

RESEARCH ARTICLE



The effect of nurse sow parity and extended lactation length on piglet weaning outcomes and subsequent prolificacy of nurse sows

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ABSTRACT

Nurse sows are used for nursing surplus piglets in hyper prolific pig herds, thereby extending their lactation. We examined weaning outcomes and effects of extended lactation length (ELL) of nurse sows on subsequent (sub) prolificacy (live-born LB, still-born SB, and mummies Ms). A total of 18,107 nurse sows were analysed. The data encompassed nurse sows of parities (P1–P6) and three ELL categories: 0–7 d, 8–14 d, and 15–21 d. General linear mixed-effects models were applied to the data. Nurse sows weaned 12.43 piglets during the 1st wean event (W1) and 10.82 piglets during the 2nd wean event (W2). Parity effects were detected ($p < 0.05$) in both W1 and W2 piglets but not group effects. The highest ($p < 0.05$) number of W1 piglets was recorded for P2 sows and the lowest for P6 sows. Parities 1–4 nurse sows weaned a higher ($p < 0.05$) number of piglets during W2 than parities 5 and 6. Subsequent LB for nurse sow parity differed significantly ($p < 0.05$), with the highest being recorded for parities 2–5. Parities 3–6 showed a significant number of Sub SB. Subsequent Ms were higher in parities 2–6. Extending lactation length for 15–21 d resulted in higher ($p < 0.05$) Sub LB for parity 1 nurse sows. A similar ELL (15–21 days) resulted in significant ($p < 0.05$) Sub Ms for P3 nurse sows. No effect ($p > 0.05$) of any ELL on Sub SB was observed. An optimal balance between piglet weaning outcomes and future reproductive performance can be achieved by selecting younger sows and carefully managing ELL.

HIGHLIGHTS

- Younger nurse sows weaned more piglets and demonstrated favourable subsequent prolificacy performance.
- Extending lactation (15–21 d) increased live born for parity 1 nurse sows but led to increased mummies for parity 3 nurse sows.
- Optimal herd productivity may require a balance between nurse sow parity and extended lactation length.

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Introduction

Hyper prolificacy in pig production is consistently bringing new challenges especially when the number of sow functional teats is less compared to her piglets born. A hyper prolific sow can farrow between 18 and 20 total born piglets. However, the number of functional teats of 14–16 restricts most of these sows from nursing their piglets. Large litter sizes have positive economic effects on pig production. However, there

are also noticeable challenges at the herd level in terms of management, housing, nutrition, and welfare.

Specifically, large litters are characterised by low average piglet birth weights (Quiniou et al. 2002) and higher within-litter variation (Lund et al. 2002), which exacerbates their mortality if no management intervention is performed. The challenge of large litter has been addressed in several ways by researchers. For example, by using nurse sows or artificial rearing. These strategies are intended to reduce pre-weaning

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mortality while guaranteeing that piglets receive adequate nutrition and care. The use of nurse sows is a natural strategy in modern intensive sow herds. A nurse sow is one that has weaned her litter and then 'given' surplus piglets to care for during a single lactation period. The goal of using nurse sows is to maximise weaning performance and improve the value of low-birth-weight piglets (Craig et al. 2020). From the perspective of the number of piglets weaned per sow per year, nurse sows that wean two litters per lactation provide an economic advantage. One common feature of the nurse sow system is the prolonged lactation period. Longer lactation periods can have multiple effects on the reproductive efficiency of sows. A longer lactation period permits more time for uterine involution (Rezac et al. 2023), which can promote follicular growth (Knox 2018), resulting in a greater subsequent litter size (Segura Correa et al. 2014). However, longer lactation periods have some performance trade-offs. This can lead to longer weaning-to-oestrus intervals (Koketsu et al. 2017), thereby negatively affecting farrowing intervals (Keyho et al. 2018). Furthermore, prolonged lactation is associated with elevated physiological demands for sustaining milk production, which could result in backfat loss in sows (Koketsu et al. 2017). Additionally, prolonged lactation has been observed to deteriorate the physical condition of sows, increasing the risk of leg ulcers and teat damage (Baxter et al. 2013; Alvåsen et al. 2017). These combined effects can result in sub-performance.

In hyperprolific sow systems, it is imperative to ensure that appropriate sows are selected to rear surplus piglets. Random selection can compromise the performance of piglets and sows. Practically, sows in parities 2–4 are typically selected over younger (first parity) or older sows because of their higher milk production potential (Tokach and Dial 1992). Younger sows are chosen to care for smaller piglets because of their small teats (Weber et al. 2009). Additionally, nurse sows should have enough functional teats to nurse the same number of piglets as they previously weaned (Sørensen et al. 2016). Adequate body condition and general health are crucial (Bruun et al. 2016, 2023) because nurse sows have to sustain prolonged nursing, which could be detrimental to their body reserve. Sow behaviour should also be considered because calm, non-aggressive sows are more likely to show good maternal care and accept foster litters. Additionally, matching the age of the foster piglets to the sow's lactation stage increases acceptability (Alexopoulos et al. 2018).

Parity as a consideration for selecting nurse sows (Bruun et al. 2016; Schmitt et al. 2019) was a focus of this study. Sow parity affects several performance indicators, such as the average piglet birth interval (Van Rens and Van der Lende 2004), total number of piglets born (Schwarz et al. 2009; Freyer 2018), and weaning-to-oestrus interval (Vesseur et al. 1994). The weaning performance of sows depends on parity. For instance, primiparous sows have reduced voluntary feed intake during lactation (Revell et al. 1998) and subsequently lower milk production capacity (Farmer et al. 2024). Therefore, they generally become less able to support large litters because of the investment required for milk production, resulting in fewer litters at weaning (Koketsu et al. 2017; Madeira Pacheco et al. 2024). In contrast, sows in mid-parities (parities 2–4) typically have greater metabolic stability and better lactational output, which may allow them to rear piglets more effectively and possibly reach larger weaning numbers. However, weaning performance tends to deteriorate in higher-parity sows owing to age-related declines in mammary function (Farmer 2019), udder problems (Vasdal and Andersen 2012), and impaired teat functionality, resulting in teat loss (Obermier et al. 2023). These physiological variations highlight the importance of considering parity when selecting nurse sows. Selecting young sows with low parity could have a significant effect on performance, as measured by the number of piglets weaned or subsequent total born. Surplus piglets can be fostered by higher-parity sows when young, and low-parity sows are limited.

Selected nurse sows undergo an extended lactation period of approximately 21 d (Baxter et al. 2013; Alvåsen et al. 2017), beyond their conventional lactation period of 21 d for example in the USA. Extended lactation differs from prolonged lactation in terms of intended purpose. The former is a deliberate and planned strategy to address a management problem (surplus piglets); therefore, it is intentional. The latter is unplanned or unanticipated owing to factors such as reproductive issues. Lactation length affects the body condition, weaning-to-oestrus interval, and overall fertility of sows (Svajgr et al. 1974; Poleze et al. 2006). Nurse sows provide an opportunity to examine the effects of extended lactation. Research on extended lactation of nurse sows has mainly focused on weaning-to-oestrus interval (Bruun et al. 2016; Iida et al. 2019), potential for backfat loss (Koketsu et al. 2017; Schmitt et al. 2019), and welfare aspects (Baxter et al. 2013; Sørensen et al. 2016), which are not the focus of this study. However, the effects of extended lactation length (ELL) on the Sub prolificacy of nurse

sows have not yet been investigated. Thus, the objectives of this study were (i) to investigate the effects of nurse sow parity on weaning outcomes and sub-reproductive performance and (ii) to investigate the effects of ELL of nurse sows on sub-total born prolificacy. The findings may provide insights into selection, breeding, and culling decisions in nurse sow systems and improve the management of ELL for better production efficiency.

Materials and methods

General farm management

We received retrospective production data from Porcitech database 2022 USA for the period 2016–2022. The data were obtained from a pig production company in Minnesota, USA. At the time of data extraction, the company managed approximately 200,000 sows with average live-born and weaned piglets of 14.63 and 12.71, respectively (company data). The sows were primarily crossbred F1 Landrace $\times$ Yorkshire, which were bred with terminal sires to produce offspring for fattening. The company utilised the farrow-to-wean system of operation, where weaned piglets were shipped to off-site fattening systems. Replacement gilts in the Gilt Development Unit (GDU) were confined to groups of 10–15 before the expected 1st oestrus. They were then relocated to separate stalls in a gestational barn for continued boar exposure. At least two inseminations were performed when sows were in heat. Sows stayed in pen gestation until one week before farrowing, when they were moved to a farrowing house. Farrowing events were recorded for each litter. Lactation period was approximately 18–25 d with an average of 21 d. Sows were fed a standard lactation diet consisting of soybean and corn as the major protein and carbohydrate sources, respectively. Specific dietary constituents were not available in archived data

Routine farm management practices relevant to the study

After weaning the initial litter (wean 1), the chosen nurse sow was relocated to the current farrowing room to nurse surplus piglets. Surplus piglets were those that cannot be accommodated by the birth sow because of limitations in the available functional teats. Typically, these piglets were healthy, of similar age, and had consumed colostrum from the birth sows. A nurse sow was given an equal number of nurse piglets as it had weaned. On her card, it was written 'nursed on' indicating the start of extended lactation. At the

end of the extended lactation period, surplus piglets were weaned as wean 2. After the sow weaned her second litter, she was taken to the weaned area in the gestation barn for boar exposure, insemination and gestation.

Study design and exclusion criteria

This was a retrospective cohort study. Each nurse sow was properly identified as follows: parity number, number of piglets weaned during the first and second weaning, and sub-total born piglets (live born LB, still-born SB and mummies Ms). Only parity 1–6 nurse sows were enrolled in the study because of the company's policy of culling sows beyond parity 6. A P1 nurse sow was a parity 1 sow that was given surplus piglets to nurse after weaning her piglets. The same interpretation was used for the other parity. ELL was defined as an extension longer than the usual 21 d of lactation for an additional 0–7, 8–14, or 15–21 d. Typically, in most farrow-to-wean swine herds in the USA, pigs are born over the course of a week but are all weaned on the same day of the week at an average age of 21 d (author observation). This is done to ensure piglet uniformity and an ideal average weaning age. However, it also provides the possibility of weaned sows being separated by 1 week between the groups. Therefore, our ELL was divided into three groups: 0–7, 8–14, and 15–21 d, to provide an interval of one week between each of the potential times derived from Baxter et al. (2013). Nurse sows that had weaned 0 piglets and those that had >2 weaning events in a single lactation ($n=412$) were excluded. Similarly, sows with parity >6 were excluded ($n=613$). In addition, nurse sows with ELLs of >21 d ($n=750$) were removed, leaving 18107 nurse sows.

Statistical analysis

Statistical analyses were performed using SPSS Statistics version 29 (IBM SPSS Statistics, version 29.0. Armonk, NY: IBM Corporation). Normality was tested using Kolmogorov–Smirnov (K-S test). ONEWAY ANOVA followed by post-hoc Tukey's HSD test was performed. General linear mixed-effects models were applied to the data using a one-factor model because the primary objective was to quantify the direct effect of parity and ELL. Model 1 analysed the effects of sow parity on sub-reproductive performance (LB, SB and Ms) using sow parity as a fixed effect. Model 2 analysed the effects of ELL on sub-reproductive performance (LB, SB and Ms) using ELL as a fixed effect. Parity

and lactation length were treated as fixed effects since their individual levels were of direct biological interest. Model assumptions were evaluated and met. Statistical significance was set at $p < 0.05$.

Results

Parity choice for nurse sows

Figure 1 shows the percentage distribution of nurse sows by parity. The distribution is unimodal and slightly skewed towards the younger side. Most nurse sows were of middle parity (2–5) rather than very young or old. A lower number of nurse sows were selected for utilisation among parity 1 (10.55%) and parity 6 sows (12.56%). The proportion of nurse sows peaked at 20.77% for Parity 3.

Number of weaned piglets

Table 1 shows the number of weaned piglets for nurse sows. On average, nurse sows weaned 12.43 piglets during W1 and 10.82 during W2. The highest wean number for W1 was recorded in parity 2 (12.78) and the lowest in parity 6 (11.88) ($p < 0.05$). The number of piglets weaned during W1 increased from parity 1 to parity 2 and declined from parity 3 to parity 6. The highest wean numbers for W2 were recorded in parities 1–4, and the lowest in parity 6 ($p < 0.05$). The number of piglets weaned in W2 decreased with increasing parity.

Subsequent total born performance of nurse sows

Table 2 shows the subsequent total born performance of nurse sows. Mean LB, SB and Ms were recorded as 14.52, 1.09 and 0.48, respectively. Subsequent live-born

per parity differed significantly ($p < 0.05$), with the highest number recorded for P 2, 3, 4 and 5. The highest and lowest sub-LB were recorded in P2 (14.85) and P1 (13.98), respectively ($p < 0.05$). The highest and lowest sub-SB were recorded in P6 (1.28) and P1 (0.73), respectively ($p < 0.05$). The highest and lowest sub-Ms were recorded in P6 (0.57) and P1 (0.36), respectively ($p < 0.05$).

Extended lactation length

Table 3 shows the sub-total born performance based on the ELL. Extending lactation length for 15–21 d resulted in a higher sub-LB for parity 1 selected nurse sows ($p < 0.05$). There was no significant effect of ELL on sub-SB. Extending lactation length for 15–21 d resulted in significant ($p < 0.05$) Ms for P3 selected nurse sows. Figures 2–4 reveal the interaction effect of parity $\times$ period effects in LB, SB and Ms.

Figure 2 shows Sub LB piglets relative to nurse sow's ELL durations (0–7, 8–14 and 15–21 d) and parity categories. Sub-LB reached its peak at parity 4, after which it gradually fell in parities 5 and 6. Sub LB

Table 1. Number of weaned piglets during wean 1 and wean 2 ($n = 18107$ nurse sows).

Parity	N	Wean 1 (Mean SE)	Wean 2 (Mean SE)
1	1910	12.65 ^b 0.03	11.06 ^a 0.04
2	3161	12.78 ^a 0.02	11.01 ^a 0.04
3	3761	12.66 ^b 0.02	10.98 ^{ab} 0.03
4	3666	12.39 ^c 0.02	10.83 ^b 0.03
5	3334	12.13 ^d 0.02	10.60 ^c 0.03
6	2275	11.88 ^e 0.03	10.36 ^d 0.04
Total	18,107	12.43 0.01	10.82 0.01

Based on estimated marginal means. The mean difference is significant at the 5% level. Adjustment for multiple comparisons: Bonferroni. SE: standard Error of the mean. ^{a, b, c, d, e} means in a column with different superscripts significantly differ at ($p < 0.05$).

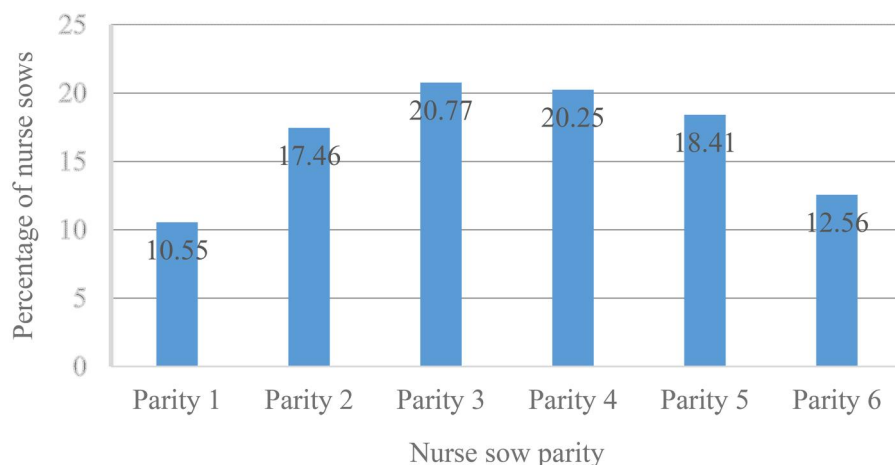


Figure 1. Nurse sows' distribution by parity of selection ($n = 18,107$).

Table 2. Nurse sows subsequent total born performance measured through live born, still born and mummies (n=18,107 nurse sows).

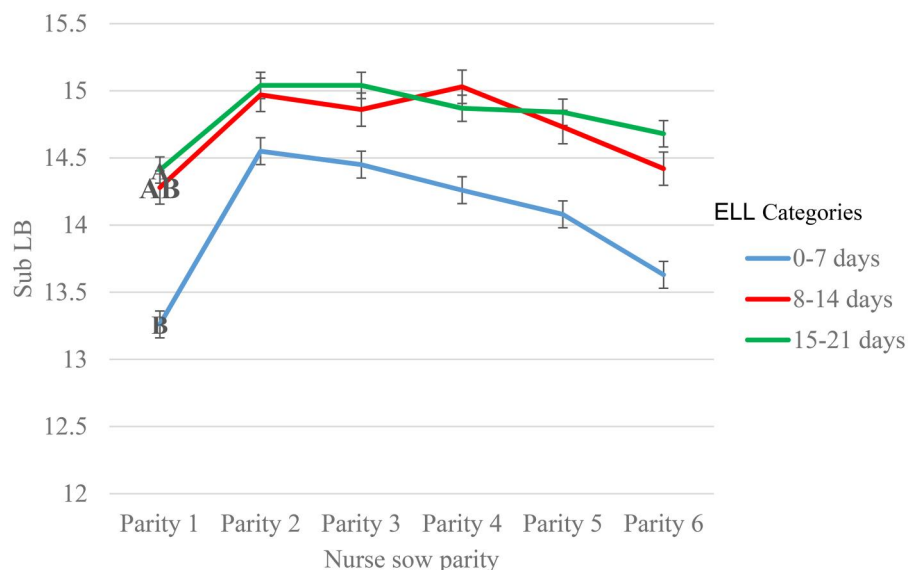
Denomination		Live born			Still born			Mummies			Total
Parity	N	Mean	%	SE	Mean	%	SE	Mean	%	SE	
1	1910	13.98 ^c	92.77	0.32	0.73 ^c	4.84	0.07	0.36 ^c	2.39	0.04	15.07
2	3161	14.85 ^a	91.55	0.32	0.92 ^b	5.67	0.06	0.45 ^{bc}	2.78	0.03	16.22
3	3761	14.78 ^a	90.07	0.32	1.13 ^a	6.89	0.06	0.50 ^{ab}	3.04	0.03	16.41
4	3666	14.72 ^a	89.59	0.32	1.23 ^a	7.49	0.06	0.48 ^{ab}	2.92	0.03	16.43
5	3334	14.55 ^{ab}	88.99	0.32	1.28 ^a	7.83	0.06	0.52 ^{ab}	3.18	0.03	16.35
6	2275	14.24 ^{bc}	86.61	0.32	1.26 ^a	7.85	0.07	0.57 ^a	3.54	0.03	16.07
Total	18,107	14.52	90.24	0.31	1.09	6.75	0.05	0.48	2.98	0.02	16.09

Based on estimated marginal means. The mean difference is significant at the 5% level. Adjustment for multiple comparisons: Bonferroni. SE: standard Error of the Mean. ^{a, b, c} means in a column with different superscripts significantly differ at ($p < 0.05$). Percentages in rows add up to 100%.

Table 3. Subsequent total born for nurse sows based on extended lactation length (ELL) (n = 18,107 nurse sows).

Denomination		0–7 d						8–14 d						15–21 days						Total		
		Sub LB		Sub SB		Sub Ms		Sub LB		Sub SB		Sub Ms		Sub LB		Sub SB		Sub Ms				
Parity	N	Mean	SE	Mean	SE	Mean	SE	N	Mean	SE	Mean	SE	Mean	SE	N	Mean	SE	Mean	SE	Mean	SE	
1	255	13.26 ^B	0.37	0.80 ^c	0.11	0.31 ^b	0.06	826	14.28 ^{AB}	0.33	0.67 ^c	0.08	0.41 ^b	0.04	829	14.41 ^A	0.33	0.73 ^b	0.08	0.38 ^c	0.04	1910
2	323	14.55	0.36	0.93 ^b	0.10	0.45 ^{ab}	0.06	1425	14.97	0.32	0.92 ^{bc}	0.07	0.45 ^b	0.03	1413	15.04	0.32	0.90 ^b	0.07	0.45 ^{bc}	0.03	3161
3	345	14.45	0.35	1.14 ^{abc}	0.10	0.48 ^{abAB}	0.06	2042	14.86	0.32	1.07 ^{ab}	0.06	0.45 ^{bb}	0.03	1374	15.04	0.32	1.18 ^a	0.07	0.57 ^{abA}	0.03	3761
4	319	14.26	0.36	1.26 ^{ab}	0.10	0.42 ^{ab}	0.06	2121	15.03	0.32	1.20 ^a	0.06	0.50 ^a	0.03	1226	14.87	0.32	1.22 ^a	0.07	0.52 ^{ab}	0.04	3666
5	330	14.08	0.36	1.40 ^a	0.10	0.47 ^{ab}	0.06	1987	14.73	0.32	1.22 ^a	0.06	0.57 ^a	0.03	1017	14.84	0.33	1.21 ^a	0.07	0.53 ^{ab}	0.04	3334
6	245	13.63	0.37	1.22 ^{abc}	0.12	0.53 ^a	0.06	1399	14.42	0.32	1.29 ^a	0.07	0.57 ^a	0.04	631	14.68	0.34	1.26 ^a	0.08	0.61 ^a	0.04	2275
Total	1817							9800							6490							18107

Based on estimated marginal means. The mean difference is significant at the five percent level. Adjustment for multiple comparisons: Bonferroni. Sub=Subsequent; LB=Live born; SB=Stillborn; Ms=Mummies and SE: standard error of the mean. ^{a, b, c, d} means in a column with different superscripts significantly differ at ($p < 0.05$). ^{A, B, C} means in a row with different superscripts significantly differ at ($p < 0.05$).

**Figure 2.** Effect of extended lactation length on subsequent live born across parities.

numbers were higher for longer ELL (8–14 and 15–21 d) than for the shorter ELL (0–7 d). The highest Sub LB numbers tended to occur between 15 and 21 d (green line), particularly in parities 2–5. Lower parities (particularly parities 1 and 2) exhibited more variation. Variability is represented by error bars.

Figure 3 shows Sub SB piglets based on ELL durations (0–7, 8–14 and 15–21 d) and parity categories. Older

sows typically had more stillborn piglets, as indicated by the larger error bars for parity 5 and parity 6 nurse sows. The 0–7 d period (blue line) typically exhibited an upward trend, although with more fluctuations. The 8–14 d period (red line) showed a consistent upward trend with greater Sub SB values at parities 5 and 6. The 15–21 d (green line) showed slightly higher Sub SB values in older parities, yet very similar to the 8–14 d category.

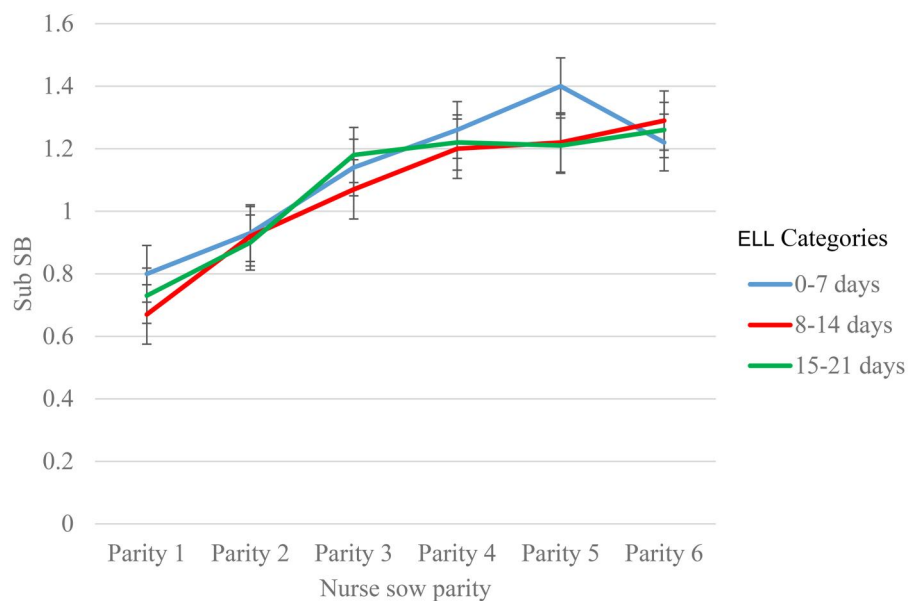


Figure 3. Effect of extended lactation length on subsequent still born across parities.

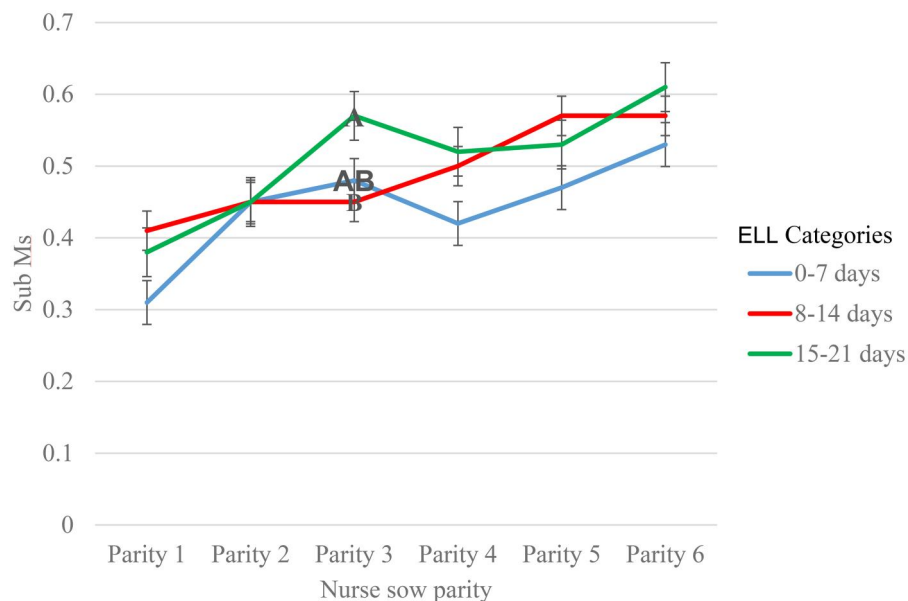


Figure 4. Effect of extended lactation length on subsequent mummies across parities.

Figure 4 shows Sub Ms relative to ELL durations (0–7, 8–14 and 15–21 d) and parity categories. Sub Ms increased with parity becoming more in older sows as indicated by the larger error bars. All ELL categories showed a similar pattern with minimal variation.

Discussion

Parity is a factor to be considered when selecting a nurse sow. Parity 1 sows were less likely to be selected (Figure 1). Parity 1s are the most vulnerable to body reserve losses during lactation (Schenkel et al. 2010).

Their optimal growth rate is highly affected by the increased demand during lactation. Nursing a second litter may place physical and physiological strain on P1s as they are still adapting to their reproductive and maternal roles. These factors may disregard their selection as nurse sows. Nevertheless, these young sows are selected as nurse sows because of their small teats and suitability for small piglets (Weber et al. 2009). Furthermore, the previous authors also observed that young sows had lower piglet mortality than older sows raising similar-sized piglets. First-parity sows can nurse additional piglets to promote mammary development.

The nurse sow system provides P1s with the opportunity to cumulatively nurse many piglets by the end of lactation. In contrast, multiparous sows can be regarded as exceptional foster dams (with experience) for nursing additional piglets. Sows in these mid-parities are regarded as best foster dams for pre-weaning performance of lightweight piglets (Huting et al. 2019) and improved piglet survival (Bruun et al. 2023). Older sows are less likely to be selected as nurse sows, partly because their age could compromise milk production and overall lactation performance (Koketsu et al. 2017). Furthermore, older sows may have long, thick teats, making them undesirable for selection as nurse sows (Bruun et al. 2023).

Pigs weaned per sow is used as a benchmark for herd performance (Koketsu et al. 2017). The findings of this study showed that nurse sows weaned an average of 12.43 piglets during Wean 1 and 10.82 piglets during Wean 2. In Denmark, Bruun et al. (2016) reported that nurse sows weaned 12.4 piglets and subsequently 11.5 piglets. According to most farm protocols, selected nurse sows are given an equal number of piglets as they previously weaned (Sørensen et al. 2016). The nursed piglets would have the opportunity to nurse from the same functional teats that previous piglets were nursing from. Nonetheless, there are a few possible reasons for the overall loss of piglets in this scenario. First, a nurse sow is expected to continuously produce milk to meet the demands of an additional litter. Physiological fatigue may set in, as sows could experience declining milk yield due to prolonged lactation (Grafoher and Plush 2023). Milk production in sow's peaks in the 3rd week and decreases as lactation increases (Curtasu et al. 2016). This is a problem because nurse sows must lactate beyond this time. These can reduce bonding and affect milk letdown, interfering with successful suckling. Sustaining the demands of an additional litter could be challenging, even if the number of piglets is the same as that previously weaned. Furthermore, milk composition changes over the course of lactation (Klobasa et al. 1987). The milk composition needs of nurse piglets may not be in tandem with the lactation stage of nurse sows. Such an imbalance can result in insufficient lactational resources, increasing the likelihood of hunger and starvation (Edwards 2002). Second, fighting as a form of competition is common among piglets (Chou et al. 2022), and can be observed through teat order reorganisation (Skok and Škorjanc 2014). Fighting in nursed piglets not only deprives them of the opportunity to nurse in a timely manner but also leaves them hungrier. Piglets

that fight for udder resources eventually become stressed and may not nurse well, putting them at a nutritionally disadvantaged stage. Weaning many piglets strains the sow, and she may retain few lactational resources to sustain the second litter. The use of nutritional strategies aimed at generating diets that can boost the milk supply of nurse sows could perhaps reduce the instances of fights among piglets when they 'run out of milk'. Another alternative would be to provide sufficient supplemental feed to piglets, such as creep feeding, which is a common practice in modern commercial pig farms (Muro et al. 2023). Parity 2 sows weaned more W1 piglets. These parities fall in the mid-parity group of sows that are starting their prime productivity; they are mature but not yet aged. Older sows would have poor weaning performance due to udder issues and a decline in milk yield (Lavery et al. 2019).

Prolificacy, a measure of reproductive success, is a key indicator of sow performance that can be used to analyse various aspects. For example, sow parity total born can be used to predict future reproductive performance in breeding objectives or to predict longevity among sows. Sow efficiency in herds can be determined by the number of LB piglets. In this study, the number of sub-live-born piglets was highest in parities 2, 3, 4 and 5. Sows develop their reproductive systems as they grow through consecutive parities, thereby increasing their uterine capacity. This may lead to improved embryonic development in the future. Older sows have lower LB due to higher embryo mortality in the early stages of pregnancy and increased foetal perinatal loss (Schwarz and Kopyra 2006). Additionally, age-related hormonal imbalances and potentially decreased ovarian activity in older sows may affect their capacity to conceive and maintain pregnancy. Culling recommendations should be applied when sows exhibit low reproductive rates.

Stillborn piglets are those that appear normal but die during the farrowing process. The number of SB per parity increased with increasing parity, representing 6.77% of the total born. The stillborn range has been reported to be within 3–8% of the total births (Vanderhaeghe et al. 2010). The number of stillborn piglets increased with parity, whereas the number of live-born piglets decreased. Stillborn piglets mostly occur in large litters, where there is prolonged farrowing with a likely delay in the expulsion of the litter. Hypoxia is the primary cause of SB and is frequently observed in cases of dystocia (difficult birth). Older sows tend to have lower muscle tone (Le Cozler et al. 2002), resulting in poor expulsion of foetuses and a

longer farrowing period. Sows that farrow SBs are not known until it happens. Investing in a stockperson on standby to retract a stuck piglet (sleeve sows) can be expensive, regardless of whether the sow gives birth to a stillborn piglet or not. However, saving one piglet that could reach weaning would increase the net return value. For instance, a 1% decrease in the SB rate could save a producer \$0.40/weaned pig or \$12/sow/year (PIC 2021). Constant farrowing supervision is an important management exercise to help reduce the number of stillborn pigs.

The identification of mummified foetuses in pig farms is important and can help optimise herd reproductive efficiency. Mummies result from foetal death after ossification. Pig mummies are characterised by their brownish or black colour, dehydrated and sunken eyes and shrivelled appearance. The number of Ms increased with parity and was parallel to that of SB. In this study, the proportion of Ms was 2.98% of the total born, which was lower than the 3.9% reported by Le Cozler et al. (2002) for French herds. Larger litters have insufficient uterine space to maintain their development and survival. Clinical signs can be observed through a high number of born dead or mummified, leaving a very low number of born alive. General mitigation can be adequate herd health management to control infectious agents of mummies.

Extended lactation can result in a longer weaning-to-oestrus interval and fewer piglets weaned per sow per year. Sows may reach a point where they cannot sustain extended lactation without compromising their ability to conceive. However, extended lactation may offer some benefits in terms of litter size. For parity 1 nurse sows, an extended lactation period of 15–21 d led to a greater ($p < 0.05$) Sub LB (Table 3). These findings can be compared from the aspect of prolonged lactation and from 'skip-a-heat' events as follows.

Extending lactation time appeared to have diverse effects on parity. In first-parity nurse sows, a longer lactation period can improve uterine involution and recovery, which supports better follicular development linked to a higher number of subsequent live-born piglets (Tantasuparuk et al. 2000; Costa et al. 2004). For instance, according to Costa et al. (2004), sows that prolonged their lactation for 18–25 d had a significantly larger subsequent litter size than those that lactated for less than 18 d. Similarly, according to Quesnel et al. (2007), sows that were weaned later had higher levels of follicle-stimulating hormone (FSH) and luteinizing hormone (LH), resulting in higher ovulation rates. Belstra et al. (2002) found that a longer lactation period produced a greater number of viable

embryos and was linked to higher progesterone levels, which decreased embryonic mortality (Knox et al. 2013). It is worth mentioning that in nature, sows usually wean their litters when piglets reach approximately 8 weeks of age. In contrast, a short lactation period may result in immature follicle growth and insufficient uterine recovery.

Skip-a-heat is a practice in pig farming, where P1 sows are mostly inseminated during the second oestrus after weaning. However, this is not automatic for all P1s. Most P1s are highly susceptible to body reserve losses during lactation and are therefore candidates for skip-a-heat. This provides ample time to improve reproductive capacity and fully recover from lactation. Some farms deliberately utilise skip-a-heat to increase farrowing rates and litter numbers in young sows (author observations). Farms may also opt for skip-a-heat to balance weekly breed targets and avoid breeding too many sows to balance with gilts (author observations). According to this study, the 15–21 d of ELL time that P1 nurse sows spend is close to the amount of time they could spend in their skip-a-heat period.

An ELL of 15–21 d resulted in a higher number of subsequent mummies for parity 3 selected nurse sows. Litter size increases with increasing parity, and a large litter leads to uterine crowding, exerting pressure on the uterine capacity. There is competition for nutrients and space which may impair foetal development and placental insufficiency, eventually resulting in more mummified foetuses (Borges et al. 2005; Raguvaran et al. 2017). More viable embryos could be produced from prolonged lactation; however, if these embryos are implanted and fail to receive sufficient placental support, they may die and mummify. Foetal mummification has a higher prevalence in parities 2–5 than in other parities (Lefebvre 2015). In conclusion, parity-specific physiological limitations combined with litter size and uterine capacity are probably responsible for the favourable effects seen in first-parity sows and the increase in mummified foetuses in third-parity sows.

Practical applications of the findings

Our study focused on hyper prolific herds. It is possible that the physiological principles driving parity effects and responses to prolonged lactation are similar in modern sows. Similar trends in how sow parity influences reproductive performance and the effects of lactation length have been observed in studies across a range of breeds and production conditions.

However, farm-specific factors, including but not limited to genetics, nutrition, housing conditions, health status, breeding and farrowing management, and fostering protocols, may affect the extent of this impact. Therefore, farms may need to customise the findings of this study to fit their herd structure, management strategy and performance objectives. Thus, our findings offer a practical framework that can be adapted to various production systems.

Conclusion

Nurse sows are used to raise surplus piglets from hyper prolific herds. This study assessed the effects of nurse sows on piglet weaning outcomes and subsequent prolificacy performance. Preference for the use of nurse sows was observed in parities 2, 3 and 4. The number of piglets weaned from nurse sows was 12.43 during the first weaning and 10.82 during the second, underscoring the need to optimise weaning performance. Extended lactation durations (15–21 d) demonstrated notable benefits in P1 nurse sows through increased subsequent live-born piglets, demonstrating positive weaning performance and reproductive outcomes across P1–4. In contrast, longer lactation in higher parities (such as P3) resulted in more mummified foetuses, suggesting that parity-specific care is required for these animals. An optimal balance between piglet weaning outcomes and future reproductive performance can be achieved by selecting younger sows and carefully managing the ELL. Future studies can assess the effects of extended lactation on aspects such as total lifetime piglet production, culling risk and herd productivity. It may be reasonable to ascertain whether extended lactation enhances or impairs lifetime reproductive efficiency or body reserve stability, especially in modern hyper prolific genotypes.

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Ethics approval

Not applicable.

Institutional review board statement

This study was approved as part of a research project investigating the use of nurse sows in swine production at the University of Debrecen, Hungary.

Declaration of interest statement

The authors declare no conflict of interest.

Declaration of generative AI and AI-assisted technologies in the writing process

The authors did not use any artificial intelligence assisted technologies in the writing process.

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Data availability statement

Data were obtained from a commercial pig company and was not deposited in a repository.

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