Original Article

Effects of the higher parity and litter size on piglet birth weight and survival rate of later born piglets

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Abstract

The objectives of this study were to evaluate the effects of higher parity and litter size (LS) on piglet birth weight (BW) and to compare the BW and survival rate of piglets born in different birth orders (BO). The study was conducted at a commercial pig farm in Thailand. Data from 230 sows and 3,500 piglets were analyzed including parity, litter size (LS), average birth weight (AvBW), coefficient of variation of piglets' BW (%CV), standard deviation of piglets' BW (SD), percentage of small piglets (%Small), individual piglet's BW, piglet birth order (BO; 1-10, 11-16, 17-25), sex and characteristics at birth (mummified fetuses (MM), stillborn piglets (SB) and born alive piglets (BAL)). Results revealed that the reduction in AvBW was prominent when LS increased ($p < 0.001$) and the expansion of BW variability (%CV, SD, %Small) was significant in the higher parity sows with large LS ($p < 0.001$). A difference in piglet BW was found among different BO; the later born piglets in BO 17-25 were lighter than the piglets born in BO 1-10 and 11-16 ($p < 0.001$). The percentage of BAL steadily decreased concomitantly with the rising of BO ($p < 0.001$), whereas the born dead piglets including MM and SB increased significantly ($p < 0.001$). This study demonstrated that higher parity and LS had negative effects on piglet BW including the reduction in mean BW with a greater variability. Moreover, the later born piglets in large litters had a lower survival rate.

Keywords: birth order, birth weight, litter size, parity, piglet, survival rate

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Introduction

Over the last decade the improvement in sow prolificacy and the ability to increase piglets per litter or litter size (LS) of middle-aged or old sows (Milligan et al., 2002) have assisted the swine industry in confronting piglet losses during peri- and post-natal periods, due to lower mean birth weight (BW) with greater variability (Quiniou et al., 2002) and prolongation of the expulsive stage (van Dijk et al., 2005).

Increased LS causes a greater proportion of small piglets with inadequate body energy, resulting in higher sensitivity to cold. Besides, they have lower ability to compete with their littermates to obtain sufficient colostrum and milk (Le Dividich, 1999). Therefore, most of them have a higher risk of post-natal mortality during the first week after birth (Quiniou et al., 2002).

Moreover, the prolonged expulsive stage in large litters raises the risk of death in later born piglets with lighter weight peri-partum, due to reduced stimuli production, which is necessary for maintenance of uterine contraction (Fraser, 1984), resulting in asphyxia (Herpin et al., 1996).

However, the severity of piglet losses varies among countries and farms (Furtado et al., 2012; Kilbride et al., 2012). In Thailand, the information on piglet losses is scarce. Therefore, the objectives of this study were to evaluate the effects of parity and LS on piglet BW and compare piglet BW and survival rate among different birth orders (BO), of a commercial pig farm in Thailand.

Materials and Methods

Animals: Animal manipulations were approved by the Animal Usage and Ethics Committee, Kasetsart University (ACKU 03555). The study was conducted from June 2012 to August 2013 in Chiang Mai, Thailand (18°47′25″ N, 98°59′04″ E) at a commercial sow breeding farm housing 5,000 sows with an evaporative cooling system which maintained the temperature at 25°C and relative humidity below 80%. The external temperature and relative humidity varied from 11.6°C to 39.7°C and 48% to 88% (Meteorological Department, 2015), respectively.

All the sows received a gestation and lactation diet that contained 15.5% crude protein (CP), 3,048 Kcal/kg metabolizable energy (ME) and 0.9% total lysine (Lys) during weeks 1-11 of gestation; 16.4% CP, 3,048 Kcal/kg ME and 0.9% Lys during weeks 12-15 of gestation; and 18.1% CP, 3,314 Kcal/kg ME and 1.2% Lys. During lactation and prior to conception, the sows were fed ad libitum four times a day. After mating, they were fed twice a day and the feed level was controlled depending on the sow's body condition score (BCS) (BCS < 3, 2.0 kg/day; BCS = 3, 1.5 kg/day; BCS > 3, 1.0 kg/day). Water was supplied through a nipple drinker and was available at all times.

Estrus monitoring after weaning was carried out at 08.00 and 15.00 by trained farm technicians using fence-line boar contact. Estrus signs were detected when the sows exhibited a standing heat reflex during a back pressure test in the presence of a boar. Traditional artificial insemination (AI) with pooled semen was done at 12 and 24 h after estrus expression.

Gestating sows were moved to a farrowing barn one week before the expected day of parturition. The farrowing pen was composed of a farrowing crate on a slatted floor under the sow and a metal slatted floor under piglets. A heat lamp was placed inside a metal box which was beside the sow to provide heat for the piglets. At one day of age, all piglets had their teeth clipped and tail docked and were injected with iron.

Data collection: Cross-bred (Large white x Landrace) sows (n = 230) were recorded for parity (1, 2, 3, 4, 5, 6, ≥ 7) and LS. After birth, piglets (n = 3,500) were individually weighed. Their individual BW, BO, sex and characteristics (mummified fetuses (MM), stillborn piglets (SB) and born alive piglets (BAL)) were also recorded. Then, the piglets' data were calculated for average birth weight (AvBW), coefficient of variation of BW (%CV), standard deviation of BW (SD) and percentage of small piglets (weighing less than one kilogram within the litter) (%Small piglets). The data collection from both sows and their litters was conducted by questionnaires.

Statistical analysis: Factors (LS and parity) that affected AvBW and BW variation (%CV, SD and %Small piglets) were identified by linear regression (Winter, 2013). The model after this procedure was $Y_{ijk} = L_i + P_j + E_{ijk}$, where Y_{ijk} = response variable (AvBW, %CV, SD and %Small piglets), L_i = litter size, P_j = parity, and E_{ijk} = residual error.

Comparison of piglet BW among different BO (1-10, 11-16, 17-25) with correction of the effect of sex (male and female) (Čechová, 2006) was determined by the two-way analysis of covariance (ANCOVA), in which LS was accounted a covariate (Quiniou et al., 2002). Significance of the ANCOVA results was further analyzed by post hoc analyses using Bonferroni (SPSS version 18, SPSS Inc., Chicago, IL, USA).

Proportions of piglets' characteristic in different BO (1-10, 11-16, 17-25) were tested by the chi-square test and Tukey-type multiple comparison (Zar, 1996).

A significant level was considered when the p-value was < 0.05. Data were presented as mean ± SEM.

Results

Effects of increased parity and LS on piglet BW: The increase in LS decreased the mean BW as described by the following equation: AvBW = 2.015 – 0.033 LS, R^2 = 0.251, $p < 0.001$. For every one piglet added to a litter, the AvBW would be reduced by 0.033 kg (Fig. 1). There was no parity effect on AvBW ($p > 0.05$) (Fig. 2). However, the variability of piglet BW depended on both parity and LS (Figs. 1-4). The higher parity and larger LS triggered the rising of SD, %CV and %Small piglet within a litter as described by the three equations as follows: SD = 0.141 + 0.012 Parity + 0.009 LS, R^2 = 0.151, $p < 0.001$; %CV = 2.492 + 0.958 Parity + 1.067 LS, R^2 = 0.245, $p < 0.001$; and %Small piglet = –10.778 + 0.873 Parity + 1.037 LS, R^2 = 0.194, $p < 0.001$.

Comparison of piglet BW among different BO: After adjusting for LS ($p < 0.001$) and correcting the effect of sex ($p = 0.003$), the main effect of BO on individual piglet BW was significant ($p < 0.001$). There was no interaction (BO × sex) effect ($p = 0.683$). The piglets born in BO 17-25 (1.40 ± 0.01 kg) were lighter than the piglets born in BO 1-10 (1.51 ± 0.01 kg) and BO 11-16 (1.46 ± 0.01 kg) ($p < 0.05$). However, there was no difference in piglet BW between BO 1-10 and BO 11-16 ($p \geq 0.05$) (Fig. 5).

Different survival rates among different BO: The percentage of BAL decreased with the increase in BO (94.34%, 84.70%, 71.09%, respectively) ($p < 0.05$), while the percentage of SB (3.06%, 10.88%, 18.58%) and MM (2.61%, 4.42%, 10.32%) grew consecutively ($p < 0.05$) (Fig. 6).

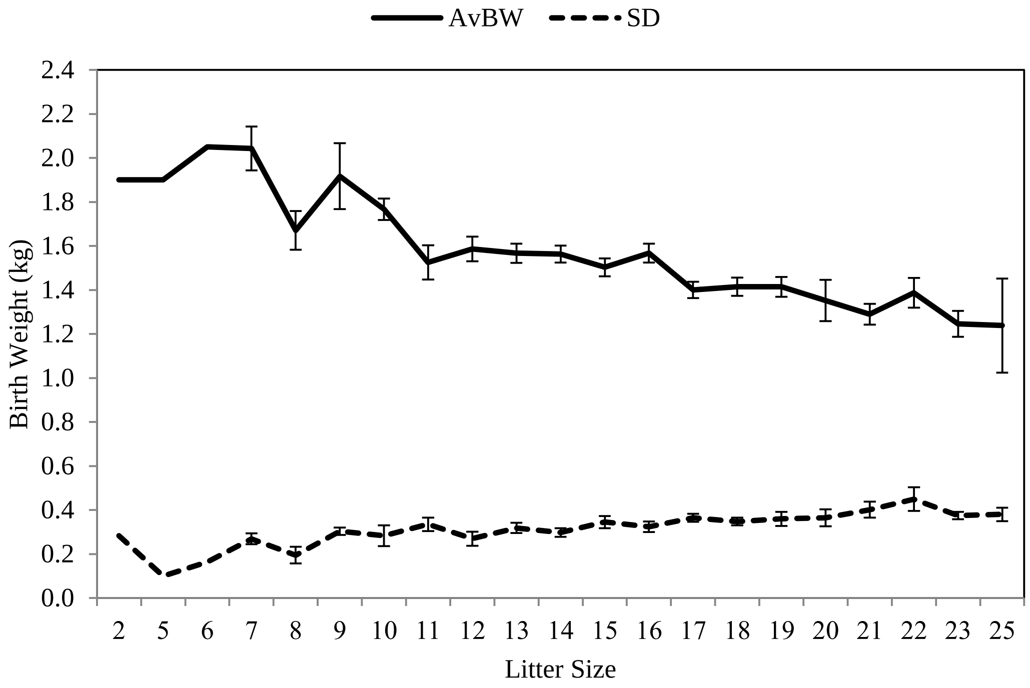

Figure 1 Piglets average birth weight (AvBW) and standard deviation of birth weight (SD) categorized by litter size (vertical error bars = ± SEM)

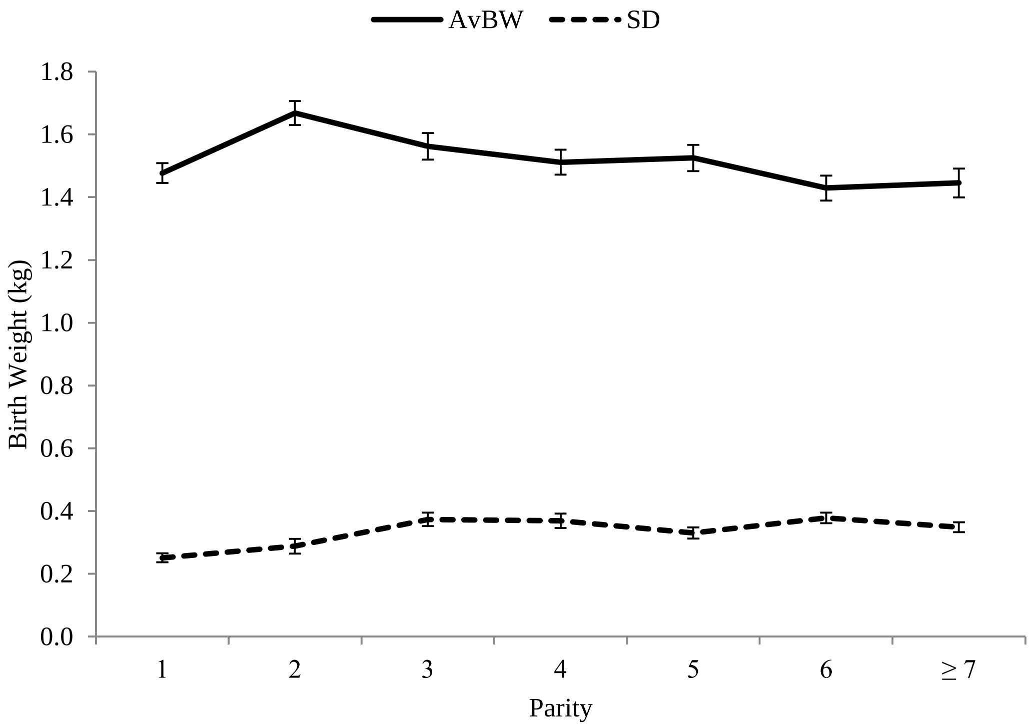

Figure 2 Piglets average birth weight (AvBW) and standard deviation of birth weight (SD) categorized by parity (vertical error bars = ± SEM)

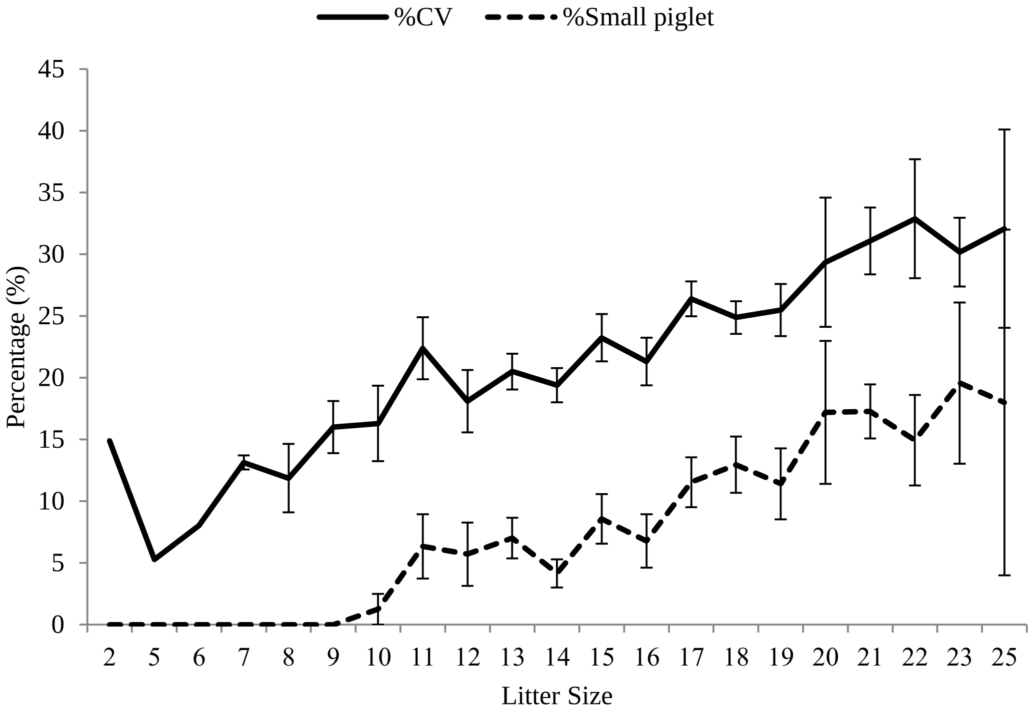

Figure 3 Coefficient of variation of piglets' birth weight (%CV) and percentage of small piglets (%Small piglet) categorized by litter size (vertical error bars = ± SEM)

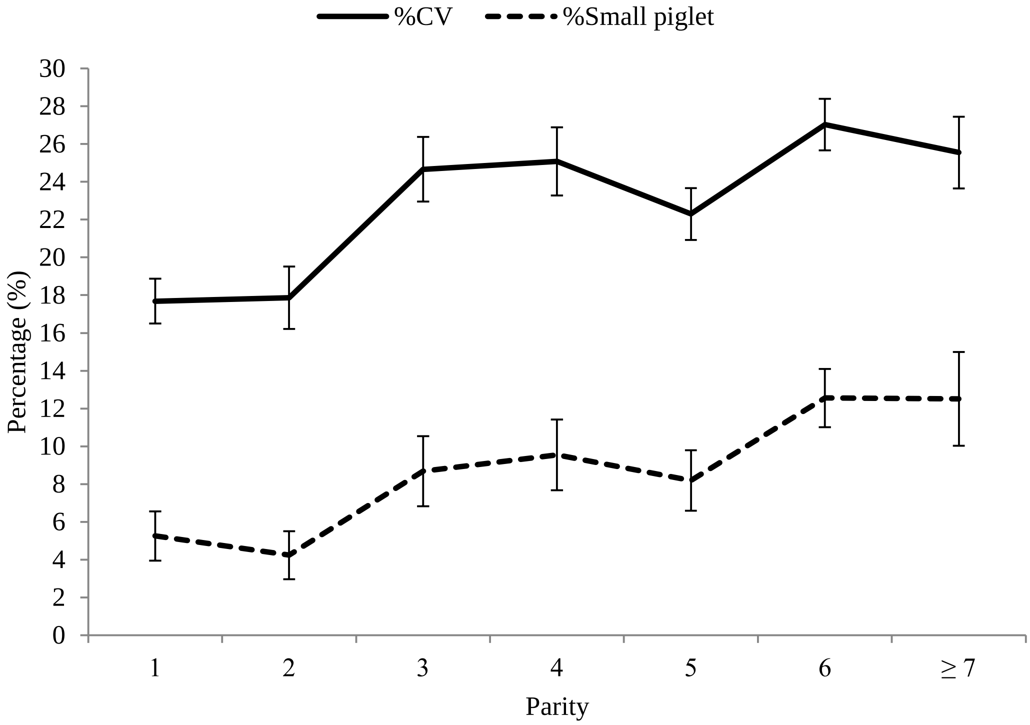

Figure 4 Coefficient of variation of piglets' birth weight (%CV) and percentage of small piglets (%Small piglet) categorized by parity (vertical error bars = ± SEM)

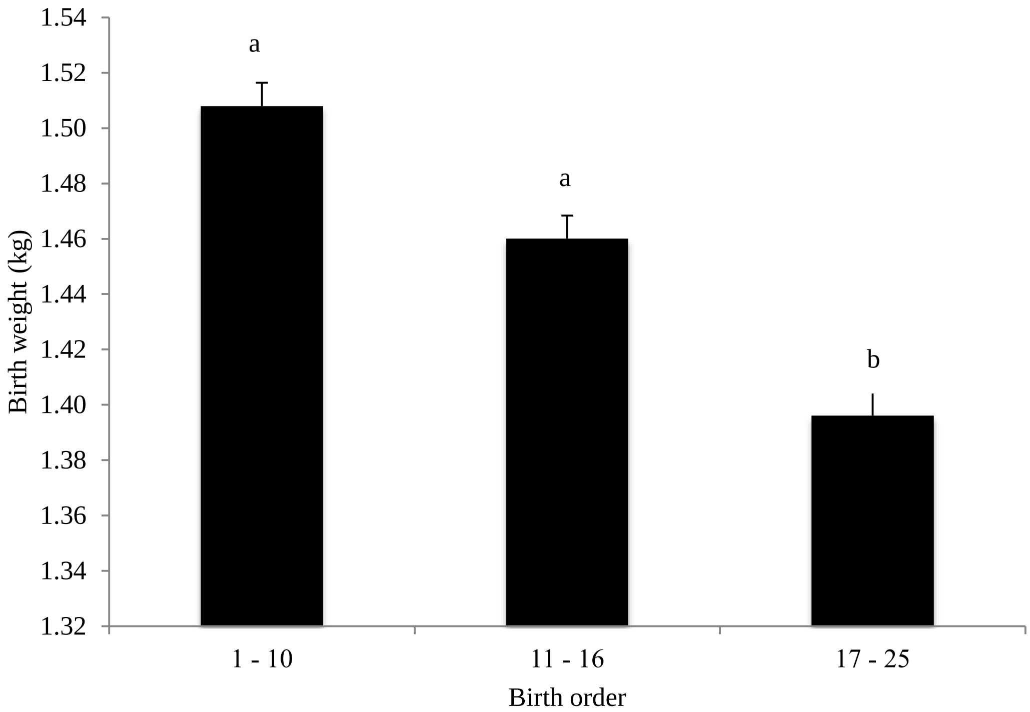

Figure 5 Piglets birth weight in different groups of birth order
a, b = Significant differences at $p < 0.05$

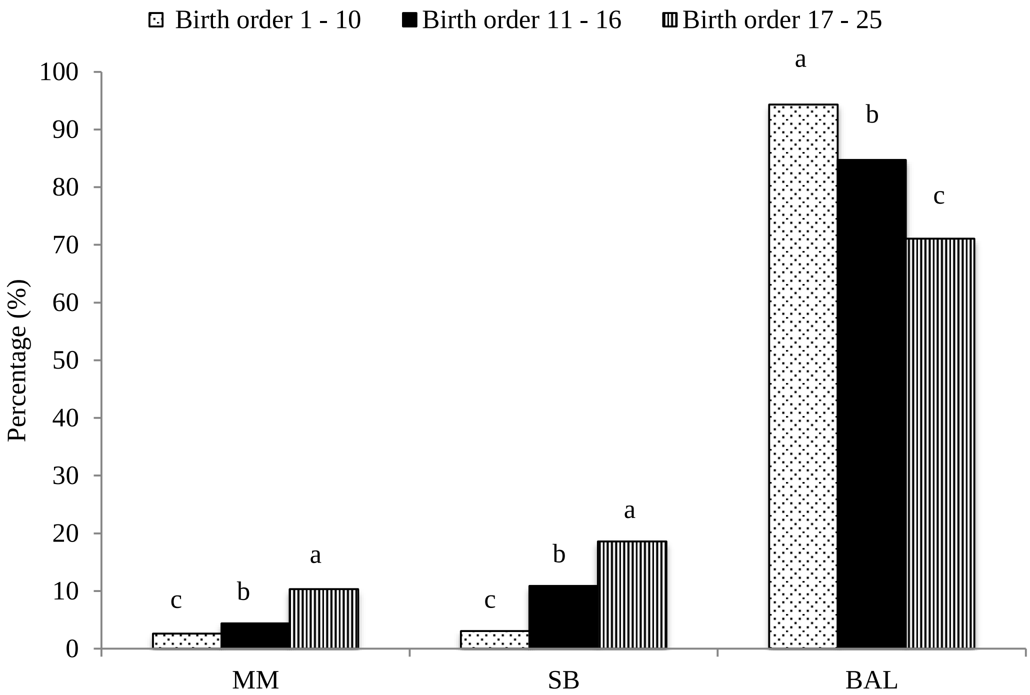

Figure 6 Percentage of mummified fetuses (MM), stillborn piglets (SB) and born alive piglets (BAL) in different birth orders
a, b, c = Significant differences at $p < 0.05$

Discussion

Negative effects of higher parity and LS on piglet BW: The reduction in mean BW was mainly affected by the increase in LS in the present study, whereas parity and LS contributed to the higher piglet BW variability. The results of this study agreed with those of Quiniou et al. (2002), who reported that the increase in LS was inappropriate for the rising of litter BW. The increase in LS from 9 to 17 piglets was an 88% increase, whereas the total litter BW increased only by 50% (21 vs 14 kg), or the increase in LS from ≤ 11 to ≥ 16 decreased mean BW from 1.59 to 1.26 kg. Besides, SD of BW rose from 0.26 to 0.30 kg and the percentage of low BW piglets (weighing less than one kilogram) rose to 11%. Increased LS is likely related to a higher ovulation rate and embryo survival of middle-aged or older sows (Wrathall, 1971; Milligan et al., 2002). Therefore, uterine crowding is a consequent problem for these sows, especially after day 35 of pregnancy, when the uterine capacity is limited for a larger number of porcine fetal development (Knight et al., 1977). Reducing uterine blood flow per fetus (Père and Etienne, 2000) and insufficient nutrient supply might be the cause of low BW in large litters (Caugant and Guéblez, 1993). Moreover, the variation of fetal development might depend on the position of implantation (Perry and Rowell, 1969) because the rates of blood flow and nutritional supply vary greatly along the length of the uterus, due to difference in vasculature structure and density (Ford et al., 2002; Wu et al., 2010), resulting in a variation of piglet weight at birth.

Observation of lighter BW in later born piglets: The piglets born in the last group of BO were lighter than the piglets born earlier. This finding is normally observed in large litters (Fraser, 1984). Homogenized embryos are distributed within the uterine horn before day 35 of pregnancy (Anderson and Parker, 1976). Thereafter, porcine fetal development depends on the position and number of fetuses in the uterus (Perry and Rowell, 1969). There is no difference in advantage between positions when there are only five or fewer fetuses in the horn (Perry and Rowell, 1969). However, in large litters, the fetal weight declines from the ovarian end of the uterus to the middle, related to the slight increase in weight of the fetuses near the cervical end (Perry and Rowell, 1969). During the farrowing process, which does not completely occur at random (Friend and Cunningham, 1966), piglets rarely overtake neighboring piglets in the same horn (Taverne et al., 1977), as a result later born piglets tend to be those positioned at the ovary end of the uterus (Friend and Cunningham, 1966) which are slightly lighter than the piglets positioned near the cervical end.

Reduction in survival rate of later born piglets caused by higher BO: The percentage of BAL significantly decreased concomitantly with the higher BO, whereas the percentage of MM and SB steadily increased. The number of piglets born positively correlates with the percentage of piglets born dead (Milligan et al., 2002; Motsi et al., 2006), due to the prolonged duration of the expulsive stage, which affects the degree of asphyxia during delivery (Herpin et al., 1996). Significantly, later born piglets located high up at the ovary end of the uterus tend to suffer from occlusion or rupture of the umbilical cord or detachment of the placenta, leading to inadequate blood flow and oxygen supply to unborn piglets (Fraser, 1984; van der Lende and van Rens, 2003). Therefore, 70% of SB are normally noticed during the last third of the farrowing period (Friend and Cunningham, 1966). In addition, the lighter BW of the last born piglets (Friend and Cunningham, 1966) might lead to a greater risk of death during the farrowing period due to the lower production of stimuli to trigger or maintain uterine contraction during fatigue (Fraser, 1984).

For the already dead piglets or MM, they could not move to reach the right position and enter the pelvic canal to be delivered. This was the reason why the higher percentage of MM was noticeable in the higher BO. Besides, BO of MM might depend on their size. Large MM are generally expelled at the same time as their littermates, while the majority of small MM are expelled with the placenta (van der Lende and van Rens, 2003).

Conclusion

The increase in parity and LS decreased the mean piglet BW, raised the variability of BW within a litter and suppressed the opportunity of survival of the later and lighter born piglets. Therefore, intensive management should be employed for those sows and piglets. For example, better supervision during delivery could reduce the number of SB and the mortality of live-born piglets (Holyoake et al., 1995), colostrum supplementation at least 200 g per piglet during the first 24 h after birth enhances piglet survival rate (Quesnel et al., 2012) and cross-fostering of small piglets to small litters (Deen and Bilkei, 2004) with similar size littermates (English, 1998) encourages the survival and weight gain until weaning (Robert and Martineau, 2001; Bierhals et al., 2012).

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บทคัดย่อ

ผลของลำดับท้องและขนาดครอกที่เพิ่มขึ้นต่อน้ำหนักแรกเกิดของลูกสุกร และอัตราการรอดชีวิตของลูกสุกรที่คลอดทีหลัง

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วัตถุประสงค์ของการศึกษาเพื่อศึกษาผลของลำดับท้องและขนาดครอกที่เพิ่มขึ้นต่อน้ำหนักแรกเกิดของลูกสุกร และเปรียบเทียบน้ำหนักแรกเกิดและอัตราการรอดชีวิตของลูกสุกรที่คลอดในลำดับการคลอดที่แตกต่างกัน ในฟาร์มสุกรเอกชนแห่งหนึ่งในประเทศไทย ทำการเก็บข้อมูลจากแม่สุกรจำนวน 230 ตัวและลูกสุกรจำนวน 3,500 ตัว ดังนี้ ลำดับท้อง ขนาดครอก น้ำหนักแรกเกิดเฉลี่ยภายในครอก ค่าสัมประสิทธิ์ความผันแปรของน้ำหนักแรกเกิด ค่าส่วนเบี่ยงเบนมาตรฐานของน้ำหนักแรกเกิด ร้อยละของลูกสุกรตัวเล็ก น้ำหนักแรกเกิดของลูกสุกรรายตัว กลุ่มลำดับการคลอด (ตัวที่ 1-10, 11-16 และ 17-25) เพศ และลักษณะของลูกสุกร (ลูกกรอก ตายคลอด และคลอดมีชีวิต) ผลการศึกษาแสดงให้เห็นว่า น้ำหนักแรกเกิดน้อยลง ($p < 0.001$) เมื่อขนาดครอกใหญ่ขึ้น และความผันแปรของน้ำหนักแรกเกิดเพิ่มขึ้น ($p < 0.001$) เมื่อแม่สุกรมีลำดับท้องมากขึ้นร่วมกับการมีครอกขนาดใหญ่ น้ำหนักแรกเกิดของลูกสุกรมีความแตกต่างกันระหว่างกลุ่มของลำดับการคลอด โดยลูกสุกรที่คลอดในกลุ่ม 17-25 มีน้ำหนักแรกเกิดน้อยกว่า ($p < 0.001$) ลูกสุกรที่คลอดในกลุ่ม 1-10 และ 11-16 ร้อยละของลูกสุกรคลอดมีชีวิตลดลง ($p < 0.001$) เมื่อลำดับการคลอดเพิ่มขึ้น โดยมีการเพิ่มขึ้น ($p < 0.001$) ของลูกสุกรที่เป็นลูกกรอกและตายคลอด การศึกษานี้แสดงให้เห็นว่าลำดับท้องที่มากขึ้นและขนาดครอกใหญ่มีผลต่อน้ำหนักแรกเกิดของลูกสุกร ทั้งในลักษณะของการมีน้ำหนักแรกเกิดลดลงและการมีความผันแปรของน้ำหนักแรกเกิดเพิ่มขึ้น นอกจากนั้น ร้อยละของลูกสุกรที่คลอดมีชีวิตในกลุ่มลำดับการคลอดทีหลังยังมีจำนวนลดลง

คำสำคัญ: ขนาดครอก น้ำหนักแรกเกิด ลูกสุกร ลำดับการคลอด ลำดับท้อง อัตราการรอดชีวิต

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