P-ISSN: 2304-3075; E-ISSN: 2305-4360
International Journal of Veterinary Science
www.ijvets.com; editor@ijvets.com

Research Article https://doi.org/10.47278/journal.ijvs/2024.275

Factors Associated with Weaning to Service Interval in the Sow

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Article History: 24-702 Received: 10-Nov-24 Revised: 18-Dec-24 Accepted: 23-Dec-24 Online First: 29-Dec-24

ABSTRACT

Weaning to service interval (WSI) is one important reproductive parameter in sows. Although several factors have been explored as risk factors of WSI, other factors may exist and need to be determined. The present study aimed to investigate the effects of original factors, including manual extraction of the piglet, farrowing duration, postpartum vaginal discharge duration, and stillbirth, and some already determined factors, including parity, gestation length, lactation length, and birth litter size, on WSI. Data were collected from 394 litters born from 394 mixed parity Landrace x Yorkshire sows on a farm in Vietnam. A forward linear regression was used to determine the significant risk factors for WSI. Linear regression analysis showed that parity, birth litter size, manual extraction of the piglet, farrowing duration, postpartum vaginal discharge duration, and lactation length significantly influenced the WSI. The average WSI was 6.2±2.8 days. By day 7 post weaning, about 75% of sows had been inseminated. Among the studied risk factors, manual extraction of the piglet (coefficient=0.874, P=0.003), farrowing duration (coefficient=0.235, P=0.001), and postpartum vaginal discharge duration (coefficient=0.452, P<0.001) was positively associated with WSI. By contrast, parity (coefficient=-0.294, P<0.001), birth litter size (coefficient=-0.096, P=0.022), and lactation length (coefficient=-0.1, P=0.005) negatively correlated with WSI. The results suggested WSI could be shortened via minimization of manual extraction of the piglet, reduction in farrowing duration and postpartum vaginal discharge duration, and selection of large birth litter sizes.

Key words: Birth litter size; Farrowing; Manual extraction; Pig; Weaning to service interval

INTRODUCTION

Normally, sows return to estrus within 7 days after weaning (Almeida et al. 2020; Martinez et al. 2020; Carrión-López et al. 2022; Reeb and Kellner 2022; Hilgemberg et al. 2023; Muzio et al. 2023). Recently, Gianluppi et al. (2020) reported that 93.6% of Landrace × Large White crossbred sows expressed estrus within 5 days after weaning. Long weaning to service interval (WSI) increases the number of non-productive days, thereby reducing the reproductive performance of pigs (Koketsu et al. 2017). When WSI increased from 4 to 10 days, about 1 piglet was decreased in the subsequent litter size, and when WSI increased from 4 to 7 days, the farrowing rate in the next parity also decreased (Tummaruk et al. 2000). When WSI increased from 1-5 days to 6-7 days, the subsequent litter size was reduced by 0.5 piglets (Tantasuparuk et al. 2000). Hoshino and Koketsu (2008) reported that sows with a WSI of 4-6 days had the highest farrowing rate and sows with a WSI of 7-20 days had the lowest farrowing rate and the smallest number of piglets born alive in the subsequent litter (Hoshino and Koketsu 2008). A similar effect of WSI on farrowing rate was also documented by Tummaruk et al. (2010). Moreover, sows with a WSI of 6 days or longer also had a higher risk of being culled in comparison with sows with a WSI of 0-4 days (Tantasuparuk et al. 2001).

Because WSI is an important reproductive trait, several studies have been conducted to determine factors that influence this parameter. Numerous factors including parity, lactation length, birth litter size, litter size at weaning, weight loss during lactation and season have been determined to influence WSI (Vesseur et al. 1994; Koketsu et al. 1997; Karvelienė et al. 2008; Gianluppi et al. 2020; Iida et al. 2021; Nam and Sukon, 2023). Recently, manual extraction of the piglet, farrowing duration, and stillbirth have been found to affect the duration of postpartum vaginal discharge (Nam 2020; Nam et al. 2022). Increased duration of postpartum vaginal discharge may be a signal of postpartum metritis which detrimentally affects uterine

Cite This Article as: Nam NH and Sukon P, 2025. Factors associated with weaning to service interval in the sow. International Journal of Veterinary Science 14(3): 565-570. https://doi.org/10.47278/journal.ijvs/2024.275

involution and postpartum cyclicity (Mateus et al. 2002). The impaired uterine involution and postpartum cyclicity may result in a longer WSI. Therefore, the present study aimed to investigate the effects of manual extraction of the piglet, farrowing duration, postpartum vaginal discharge duration, birth litter size, stillbirth, parity, gestation length and lactation length on weaning to service interval.

MATERIALS AND METHODS

Ethical approval

This was an observational study that did not involve sample collection. All the procedures used in the present study were routinely applied on the studied farm, so they were waived from the animal care and use committee.

Animals

This study was conducted in a breeding swine farm that had over 1000 Landrace-Yorkshire sows in Hoa Binh province in the Northwest region of Vietnam from April to September 2020. This region has a tropical monsoon climate which is hot and humid in the summer and cold in the winter. The average temperature and relative humidity per year in the region were 23°C and 85%, respectively. The hot season was from April to September and the cold season was from October to March. Sows were kept in individual crates which were in closed facilities. About a week before farrowing, pregnant sows were moved to farrowing rooms in which they were allocated into individual farrowing crates. Cooling systems including fans and dripping water were used when the temperature was high. Pregnant sows were fed 1.8-3.0kg of industrialized feeds with 2900-3000 Kcal/kg of a metabolizable energy and 14-16% of crude protein. During the first 7 days after insemination, sows received 1.8kg per day. From day 8th to 30th sows received 2.5kg, and from day 31st to 80th sows received 2.2kg per day. From day 81st to 107th sows received 3kg per day. During the last week of gestation, sows received 1.5kg per day. From day 1st to 6th after farrowing, sows received feed in a gradually increasing pattern to about 6kg per day which was maintained to the end of the lactation. Farrowing sows were supervised from the birth of the first to the birth of the last piglets. Piglets were cleaned and breastfed 30-45 minutes after birth and cross-fostered so that each sow nursed 11-12 piglets. Piglets were weaned at different lactation lengths (varying between 14-40 days) depending on their birth weight. Weaned sows received 3.0kg per day. Estrus detection was conducted twice per day in the morning and afternoon by experienced technicians with the presence of boars. Sows were inseminated twice during standing estrus with an interval of 8-12 hours. Water was *ad libitum* provided to sows via a bite nipple system.

Data collection and definition

Data including parity, gestation length (d), farrowing duration (h), number of total born, stillbirth (yes/no), manual extraction of the piglet (yes/no), duration of vaginal discharge (d), and weaning to service interval (WSI, d) were collected. Gestation length was the interval between the first artificial insemination and farrowing. Stillborn piglets were those born dead without signs of autolysis. The farrowing duration was the interval between the birth of the first and the last piglets. After farrowing, vaginal discharge was monitored twice per day until its clearance. The duration of vaginal discharge was the interval from the end of farrowing to the time when no discharge was observed. The duration of discharge rather than its characteristics was observed because observation of its duration was more objective than its characteristics. Lactation length was the interval from the end of farrowing to weaning. WSI was the interval from weaning to the first service. In total, full information was collected from 394 sows.

Statistical analysis

Descriptive statistics were conducted for parity, gestation length, litter size, farrowing duration, lactation length, and weaning to service interval as mean and standard deviation. Stillbirth and manual extraction of the piglet were shown in percentage. Linear regression was used to determine the risk factors for WSI in two steps. At first, univariate analysis was performed to determine the potential risk factor for WSI. In the second step, all significant factors ($P<0.1$) were analyzed in a forward multivariate linear regression to build the final model for explaining WSI. All tests were performed in SPSS Version 22 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). A p-value <0.05 was set as the significance level.

RESULTS

The descriptive statistics of the investigated sows was shown in Table 1. The average WSI was 6.2±2.8 days varying between 2-17 days. The average weaning age of piglets was 22.5 days ranging from 14 to 40 days. Half of the farrowing had at least one stillborn piglets. About one third of the sows needed manual extraction of the piglet during parturition. The duration of postpartum vaginal discharge varied between 2 and 12.5 days. The average farrowing duration was 4.2 hours with the shortest one of 0.5 hour and the longest one of 10 hours. The smallest litter size was 2 and the biggest one was 22 resulting in an average of 13.0 piglets. The gestation length varied between 111 and 123 days. The distribution of WSI in the investigated sows was depicted in Fig. 1. Most of the sows had a WSI ranging from 3-8 days (79.2%). The highest percentage was observed during days 4-7 (13.2-18.5%). Univariate analysis showed that all investigated factors except gestation length were potentially associated with WSI (Table 2). In the forward variable selection pattern, the multivariate linear regression analysis step-by-step selected the duration of vaginal discharge, parity, manual extraction of the piglet, farrowing duration, lactation length, and litter size for the final model that explained the highest variation of WSI (19%, R^2=0.19). The adding of each variable increased the R square, adjusted R square, and lowered the standard error of estimate of the new model (Table 3). Parity, lactation length, and litter size negatively correlated with, and duration of vaginal discharge, manual extraction of the piglet, and farrowing duration positively correlated with WSI. VIFs of all the independent variables ranged from 1.01 to 1.18 showing that the variances of regression coefficients were only slightly inflated (Table 3).

Table 1: Descriptive statistics of 394 investigated sows

Parameters	Mean±SD/%	Min-Max
Parity	3.2±1.9	1-9
Gestation length (day)	115.5±1.4	111-123
Litter size	13.0±3.2	4-22
Farrowing duration (h)	4.2±1.9	0.5-10
Vaginal discharge duration (d)	4.6±1.3	2-12.5
Proportion of farrowings needed manual extraction (%)	33 (130/394)	-
Proportion of farrowings had stillborn piglet(s) (%)	50 (197/394)	-
Lactation length (day)	22.5±3.6	14-40
Weaning to service interval (day)	6.2±2.8	2-17

SD: Standard deviation; Min: Minimum; Max: Maximum.

Table 2: Univariate linear regression analysis of factors associated with weaning to service interval in 394 Landrace-Yorkshire sows from a farm in Vietnam

Parameters	Regression Coefficients	95% CI	Significance
Manual extraction	1.43	0.852-2.009	<0.001
Stillbirth	0.477	-0.081-1.035	0.093
Lactation length (day)	-0.088	-0.164-(-0.011)	0.025
Vaginal discharge duration (day)	0.523	0.314-0.731	<0.001
Farrowing duration (h)	0.336	0.190-0.482	<0.001
Gestation length (day)	-0.143	-0.349-0.0564	0.174
Birth litter size	-0.079	-0.166-0.009	0.078
Parity	-0.331	-0476-(-0.186)	<0.001

CI: confidence interval.

Table 3: Multivariate linear regression analysis of factors associated with weaning to service interval in 394 Landrace-Yorkshire sows from a farm in Vietnam

Parameters	Coefficient of Regression/95% CI	R square	Adjusted R square	Standard Error of Estimate	VIF
Constant	7.28/5.26-9.29**				
Vaginal discharge duration (d)	0.45/0.24-0.66**	0.06	0.06	2.74	1.18
Parity	-0.29/-0.43-(-0.16)**	0.12	0.11	2.66	1.05
Manual extraction	0.87/0.30-1.448**	0.14	0.14	2.63	1.13
Farrowing duration (h)	0.24/0.093-0.38**	0.16	0.15	2.60	1.10
Lactation length (d)	-0.10/-0.17-(-0.03)*	0.18	0.17	2.58	1.01
Birth litter size	-0.10/-0.18-(-0.014)*	0.19	0.18	2.56	1.06

CI: confidence interval; VIF: variance inflation factor; ** significant at level <0.001; * significant at level <0.05. From top to the bottom of the table, the order of independent variables was arranged according to the order of variable selection by the forward multivariate linear regressions. The R-squares and adjusted R-Squared increased from 0.06 to 0.19 and 0.06-0.18, respectively, when the number of independent variables in the model increased from 1 to 6. The coefficient of regression and 95% CI belonged to the 6 variable-model. VIFs belonged to the six independent variables in the final model. The final multivariate linear regression model explained 19% variation of weaning to service interval.

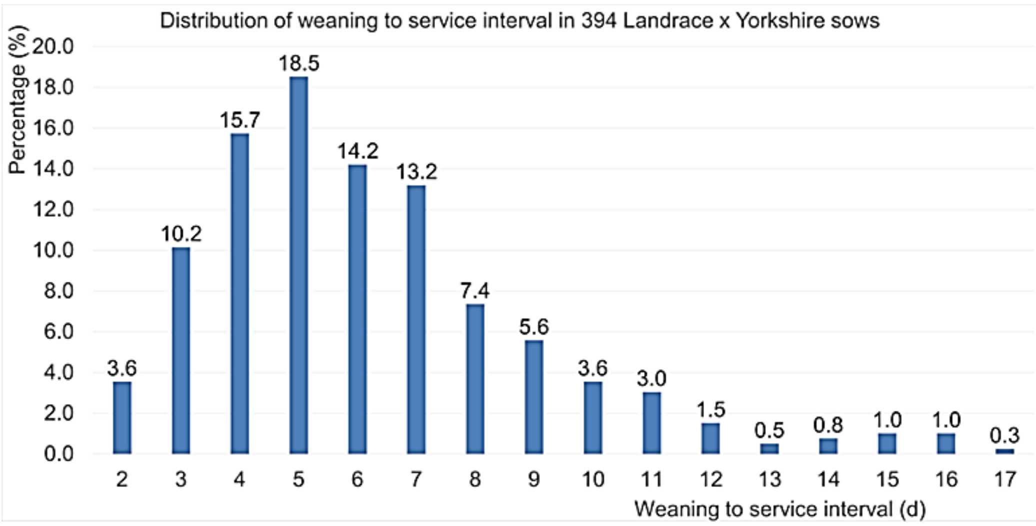

Fig. 1: Distribution of weaning to service interval in studied sows

DISCUSSION

WSI is an important reproductive criterion since it influences sows' performance and longevity (Tantasuparuk et al. 2001). The WSI in the present study was quite in the range of the findings by previous studies where it was reported to vary between 5.2 and 9.34 days (Tummaruk et al. 2000; Alexopoulos et al. 2001; Tantasuparuk et al. 2001; Karvelienė et al. 2008; Nam and Sukon 2023). Other studies reported that weaning to estrus interval ranged between 5.3 and 6.9 days (Vesseur et al. 1994; Sterning et al. 1998; Bruun et al. 2016).

Previous studies reported that the WSI was influenced by several factors such as parity, litter size at weaning, weight loss during lactation, lactation length and season (Vesseur et al. 1994; Tummaruk et al. 2000; Karvelienė et al. 2008). In the current study, we reported significant effects of some original risk factors, including manual extraction of the piglet, farrowing duration and duration of postpartum vaginal discharge, and some previously reported factors, including parity, birth litter size and lactation length, on WSI.

The negative association between parity and WSI in the present study corroborates previously reported results (Vesseur et al. 1994; Karvelienė et al. 2008). In comparison with older sows, the parity 1 sows are more prone to heat stress (Iida and Koketsu, 2013; Sasaki et al. 2018; Iida et al. 2021). It was reported that the parity 1 sows had a 3-8°C lower threshold temperature for declined fertility than the older sows (17°C vs. 25°C) (Iida et al. 2021). The present study was conducted in a tropical region with an annual average temperature of 23°C. Therefore, it might be suggested that WSI in the parity-1 sows was more detrimentally influenced by the heat stress and was consequently prolonged. Moreover, the parity-1 sows had fewer body reserves, less feed intake during lactation, and lost higher percentage of body fat during lactation (26% in comparison with 20 and 16% in parity-2 and parity-3,4 sows) (Strathe et al. 2017) which might subsequently result in fewer pulses and lower amplitude of luteinizing hormone during mid-lactation and postweaning (Koketsu et al. 1996). This hormonal deficit might prevent the growth of follicles resulting in delayed estrus and prolonged WSI.

The negative association between WSI and lactation length in this study are in line with previously reported results (Iida et al. 2021). This association can be explained through following potential mechanism. A long lactation length provided sows some additional time to recover from negative energy balance, then subsequently reduced the detrimental effect of heat stress on WSI (Iida et al. 2021). Therefore, sows with shorter lactation lengths might suffer more seriously from a negative energy balance. This condition might reduce the development of follicles characterized by lower β-estradiol, progestins, and androgens (Costermans et al. 2019). Moreover, a shorter lactation length increases myometrial thickness, uterine weight, and uterine length implying a lower level of uterine involution (Hays et al. 1978). As a consequence, less developed follicles and impaired uterine involution increased the WSI in sows with short lactation lengths. Because an increase in the lactation length increases nonproductive days, shortening WSI by lengthening the lactation length should be conducted with multifaceted considerations.

The effect of WSI on subsequent birth litter size has been studied intensively and their association has been widely reported (Tantasuparuk et al. 2000; Tummaruk et al. 2000; Segura Correa et al. 2014). However, how the birth litter size influences WSI has been rarely reported (Nam and Sukon 2023). The birth litter size is dependent on many factors such as the number of released and fertilized oocytes, and the nurturing competence of uteri. The birth litter size is a genetic inhabitant trait (Banville et al. 2015; Putz et al. 2015). In other words, sows with a larger birth litter size in the current litter are more likely to have a larger birth litter size in the subsequent litter. The increased birth litter size may be the result of an increase in the number of mature and ovulatory follicles which produce a larger amount of estrogen (Perry et al. 2014; Segawa et al. 2015). Estrogen content is directly proportional to the degree of the estrus symptoms of the sows (Li et al. 2022), so an increase in estradiol level would result in earlier estrus, i.e., shorter WSI. Therefore, large birth litter sizes shortened WSI. Because the effect of birth litter size on WSI is rarely documented, future studies are necessary to confirm whether this relationship is real and repeated in other sow populations. Furthermore, the litter size at weaning positively correlated with WSI (Vesseur et al. 1994) due to sucking density, the effect of both factors on WSI should be studied simultaneously.

The mechanisms that manual extraction of the piglet, farrowing duration, and vaginal discharge duration influenced the WSI are still unclear. Manual extraction of the piglet and long farrowing duration increased the risk of postpartum uterine infection and prolonged vaginal discharge duration (Nam 2020; Nam et al. 2022). Prolonged farrowing also impaired uterine involution in sows (Peltoniemi et al. 2016). In cows, abnormal vaginal discharge can increase the risk of delayed postpartum cyclicity (Opsomer et al. 2000). Similarly, cows with higher bacterial scores on day 7 had a lower plasma estradiol concentration on days 15-16 postpartum (Sheldon et al. 2002). As a result, lower estradiol concentration affected the estrus expression in dairy cows (Perry et al. 2014). There is no direct evidence of the effect of postpartum uterine infection on such events in sows. However, it can be suggested that the mechanisms that uterine infection affects estradiol concentration, ovarian activity, and estrus expression in cows may also work in sows. In the sow, follicles that are selected and develop during lactation continue to develop and mature after weaning, and the size of follicles at weaning decides the WSI (Lopes et al. 2020). Therefore, manual extraction of the piglet, long farrowing, and long vaginal discharge duration might negatively affect the uterine involution, estradiol concentration, and follicles' size at weaning and subsequently increased the WSI in such investigated sows. Future research needs to investigate postpartum uterine involution, measure estradiol concentration and follicles' size in this type of study to confirm this hypothesis.

Conclusion

The present study indicated that parity, birth litter size, farrowing duration, manual extraction of the piglet, postpartum vaginal discharge duration, and lactation length influenced the WSI in the sow. Reducing the incidence of manual extraction of the piglet and shortening the farrowing and vaginal discharge duration could reduce the WSI. The result of the present study also suggested that the selection of sows with large birth litter sizes may be a measure to reduce WSI.

Acknowledgement: The authors are grateful to the farm owner and veterinarians for their help during the study.

Conflict of interest: The authors declare that they have no conflict of interest.

Author's Contribution: Both authors contributed to the study conception and design. Nguyen Hoai Nam collected and analyzed the data, interpreted the results and prepared the first draft. Peerapol Sukon prepared the final manuscript.

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