gilts with different growth rates. It was found that gilts with a growth rate of 500–599 g/day had a heavier uterus than those with a growth rate < 400 g/day. This indicates that the gilts with a high growth rate may have a better uterine development than those with a low growth rate. Therefore, the growth rate of replacement gilts is also associated with their uterine capacity. Based on our data, to obtain an optimal size of the uterus, replacement gilts with growth below 500 g/day should not be used. However, since the growth rate of the gilts is a direct combination between the age and weight, multiple regressions has been performed. The results reveal that the effect of growth rate on uterine size can be explained by the gilt body weight rather than its age. Therefore, replacement gilts should be selected from those with optimal body weight.

The limitation of the present study is that the uterine size was obtained from replacement gilts from different commercial swine herds with different genetic backgrounds, nutrition, and management. Moreover, most of the gilts had been culled due to reproductive failure. Nevertheless, only normal genital organs based on post-mortem examination were selected. Therefore, the uterine size of gilts in the present study is based on data from a selected group of LY crossbred gilts culled from many commercial swine herds in Thailand. The clinical implementation of this data should be made with special concern being paid to genetic background, nutrition, and management. However, the data in this study can be used as a benchmark for uterine size associated with body weight, age, and growth rate of LY crossbred gilts raised in tropical climates.

CONCLUSION

In conclusion, the body weight and growth rate of the gilts significantly correlated with the size of the uterus. For every 10 kg increase in the body weight, an increase of 67 g of uterine weight and 21 cm of uterine length resulted. Based on data from selected groups of LY crossbred gilts in Thailand, the largest uterine sizes were observed at a body weight ≥ 161 kg.

Acknowledgement. Our thanks are due to Assist. Prof. Simon Wright, Chulalongkorn University, for language editing of the manuscript.

REFERENCES

Karlbom I. (1982): Attainment of puberty in female pigs: influence of boar stimulation. Animal Reproduction Science, 4, 313–319.

Koketsu Y., Takahashi H., Akachi K. (1999): Longevity, lifetime pig production and productivity, and age at first conception in a cohort of gilts observed over six years on commercial farms. Journal of Veterinary Medical Science, 61, 1001–1005.

Kummer R., Bernardi M.L., Wentz I., Bortolozzo F.P. (2006): Reproductive performance of high growth rate gilts inseminated at an early age. Animal Reproduction Science, 96, 47–53.

Patterson J.L., Beltranena E., Foxcroft G.R. (2010): The effect of gilt age at first oestrus and breeding on third oestrus on sow body weight changes and long-term reproductive performance. Journal of Animal Science, 88, 2500–2513.

Roongsitthichai A., Cheuchuchart P., Chatwijitkul S., Chantarothai O., Tummaruk P. (2013): Influence of age at first estrus, body weight, and average daily gain of replacement gilts on their subsequent reproductive performance as sows. Livestock Science, 151, 238–245.

Schukken Y.H., Buurman J., Huirne R.B.M., Willemse A.H., Vernooy J.C.M., van den Broek J., Verheijden J.H.M. (1994): Evaluation of optimal age at first conception in gilts from data collected in commercial swine herds. Journal of Animal Science, 72, 1387–1392.

Stalder K.J., Saxton A.M., Conatser G.E., Serenius T.V. (2005): Effect of growth and compositional traits on first parity and lifetime reproductive performance in U.S. Landrace sows. Livestock Production Science, 97, 151–159.

Tarres J., Tibau J., Piedrafita J., Fabrega E., Reixach J. (2006): Factors affecting longevity in maternal Duroc swine lines. Livestock Science, 100, 121–131.

Tummaruk P., Lundeheim N., Einarsson S., Dalin A.-M. (2000): Factors influencing age at first mating in purebred Swedish Landrace and Swedish Yorkshire gilts. Animal Reproduction Science, 63, 241–253.

Tummaruk P., Lundeheim N., Einarsson S., Dalin A.-M. (2001): Effect of birth litter size, birth parity number, growth rate, backfat thickness and age at first mating of gilts on their reproductive performance as sows. Animal Reproduction Science, 66, 225–237.

Tummaruk P., Sukamphaichit N., Kitiarpornchai W., Musikjearanan S., Tantasuparuk W. (2006): Seasonal influence on causes of culling in gilts. In: Proc. 19th Internat. Pig Veterinary Society Congress, Copenhagen, Denmark, 498.

Tummaruk P., Tantasuparuk W., Techakumphu M., Kunavongkrit A. (2007): Age, body weight and backfat thickness at first observed oestrus in crossbred Landrace × Yorkshire gilts, seasonal variations and their influence on their subsequent reproductive performance. Animal Reproduction Science, 99, 167–181.

Tummaruk P., Kesdangsakonwut S., Kunavongkrit A. (2009a): Relationships among specific reasons for culling, reproductive data and gross-morphology of the genital tracts in gilts culled due to reproductive failure in Thailand. Theriogenology, 71, 369–375.

Tummaruk P., Tantasuparuk W., Techakumphu M., Kunavongkrit A. (2009b): The association between growth rate, body weight, backfat thickness and age at first observed oestrus in crossbred Landrace × Yorkshire gilts. Animal Reproduction Science, 110, 108–122.

Tummaruk P., Kesdangsakonwut S., Prapasarakul N., Kaeoket K. (2010a): Endometritis in gilts: reproductive data, bacterial culture, histopathology, and infiltration of immune cells in the endometrium. Comparative Clinical Pathology, 19, 575–584.

Tummaruk P., Tantasuparuk W., Techakumphu M., Kunavongkrit A. (2010b): Seasonal influences on the litter size at birth of pig are more pronounced in the gilt than sow litter. Journal of Agricultural Science, 148, 421–432.

van der Lende T., Schoenmarker G.J.W. (1990): The relationship between ovulation rate and litter size before and after day 35 of pregnancy in gilts and sows: an analysis of published data. Livestock Production Science, 26, 217–229.

Wu M.C., Dziuk P.J. (1995): Relationship of length of uterus in prepubertal pigs and number of corpora lutea and fetuses at 30 days of gestation. Animal Reproduction Science, 38, 327–336.

Wu M.C., Hentzel M.D., Dziuk P.J. (1987): Relationships between uterine length and number of fetuses and prenatal mortality in pigs. Journal of Animal Science, 65, 762–770.

Young M.G., Tokach M.D., Aherne F.X., Dritz S.S., Goodband R.D., Nelssen J.L., Loughin T.M. (2008): Effect of space allowance during rearing and selection criteria on performance of gilts over three parities in a commercial swine production system. Journal of Animal Science, 86, 3181–3193.

Received: 2013–11–12
Accepted after corrections: 2014–05–22

Corresponding Author

Associate Professor Dr. Padet Tummaruk, Chulalongkorn University, Faculty of Veterinary Science, Department of Obstetrics, Gynaecology and Reproduction, Bangkok, Thailand 10330
Phone: +66 022 189 644–5, e-mail: Padet.T@chula.ac.th