Comp Clin Pathol (2012) 21:1–7
DOI 10.1007/s00580-010-1055-9

ORIGINAL ARTICLE

Factors affecting the incidence of cystic ovaries in replacement gilts

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Received: 24 April 2010 / Accepted: 24 June 2010 / Published online: 7 July 2010

Abstract The aim of the present study was to investigate the incidence of cystic ovaries in replacement gilts in relation to age, body weight, estrus behavior, season, and reasons for culling. Data and genital organs of 336 slaughtered gilts from six commercial herds in Thailand were investigated. The reproductive organs were collected at the slaughter house and transported on ice to the laboratory within 24 h for post-mortem examination. Cystic ovaries were characterized by the presence of single or multiple cysts whether accompanied by any other normal structure or not. Cystic ovaries were observed in 44 of 336 (13.1%) gilts. Of these gilts, 26 (59.1%) gilts had multiple cysts and 18 (40.9%) gilts had single cysts. Gilts culled due to abnormal vaginal discharge were more likely to have cysts than gilts culled due to anestrus (19.4% versus 9.1%, $P=0.043$). The gilts that were culled at a body weight of ≥161 kg had a higher incidence of cystic ovaries than gilts culled at a body weight of ≤130 kg (8.1% versus 20.3%, $P=0.045$). The incidence of cystic ovaries was lower in those that had not shown estrus than those that had shown estrus (5.2% versus 19.7%, $P<0.001$). The incidence of cystic ovaries tended to be higher in the gilts culled in cool (18.6%) compared to hot (10.0%, $P=0.092$) and rainy (11.4%, $P=0.129$) seasons.

Keywords Gilt · Cystic ovary · Reproduction · Culling

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Introduction

The cystic ovaries in pigs vary in number and size involving one or both ovaries (Ryan and Raeside 1991; Ebbert and Bostedt 1993), and are a common cause of non-infectious infertility lead to abnormal estrous behavior (Castagna et al. 2004). The incidence of cystic ovaries in sows and gilts culled for infertility problems varies from 1.7% up to 24.0% (Einarsson et al. 1974; Ryan and Raeside 1991; Heinonen et al. 1998; Tummaruk et al. 2009a). The cystic ovaries in swine can be unilateral, or bilateral, while the cysts could be single or multiple and small (<1.5 cm) or large (≥1.5–6.0 cm; Miller 1984; Ebbert and Bostedt 1993). Most of the cystic animals may have both large and small cysts on the same ovary (Miller 1984; Tummaruk et al. 2009a). The physiology and behavior of the animals depend on the types of cystic changes. The single ovarian cysts, in most cases, do not affect fertility or the estrous cycle. However, single ovarian cysts have the potential to become multiple ovarian cysts, which may affect the estrus cycle and/or conception. Most of the multiple large cysts result from luteinized ovarian follicles that produce sufficient progesterone (P_4) to inhibit the estrous cycle. The multiple small cysts often secrete estrogens resulting in irregular estrous cycles. In both situations, ovulation is compromised. In practice, most of the affected sows are culled due to failure to farrow or after they have been repeatedly mated without conception. This problem leads to an increase in the non-productive days of the breeding herd (Castagna et al. 2004). Sows with ovarian cysts have been reported to have a higher incidence of return-to-estrus (34%), not-in-pig (10.6%), and a low farrowing rate (52.2%; Castagna et al. 2004).

In live animals, follicles maintained with a diameter of ≥2.0 cm for >5 days after the onset of estrus have been regarded as cystic ovaries (Castagna et al. 2004). Using a real-time B-mode ultrasonographic examination, cystic ovaries were observed in 2.4% of sows in commercial swine herds (Castagna et al. 2004). Gilts with ovarian cysts may show estrus irregularly or may be intermittently or permanently in anestrus. Cystic ovaries can be accompanied with or without normal copora lutea (CL) on the same ovary. Based on slaughterhouse material, Ebbert and Bostedt (1993) have shown that cystic ovaries without CL, in most cases, have a larger diameter and/or volume than cystic ovaries with CL. Up to 75% of the cystic ovary-sows with either a pale CL or without a CL showed no estrous activity (Miller 1984). Cystic ovaries have been reported in both pregnant and non-pregnant sows (Miller 1984; Castagna et al. 2004). In sows, a lactation length of shorter than 14 days, and weaning-to-oestrus interval of ≤3 days led to a high incidence of cystic ovaries (Castagna et al. 2004).

In practice, replacement gilts taken to the commercial swine herds to substitute the culled sows accounted for 40–50% of number of the sows inventory annually (Lucia et al. 2000; Engblom et al. 2007). Age, body weight, and estrous expression are the criteria to be considered for the first insemination of gilts. In general, the replacement gilts are recommended to be bred when the second estrus or higher were noticed, along with a body weight of at least 130 kg. To achieve a high economic efficiency, the gilts should be conceived before 220 days of age (Schukken et al. 1994). In Thailand, the gilts' age at first observed estrus is often delayed (Tummaruk et al. 2009b) and a considerable number of the replacement gilts are culled before the first litter was accomplished (Tummaruk et al. 2009a). Thus, it is important to investigate pathological changes of the gilts reproductive organs, particularly the ovarian function, to gain more knowledge to minimize the number of culled replacement gilts. Cystic ovary in pig is influenced by herd and season, and has been reported to be related to the presence of zearalenone in feed (Gherpelli and Tarocco 1996). There is limited information on the incidence of cystic ovaries in replacement gilts. Thus, the aim of the present experiment was to study the incidence of cystic ovaries in replacement gilts and investigate how it could be affected by their age, body weight, estrus behavior, and relate it to the season as well as reasons for culling.

Materials and methods

Animals and management

The study was conducted on 336 gilts (311 Landrace × Yorkshire, 14 Yorkshire and 11 Landrace) from six commercial herds that were located in the Northeastern (two herds), eastern (two herds), central (one herd), and western (one herd) parts of Thailand between latitude 13° and 17° N and between longitude 100° and 104° E. The number of sows on production varied among the herds from 900 to 4,400 sows per herd. The housing in all herds was an open-housing system with facilities to reduce the impact of high temperatures such as fan, water sprinklers, and roofs with heat-reflecting material. Replacement gilts entered the gilt pool at a body weight of 80–100 kg in all the herds. Gilts were usually vaccinated against classical swine fever, foot-and-mouth disease, Aujeszky's disease, and porcine parvo virus at 22–30 weeks of age. In all herds, the gilts were kept in pens in groups of 6-15 gilts/pen with a space allowance of 1.5-2.0 m^2/gilt. Estrus detection was performed daily in the presence of a mature boar. The gilts were provided water ad libitum using water nipples and were fed twice a day (about 3kg of feed/gilt/day) with a rice-corn-soybean-fish base containing 16-18% crude protein, 3,000-3,250 kcal/kg metabolizable energy, and 0.85-1.10% lysine. In general, the herd management recommended breeding the replacement gilts from 32 weeks of age onwards at the second or a later estrus and at a body weight of at least 130 kg. All herds used conventional artificial insemination.

The data were collected prior to culling regarding herd, gilt identity, breed, date of birth, date of entry into the herd, first observed estrus, date of insemination, date of culling, body weight at culling, and the reason for culling. Age at entry into the gilt pool, at first observed estrus and at culling, and the interval from entry into the gilt pool to culling were calculated. The average daily gain (ADG) from birth to culling was calculated: $\mathrm{ADG}(g/d) = (\text{body weight at culling(kg)} - 1.5/\text{age at culling}) \times 1,000$. Gilts were classified according to the age at first observed estrus as those that had not shown signs of estrus (n=154) and those that had first observed estrus at ≤30 (n=55), 31–34 (n=75) and ≥35 (n=52) weeks of age. The gilts were also classified according to the season when they were culled: cool (15 October–14 February; n=96), hot (15 February–14 June; n=100), and rainy (15 June–14 October; n=140). On average, the 24-h outdoor temperature and relative humidity were 25.1±2.7°C/64.4±8.7%, 28.9±2.5°C/67.1±10.7%, and 27.9±1.3°C/81.5±6.5%, in cool, hot, and rainy seasons, respectively. All gilts were weighed individually before culling and the body weight at culling was classified into five groups: ≤130 (n=74), 131–140 (n=50), 141–150 (n=71), 151–160 (n=59), and≥161 kg (n=74). The gilts were also grouped according to age at culling as <40 (n=126), 41–45 (n=118), and 46–51 (n=84) weeks of age. After culling, the reproductive organs were collected at the slaughter house and transported on ice to the laboratory within 24 h for post-mortem examination.

Post-mortem examination

The ovaries were dissected free from mesovarium. The stage of estrous cycle of the gilts was determined by the presence of

CL and follicle size on the ovaries. The ovaries were defined as either inactive or normal cyclic (i.e., luteal and follicular phase) according to the structure present (Fig. 1). Cystic ovaries were distinguished from CL or normal follicles by their size within the same ovary. Cystic ovaries were classified having either single (one cyst/gilt) or multiple cysts (≥two cysts/gilt) with and without normal structures (Miller 1984).

Statistical analyses

Statistical analyses were performed by using SAS version 9.0 (SAS Inst. Inc., Cary, NC, USA). Descriptive statistics (means, standard deviation, and range) and frequency tables were calculated for all reproductive parameters. Continuous data, i.e., age and body weight at culling, ADG, entry-to-cull interval, and age at first-observed estrus were compared among gilts that had cystic, inactive, or normal ovaries by analysis of variance. Normal distribution of the data was tested using the UNIVARIATE procedure option NORMAL of SAS. Skewness, kurtosis, and Kolmogorov-Smirnov D statistic of all continuous variables were evaluated. Least-squares means and standard error of the means were obtained and were compared among groups by least significant different test. Proportional data, i.e., the incidence of cystic ovaries, were compared among different group of gilts classified by age at culling, body weight at culling, reasons for culling, age at first observed estrus, and culling season by using logistic regression analysis by GLIMMIX macro of SAS. A value of $P<0.05$ was considered as statistically significant.

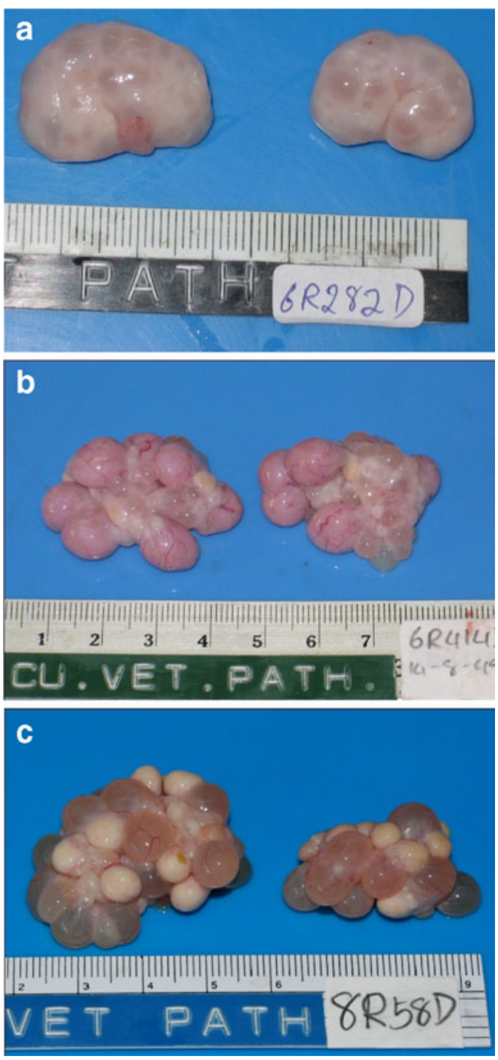

Fig. 1 Normal structure of the gilt's ovaries at different stage of estrus cycle **a** inactive phase **b** luteal phase **c** follicular phase

Results

Data

The average age at culling was 300.9±49.4 (209–504) days. The average body weight at culling was 145.4±20.2 (92.0–205.5) kg. Of all the gilts, 182 (54.2%) gilts were pubertal and had shown at least one signs of estrus, and 125 (37.2%) gilts had been mated. The average age at first observed estrus was 233.2±32.2 (152–374) days and age at first insemination was 263.5±28.0 (204–374) days. The gilts were culled at 86.9±53.6 (6–273) days after entering the gilt pool. The gilts that had cystic ovaries had a shorter interval from entry-to-cull than those that had normal and inactive ovaries (Table 1). The reasons for culling include anestrus (153 gilts, 45.5%), abnormal vaginal discharge (62 gilts, 18.5%), repeat breeding (41 gilts, 12.2%), and miscellaneous (e.g., abortion, no pregnancy, etc.; 80 gilts, 23.8%).

Gross morphology

Cystic ovaries were observed in 44 of 336 (13.1%) gilts. Of these gilts, 26 (59.1%) gilts had multiple cysts and 18 (40.9%) gilts had single cysts (Fig. 2). Beside cystic ovaries, other gross morphological findings were normal cyclic ovaries (n=187, 55.7%), inactive ovaries (n=89, 26.5%), and miscellaneous (e.g., ovarian adhesion, ovo-testis, etc., n=16, 4.8%). Of the normal cyclic ovaries, 148 (79.1%) gilts were in luteal phase, and 39 (20.9%) gilts were in follicular phase. In addition, par-ovarian cysts were observed in 120 out of 336 gilts (35.7%).

Cystic ovaries associated with reasons for culling

The incidence of cystic ovaries classified by reasons for culling is displayed in Table 2. The gilts with cystic ovaries (n=44) were culled due to different reasons including

Table 1 Reproductive data of gilts with normal, inactive, and cystic ovaries (least-squares means±SEM)

Variables	Normal (*n*=187)	Inactive ovaries (*n*=89)	Cystic ovaries (*n*=44)	Others (*n*=16)
Age at culling (day)	303.8±3.6a	296.1±5.2a	299.0±7.4a	300.1±12.4a
Entry-to-cull (day)	76.1±3.9a	119.0±5.5b	57.4±7.6c	114.1±13.1b
Body weight (kg)	148.1±1.5a	136.6±2.1b	151.2±2.9a	148.2±4.9a
Average daily gain (gram/day)	490.8±6.6a	470.7±9.3a	495.7±13.1a	505.1±21.7a
Age at first estrus (day)	233.2±2.6a	NA	235.6±4.9a	NA
Age at first mating (day)	261.9±2.9a	NA	264.5±5.6a	NA

Different letters within row differed significantly ($P<0.05$)

NA not available

anestrus (14 gilts), abnormal vaginal discharge (12 gilts), repeat breeding (seven gilts), and miscellaneous (11 gilts). The incidence of cystic ovaries was 14/153 (9.2%), 12/62 (19.4%), 7/41 (7.1%), and 11/80 (13.7%) in the gilts that were culled due to anestrus, abnormal vaginal discharge, repeat breeding and miscellaneous, respectively. Gilts culled due to abnormal vaginal discharge had a higher incidence of cystic ovaries than those culled due to anestrus (19.4% versus 9.2%, $P=0.043$) (Table 2).

Cystic ovaries associated with age and body weight at culling

Cystic ovaries were observed in gilts of different ages at culling: younger than 40 weeks of age (15 gilts, 34.1%), 41–45 week of age (20 gilts, 45.5%), and 46–51 week of age (nine gilts, 20.5%; $P=0.375$).

On average, the gilts that had cystic ovaries were heavier at culling than those that had inactive ovaries (151.2 versus

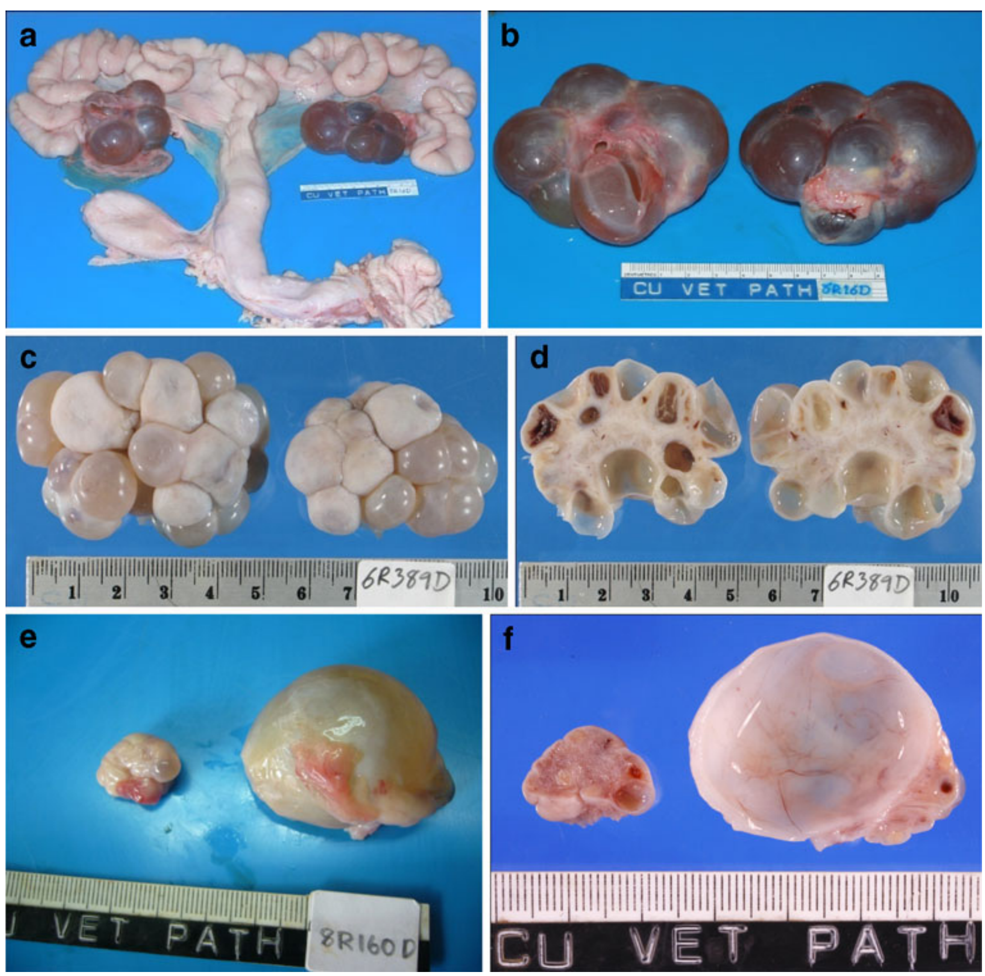

Fig. 2 Different types of cystic ovaries observed in replacement gilts **a** and **b** multiple large cysts **c** and **d** multiple small cysts **e** and **f** single large cysts

Table 2 Incidence of normal, inactive and cystic ovaries by reasons for culling

Reasons for culling	*N*	Ovarian appearance			
		Normal	Inactive	Cyst	Others[a]
Anestrus	153	56 (36.6%)a	74 (48.4%)a	14 (9.2%)a	9 (5.9%)
Abnormal vaginal discharge	62	42 (67.7%)b	5 (8.1%)b	12 (19.4%)b	3 (4.8%)
Repeat-service	41	29 (70.3%)b	1 (2.4%)b	7 (17.1%)ab	4 (9.8%)
Miscellaneous	80	60 (75.0%)b	9 (11.2%)b	11 (13.8%)ab	0 (0.0%)
All	336	187	89	44	16

Different letters within column differ significantly ($P<0.05$)

[a] Data were not compared to others

136.6 kg, $P<0.001$; Table 1). The incidence of cystic ovaries was 6/74 (8.1%), 4/50 (8.0%), 14/71 (19.7%), 5/59 (8.5%), and 15/74 (20.3%) in the gilts that were culled at a body weight of ≤130, 131–140, 141–150, 151–160, and ≥161 kg, respectively. The gilts that were culled at a body weight of ≥161 kg had a higher incidence of cystic ovaries than the gilts that were culled at a body weight of ≤130 kg (20.3% versus 8.1%; $P=0.045$).

Cystic ovaries associated with age at first observed estrus

Of all the culled gilts, 182 (54.2%) had first observed estrus at an age of 32.9±4.6 (21–53) weeks. Standing estrus was shown in 55 (16.3%), 75 (22.3%), and 52 (15.5%) gilts at ≤30, 31–34 and ≥35 weeks of age, respectively. The incidence of cystic ovaries was 11/55 (20.0%), 13/75 (17.3%), and 12/52 (23.1%) in these age groups, respectively, and did not differ among them ($P=0.726$). Among the gilts that had not shown standing estrus, the incidence of cystic ovaries was 0/10 (0.0%), 0/7 (0.0%), and 8/137 (5.8%) in the gilts culled at ≤30, 31–34 and ≥35 weeks of age, respectively ($P=0.592$). The incidence of cystic ovaries was lower in the gilts that had not shown estrus (8/154, 5.2%) than those that had shown estrus (36/182, 19.8%; $P<0.001$).

Seasonal influence on the incidence of cystic ovaries

The incidence of cystic ovaries was 18.7% (18/96 gilts), 10.0% (10/100 gilts), and 11.4% (16/140) in those that were culled during cool, hot, and rainy seasons, respectively. The incidence of cystic ovaries tended to be higher in the gilts culled in the cool compared to the hot ($P=0.092$) and the rainy ($P=0.129$) seasons.

Discussion

The present study demonstrated an incidence of 13.1% cystic ovaries in culled replacement gilts in swine herds in Thailand. This is a relatively high figure compared to earlier reports for culled female pigs in the USA (10.0%) and Europe (6.2%; Miller 1984; Heinonen et al. 1998). In the present study, comparatively higher incidence of cystic ovaries was associated with gilts having ≥161 kg body weight, gilts that had shown estrus signs or abnormal vaginal discharge, and those that were culled in cool season. These gilts were culled due to different reasons. Reproductive failure and the incidence of cystic ovaries tended to be related to abnormal vaginal discharge rather than anestrus. Moreover, the incidence of cystic ovaries in the replacement gilts was higher in those that had shown signs of estrus than in those that had not shown signs of estrus. This indicates a close relationship between hormonal function and the formation of cystic ovaries. The hormonal disturbance caused by cystic ovaries might also influence the endometrial function (Szulanczyk 2009) and might lead to the occurrence of abnormal vaginal discharge.

In pigs, the mechanism that causes cystic ovaries has not been comprehensively evaluated. However, many factors could be involved in the formation of cystic ovaries. For instance, Whisnant et al. (1998) demonstrated that manual manipulation of the ovaries induced ovarian cysts in gilts, and suggested that local factors, e.g., tissue-type plasminogen activator, play an important role in blocking ovulation in the manipulated follicles of the gilts. The levels of pulsatile-LH released in the sows with ovarian cysts have been shown to be comparable to those during diestrus. Cystic ovary sows produced insufficient LH to complete luteinization (Almond and Richards 1991). It has been hypothesized that cystic ovaries is caused by a deficiency in the release of LH at estrus or gonadotropin-releasing hormone or a lack of LH or follicle-stimulating hormone receptors in the developing follicles (Liptrap and McNally 1977; Miller 1984; Castagna et al. 2004). In replacement gilts, elevation of cortisol might have occurred due to various stressful stimuli, such as intensive acclimatization, overcrowding, and hot and humid climates. An increase of the plasma cortisol in the replacement gilts is associated with an alteration of the local immune cells in the gilts' endometrium and might lead to endometritis (Roongsitthichai et al. 2009). Furthermore, it has been shown that ACTH treatment can induced cystic ovaries in pig (Liptrap and McNally 1977). Based on the present results, stressful stimuli should be minimized in the replacement gilts that have shown estrus signs, those with a body weight of more than 161 kg and those entering the gilts pool in the rainy seasons.

In Europe, cystic ovaries have been reported as being twice as likely to develop during the spring as in the autumn (Ryan and Raeside 1991). In the present study, gilts culled during the cool season had the highest incidence of cystic ovaries. At the time of entry into the herds, these gilts seem to be stressed due to the hot and humid climates of the rainy season and were culled only 57.4 days later. This may suggest that the exposure to previous stress (in this case, about 60 days earlier) might have carried over, and that resulted in a higher incidence of cystic ovaries in the cool season. Stressful stimuli, such as extreme environmental temperature, disease, overcrowding, lameness, prolonged shipping, malnutrition, and premature weaning can increase the incidence of ovarian cysts (Gherpelli and Tarocco 1996; Castagna et al. 2004). For instance, up to 19% of sows weaned at day 0 have been reported to have ovarian cysts (Kunavongkrit et al. 1983).

The incidence of cystic ovaries in the culled replacement gilts was relatively high as some 15–22% replacement gilts suffered from it. It is therefore important to diagnose the problem and give appropriate treatment to avoid any losses in herd production. Another feature of the cystic ovaries was their association with abnormal vaginal discharge (19.4%). This might have resulted from the abnormal hormonal balance (caused by cystic ovaries) that may affect immune cells in the endometrium, leading to malfunction of the uterus (Tummaruk et al. 2010) and thus vaginal discharge. For clinical diagnosis in the live animal, either P_4 assays or ultrasonography can help differentiate between follicular and luteal cysts (Chung et al. 2002; Castagna et al. 2004). Up to 85% of the cystic ovaries showed signs of luteinization (Tummaruk et al. 2009a). In general, veterinarians often treat the sows suspected cystic ovaries by administration of pregnant mare serum gonadotropin 400 IU in combination with hCG 200 IU (Dalin 1984; van de Wiel and Booman 1993; Chung et al. 2002). However, in occasional cases, $PGF_{2\alpha}$ is used (Liptrap and McNally 1977; Chung et al. 2002).

In conclusion, cystic ovaries were observed in 13.1% of the culled replacement gilts in Thailand. High incidence of cystic ovaries was associated with gilts with a body weight of ≥161 kg, gilts that had shown estrus signs, gilts culled due to abnormal vaginal discharge, and those culled during the cool season. These data imply that the occurrence of cystic ovaries in replacement gilts should be investigated, diagnosed, and appropriate treatment given to minimize the culling of gilts due to reproductive failure. Special attention should focus on the gilts that enter the herd during the rainy season, gilts that had shown estrus signs and gilts with a body weight of ≥161 kg.

Acknowledgement The present study was funded by the Thailand Research Fund (MRG4880127) and the National Research Council of Thailand (NRCT). Language editing of the manuscript has been coordinated by Chula Unisearch, Chulalongkorn University.

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