

Farrowing performance and piglet characteristics of highly prolific sows in a tropical environment

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Abstract

The swine industry has witnessed a remarkable increase in average litter size in recent decades, driven by genetic advancements and breeding programs aimed at enhancing prolificacy. This rise in hyperprolificacy has presented both opportunities and challenges, particularly in tropical environments where factors such as ambient temperature and humidity can influence reproductive performance. This review synthesizes current knowledge on farrowing performance and piglet characteristics of highly prolific sows in tropical settings. Studies have reported a consistent increase in litter size globally, leading to challenges in farrowing management and piglet survival. Factors such as elevated ambient temperatures and extended farrowing durations have been observed, impacting sow health and welfare. Furthermore, the increase in litter size has led to increased variation in piglet birth weights and colostrum intakes, with larger litters often facing challenges in receiving sufficient colostrum. Management strategies such as optimizing nutrition, implementing environmental controls, and enhancing colostrum production have been explored to address these challenges. For instance, raising feed levels during the pre-farrowing period has shown promising results in boosting sow colostrum production and piglet colostrum intake. However, further research is needed to optimize these strategies and mitigate the negative impacts of hyperprolificacy on sow and piglet health. Overall, this review underscores the importance of tailored management practices and targeted interventions to ensure optimal farrowing performance and piglet characteristics in highly prolific sows, especially in tropical environments where environmental factors can significantly influence reproductive outcomes

Keywords: Colostrum, Litter size, Parturition, Prolificacy, Temperature

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Introduction

During the past decade, an increase in litter size in most swine breeding herds have been reported worldwide (Tokach *et al.*, 2019; Ward *et al.*, 2020; Bortolozzo *et al.*, 2023; Bruun *et al.*, 2023; Tummaruk *et al.*, 2023; Adi *et al.*, 2024c). These increases result from practices that began five to six decades ago to enhance prolificacy in the pig industry (Legault, 1985). However, during the first 20 years of these genetic practices, litter size at birth remained relatively constant at the commercial level. This situation seems to be attributed to the low efficiency of classical methods of genetic improvement, which rely on within-herd selection and crossbreeding between European or American breeds (Legault, 1985). The scenario underwent a transformation with the introduction of selection between lines in a few experiments and the adoption of formal crossbreeding programs. These changes led to significant improvements in litter size commercially (Bichard and David, 2020; Thongkhuy *et al.*, 2020). Consequently, in Europe, there has been a consistent increase in litter size over the past three decades due to the utilization of superior maternal line genetics (Lyderik *et al.*, 2023; Oliviero, 2023).

It is no longer surprising to find sows in commercial herds worldwide with a total number of piglets born per litter exceeding the number of functional teats, a condition known as hyperprolificacy (Figure 1). In European countries, the average total number of piglets born per litter from highly prolific sows can be as high as 19.0 (Han *et al.*, 2021) and 19.8 (Hansen, 2022). Meanwhile, in a tropical country such as Thailand, the increase in litter size has been driven by the importation of highly prolific sow genetics from

various countries, including Canada, Denmark, and France (Thongkhuy *et al.*, 2020; Adi *et al.*, 2022; Dumniem *et al.*, 2023; Adi *et al.*, 2024a; Adi *et al.*, 2024c). A recent study reported average total number of piglets born per litter in Thailand can reach 17–18 piglets, slightly lower compared with the maternal genetic line originating from European countries (Hansen, 2022; Tummaruk *et al.*, 2023; Adi *et al.*, 2024c) (Figure 1). However, a prior study found a correlation between suboptimal litter size of sows in Thailand and an elevation in ambient temperature and humidity during pregnancy (Tummaruk *et al.*, 2004). Specifically, an increase of 1.0 °C in the maximum daily temperature during the initial 4 weeks of gestation resulted in a reduction of approximately 0.07 piglets per litter in the old genetic lines (Tantasuparuk *et al.*, 2000). However, information regarding the impact of temperature and/or humidity on the litter size of modern, highly prolific sow genetics is still lacking and ultimately needs further investigation.

It is important to note that the average ambient temperature within barns in general commercial swine herds in Thailand equipped with evaporative cooling systems can range from 25.5 to 27.0 °C, with daily minimum and maximum temperatures ranging from 23.8 to 24.4 °C and from 28.6 to 32.0 °C, respectively (Jeeraphokhakul *et al.*, 2023). This exceeds the temperature comfort zone for modern, highly prolific sows, as noted by Robbins *et al.* (2021), who suggest that individual sows should be housed in temperatures between 12.6 °C and 16.4 °C, to optimize production and improve overall well-being. Moreover, to establish appropriate management, it is important to understand the sow farrowing performance and piglet characteristics, especially in highly prolific sows housed in a tropical environment.

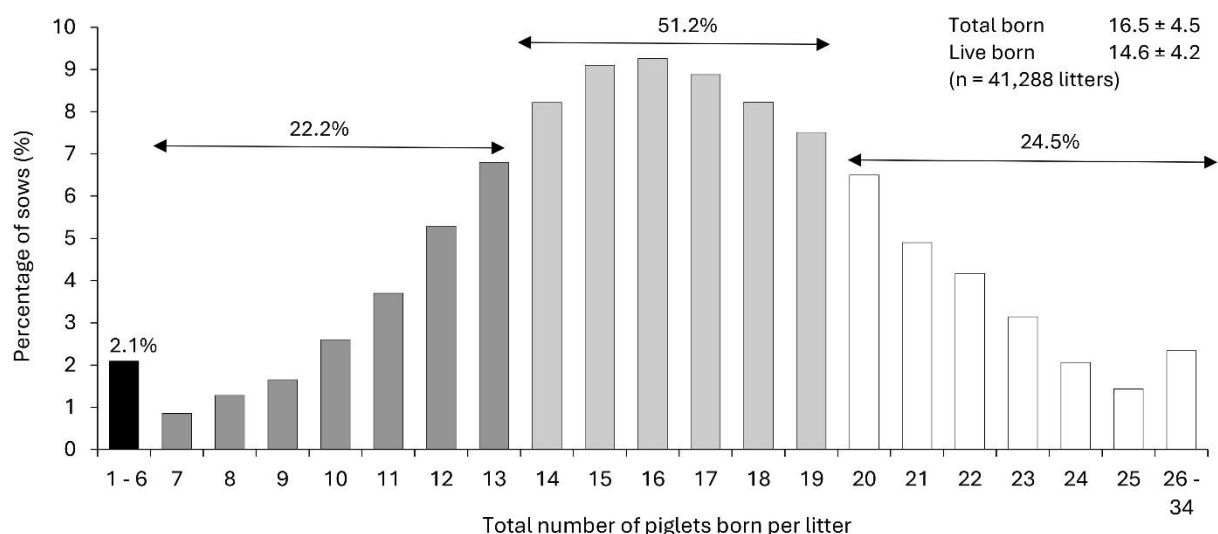


Figure 1 Frequency distribution of the total number of piglets born per litter in a commercial swine herd in Thailand from 2020 to 2022, based on 41,288 litters from crossbred Danish Landrace × Yorkshire sows (Tummaruk, unpublished data).

Fertility traits and weaning-to-service interval

In general, various factors, including insemination technique, climate, season, and ambient temperature, affect the weaning-to-service interval, as well as conception and farrowing rates (Chanapiwat *et al.*, 2014; Sevilano *et al.*, 2016; Koketsu *et al.*, 2017; Mellado *et al.*, 2018; Pearodwong *et al.*, 2020). A previous study in Thailand found that season and the type of insemination—conventional or fixed-time—had no impact on regular returns or farrowing rates (Pearodwong *et al.*, 2020). However, the total number of piglets born per litter was smaller with fixed-time insemination, but only during the hot season (Pearodwong *et al.*, 2020). This may indicate a seasonal effect on oocyte quality or suggest that the timing of ovulation relative to insemination was altered. In fact, heat stress has been linked to reduced developmental competency *in vitro* fertilized ova (Isom *et al.*, 2007).

The farrowing rates of approximately 90% reported in Thailand by Chanapiwat *et al.* (2014) and Pearodwong *et al.* (2020) are comparable to those observed in Murcia, a subtropical region of Spain (Carrion-Lopez *et al.*, 2022). Similarly, the weaning-to-service interval of 4.0 days aligns with accepted commercial norms. In contrast, Mellado *et al.* (2018) reported a negative impact of the temperature-humidity index on conception and farrowing rates at a pig farm in a subtropical climate in Mexico, with lower rates observed in the spring and summer compared to the fall and winter. It is likely that the farm studies used open-sided buildings, whereas the recent Thai study farms had more advanced environmental controls. Notably, earlier studies in Thailand, based on older sow genetics, demonstrated significant effects of the month on fertility performance, including farrowing interval, weaning-to-service interval, weaning-to-conception interval, and farrowing rate (Tantasuparuk *et al.*, 2000; Tummaruk *et al.*, 2002). The farrowing rate decreased by 1.8% with each 1.0 °C increase in temperature and heat index (within the range of 26–38 °C) during the first 4 weeks after mating, while the weaning-to-first-service interval lengthened by 0.17 days for every 1.0 °C rise in average maximum temperature during lactation (Tantasuparuk *et al.*, 2000). Overall, these findings suggest that employing a closed-house system with evaporative cooling for swine herds in tropical environments can help control ambient temperature and humidity within the barn (Tummaruk *et al.*, 2023). Nevertheless, the effects of seasonal changes and extreme climatic conditions typically observed in tropical regions on the fertility traits of highly prolific sows still require comprehensive analysis.

Farrowing performance of highly prolific sows in a tropical environment

Litter traits: A report from Denmark and the United Kingdom showed that the gradual increase in litter size over several years was linked not only to a higher number of piglets born alive per litter but also to an increase in the stillbirth rate (Rutherford *et al.*, 2013). The same pattern was reported for Brazil, where between 2008 and 2021 the stillbirth rate increased in line with the rise in the total number of piglets born per litter, while

the percentage of mummified fetuses remained relatively constant in highly prolific sows (Bortolozzo *et al.*, 2023). Similarly, a previous study in Thailand found that highly prolific sows with a total born of litter size of 17.1 piglets per litter had a stillbirth rate of 6.4%, significantly higher than sows with a total born of 10.6 piglets per litter, which had a rate of 5.5% (Adi *et al.*, 2022). However, the percentage of mummified fetuses did not differ between the two groups, remaining at 5.4% and 6.0%, respectively (Adi *et al.*, 2022). These data are similar to those of Thongkhuy *et al.* (2020), who found that highly prolific sows with an average of 17.5 total piglets born per litter had 15.3 piglets born alive, with stillbirth and mummified fetus rates of 6.6% and 5.4%, respectively. Similarly, a more recent study reported that highly prolific sows with an average total number of piglets born per litter of 18.2 had 15.6 live-born piglets, a 7.5% stillbirth rate, and 5.3% mummified fetuses (Adi *et al.*, 2024c). However, the number of live-born piglets per litter, stillbirth rates, and rates of mummified fetuses can vary among herds within Thailand and globally. This variation is attributed to factors including litter size, parity number, extended farrowing, genetic diversity, farm management practices, and environmental conditions in housing (Thiengpimol *et al.*, 2020; Kirkwood *et al.*, 2021; Sens Junior *et al.*, 2023).

Farrowing duration: The duration of farrowing has seen an increase in most domestic pig breeds native to Europe, such as Landrace and Yorkshire, advancing from roughly 2 hours for 12 total number of piglets born per litter to 6 hours and 40 minutes for 19 total number of piglets born per litter (Peltoniemi *et al.*, 2020). Oliviero *et al.* (2010) noted that the typical farrowing duration in contemporary swine production can range from 156 to 262 minutes, with a farrowing surpassing 300 minutes can be classified as prolonged. In a similar vein, Ju *et al.* (2022) suggested that the ideal farrowing duration for Landrace × Yorkshire hybrid sows on commercial pig farms with 5 to 22 total number of piglets born per litter falls within the range of 240 to 300 minutes while one study in Thailand found that modern prolific sows, with an average total number of piglets born per litter of 17.5, required approximately 330.6 minutes for farrowing (Udomchanya *et al.*, 2019). Extended farrowing durations can negatively affect both sows and piglets, with increased incidences of post farrowing discharge and hypoglycemia in sows adversely affecting their litters (Tummaruk and Pearodwong, 2015; Akkhaphana *et al.*, 2024). Furthermore, prolonged farrowing was linked to an elevated occurrence of post-parturient fever, diminished lactation feed intake, excessive backfat loss during lactation, and prolonged vaginal discharge in sows (Tummaruk and Sang-Gassanee, 2013; Tummaruk, 2013; Nam, 2020). Extended farrowing has been associated with a higher likelihood of piglet intrapartum hypoxia (Peltoniemi *et al.*, 2020; Laothong *et al.*, 2024) with consequent stillbirth or neonatal mortality in newborn piglets (Kirkwood *et al.*, 2021). Laothong *et al.* (2024) showed that piglets born with meconium staining, a biological marker of hypoxia in newborns, are most common among those with a cumulative expulsion interval exceeding 240 minutes. This suggests that the incidence of hypoxia in piglets significantly

increases when the farrowing duration extends beyond 240 minutes or 4 hours. Moreover, the duration of farrowing also impacts the colostrum intake of piglets. Laothong *et al.* (2024) found that in litters with 18 or more piglets, those born in the third quartile consumed less colostrum compared to those born in the first quartile. Additionally, colostrum intake decreased as the cumulative expulsion interval lengthened, with a significant decline observed starting at 90 minutes post-farrowing compared to piglets born within the first 30 minutes (Laothong *et al.*, 2024). Consequently, the issue of extended farrowing duration in modern prolific sows has gained significant prominence in recent times (Wongwaipisitkul *et al.*, 2024). Wongwaipisitkul *et al.* (2024) analyzed farrowing data from 352 Landrace × Yorkshire crossbred sows and 5,554 piglets across five commercial swine herds in Thailand, finding that the average farrowing duration for sows with an average of 15.8 total piglets born was approximately 280 minutes. Notably, the percentage of sows requiring farrowing assistance was as high as 29.8%, with some herds reporting an increase to 53.3% (Wongwaipisitkul *et al.*, 2024). Although the colostrum yield of sows needing farrowing assistance did not differ from those that farrowed unassisted, piglets born to sows that required assistance consumed less colostrum than those born to unassisted sows (Wongwaipisitkul *et al.*, 2024). This highlights the need for improved farrowing assistance by well-trained staff to minimize the negative impact of farrowing assistance, which is often unavoidable in hyperprolific sows.

Parturition may be prolonged in larger litters due to the increased time required for the delivery of each piglet (Rutherford *et al.*, 2013; Adi *et al.*, 2022; Laothong *et al.*, 2024). A recent study found that farrowing duration lengthened as litter size grew (van den Bosch *et al.*, 2023). This was further supported by a large-scale analysis of data from a commercial swine farm in Thailand (Adi *et al.*, 2022), which showed that the farrowing duration increased from 199.9 minutes to 228.2 minutes and 237.9 minutes as the number of piglets born per litter rose from 8–12 to 13–15 and ≥16, respectively (Figure 2). Additionally, the percentage of sows with prolonged farrowing increased from 17% to 22.9% and 25.9% in sows with 8–12, 13–15, and ≥16 piglets, respectively (Adi *et al.*, 2022). At the commercial level, prolonged farrowing (>300 minutes) was observed in 21.7% of all cases (Adi *et al.*, 2022). However, the relationship between farrowing duration and litter size is not absolute. In a clinical trial, despite an average litter size of 18.2 piglets, the mean farrowing duration was relatively short at 259 minutes, ranging from 66 to 770 minutes (Adi *et al.*, 2024c). This suggests that management practices, such as the routine use of oxytocin to stimulate uterine contractions, feeding strategies during the transition period, intravenous administration of supportive fluids during early fetal expulsion, and frequent manual intervention, may significantly impact farrowing outcomes in some commercial swine farms in Thailand (Tummaruk, 2013; Adi *et al.*, 2022; Adi *et al.*, 2024c; Boonprakob *et al.*, 2024; Dumniem *et al.*, 2024; Wongwaipisitkul *et al.*, 2024).

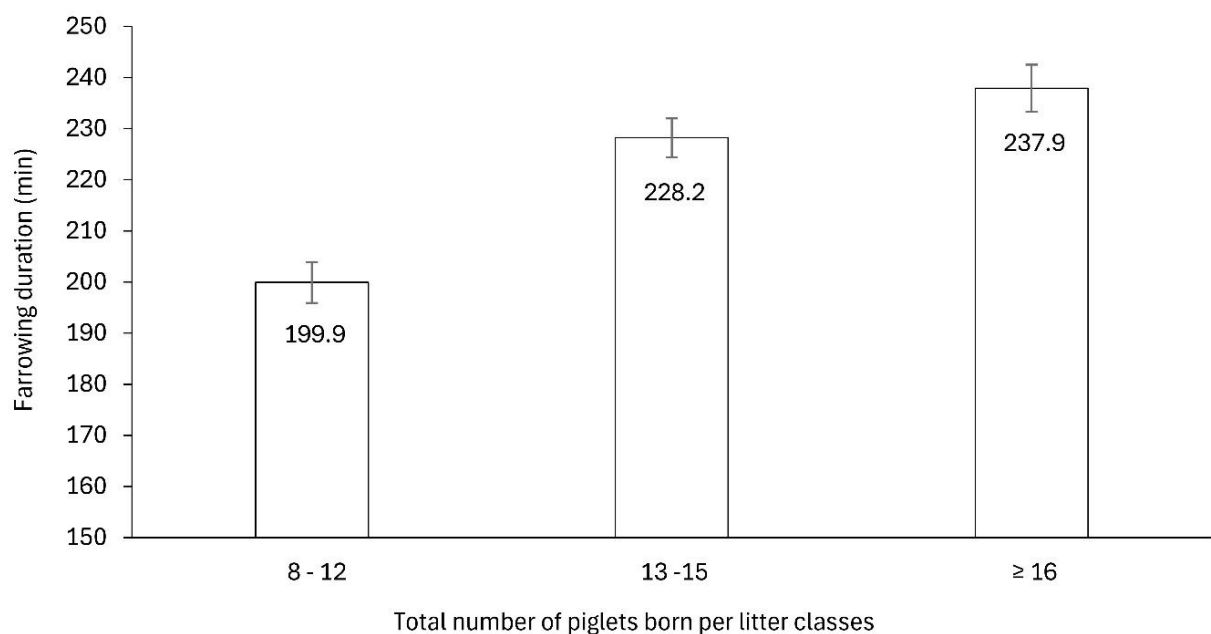


Figure 2 The association between farrowing duration and total number of piglets born per litter based on farm records consisting of 2693 farrowing data (modified after Adi *et al.*, 2022).

Parity number: Studies conducted in tropical environments have consistently shown that the duration of farrowing is longer in highly prolific sows with higher parity numbers compared to those with lower parity numbers (Adi *et al.*, 2022; Tummaruk *et al.*, 2023; Adi *et al.*, 2024c). This contrasts with European data observing no parity effect on the duration of the expulsive phase (van Dijk *et al.*, 2005). However, the litter sizes in this study were relatively small and not comparable to modern prolific sows. Notably, Adi *et al.* (2024b) demonstrated that older, highly prolific sows (parity ≥ 6) exhibited lower oxytocin receptor expression compared to primiparous sows. This supports existing evidence of higher intensity of uterine contraction in gilts compared to multiparous sows (Olmos-Hernández *et al.*, 2008), possibly affecting farrowing duration in older sows. However, further investigation is needed to address the impact of aging on farrowing duration in multiparous sows. Wongwaipisitkul *et al.* (2024) demonstrated that the frequency of farrowing assistance varied significantly among different parity groups of highly prolific sows, ranging from 22.2% to 52.9%. Highly prolific sows in parity groups 1 and 2 to 4 required farrowing assistance less frequently than those in parity group 7 or higher. However, no significant difference was observed between sows in parity groups 5 to 6 and those in groups 1 to 4 (Wongwaipisitkul *et al.*, 2024). Similarly, among the highly prolific sows needing farrowing assistance, those in parity group 7 or higher had a higher number of piglets requiring birth assistance compared to sows in parity groups 5 to 6. These findings clearly indicate that, under field conditions, more than half of highly prolific sows with a parity number of 7 or higher require farrowing assistance. Therefore, it is crucial to closely monitor pre-partum feeding and maintain optimal body condition in these high-parity sows. Additionally, further investigation is needed to reduce the need for farrowing assistance in older, highly prolific sows.

Heat stress: Another factor that may have influenced farrowing duration in highly prolific sows kept under tropical conditions is heat stress (Adi *et al.*, 2022). In tropical environments, temperatures inside barns typically fluctuate between 24.2 °C and 33.1 °C, averaging at 28.9 ± 2.0 °C (Taechamaeteekul *et al.*, 2022). This exceeds the thermal comfort zone for late gestating sows, which is between 12.6 and 16.4 °C, as indicated in a study by Robbins *et al.* (2021). A study conducted in Denmark found that sows housed at lower room temperatures (15 °C) experienced shorter birth intervals and farrowing durations compared to sows kept in higher room temperatures (20 °C and 25 °C) (Malmkvist *et al.*, 2012). Similarly, Muns *et al.* (2016) showed that second-parity sows exposed to an initial room temperature of 20 °C, which gradually increased to 25 °C from days 112 to 115 of gestation, had a longer farrowing duration compared to sows maintained at a constant room temperature of 20 °C. In tropical conditions, a previous study reported that the maximum temperature and the maximum temperature-humidity index during the 7 days preceding farrowing were positively correlated with farrowing duration in multiparous sows (Adi *et al.*, 2022). Therefore, swine herds in tropical zones are recommended to use closed

houses with an evaporative cooling system (Tummaruk *et al.*, 2023). Additionally, both heat stress and noise stress appear to affect the process of parturition by increasing cortisol levels, which in turn have a reciprocal effect on oxytocin (Broucek, 2014; Li *et al.*, 2019). A study found that sows beginning farrowing during working hours experienced longer farrowing durations than those starting during non-working hours (Adi *et al.*, 2022). Loud noises can occur during working hours, stemming from either the sows themselves (e.g., like screaming during feeding times) or environmental sources (e.g., mechanical ventilation, high-pressure cleaning, feed mixing, and manure removal lines) (Sistkova *et al.*, 2015).

Colostrum yield: A prior study showed that genetic selection for hyper-prolificacy has led to an increase in the average number of liveborn piglets per litter from 12.5 to 21.7 over the past 13 years (Theil *et al.*, 2023). Concomitantly, the sow's colostrum yield has risen from 5.3 to 6.9 kg per sow (Theil *et al.*, 2023). This supports the data of Hasan *et al.* (2019), who demonstrated a positive correlation between colostrum yield and the number of liveborn piglets per litter. A recent study of highly prolific sows in Thailand also demonstrated that sows with 12.1 liveborn piglets yielded 4.6 kg of colostrum, which is lower than the colostrum yields of sows with 15.8 (5.4 kg) and 18.6 liveborn piglets (5.7 kg) (Adi *et al.*, 2024c). Nonetheless, colostrum yield can differ among individual sows, influenced by various factors including parity number, farrowing duration, physiological status during farrowing, sow body condition, and plasma haptoglobin (Decaluwé *et al.*, 2013; Hasan *et al.*, 2019; Nuntapaitoon *et al.*, 2020; Wongwaipisitkul *et al.*, 2024). Under tropical conditions, the average colostrum yield of Danish Landrace $\times$ Yorkshire crossbred sows with 15.3 live-born piglets per litter reached 6.1 kg, ranging from 2.9 to 10.5 kg (Nuntapaitoon *et al.*, 2020). Recent data on Danish Landrace $\times$ Yorkshire sows in tropical climates shows that multiparous sows produced higher colostrum yields (6.2 kg vs. 4.3 kg) and had greater IgA concentrations compared to primiparous sows (8.3 mg/ml vs. 6.3 mg/ml) (Juthamanee *et al.*, 2024). However, even with the increase in colostrum yield, the sow's capacity to produce sufficient colostrum to accommodate the large litter sizes is limited (Devillers *et al.*, 2011). Researchers are currently focused on studying colostrogenesis, aiming to enhance the colostrum yield of sows through diverse dietary interventions. These interventions have encompassed variations in dietary components such as fat, fiber, protein, and energy content, as well as adjustments in feeding levels (i.e., daily energy provision), management of body condition, and glucose infusion (Theil *et al.*, 2023). However, it is noteworthy that the advancements made in improving sow colostrum yield have not kept pace with the increase in litter size achieved by breeding companies. Consequently, this discrepancy has led to a substantial reduction in the colostrum intake of individual piglets (Theil *et al.*, 2023; Laothong *et al.*, 2024). In field conditions, the percentage of piglets with inadequate colostrum intake (<300 g) was higher in litters with 18 or more piglets compared to litters with 10–13 piglets (33.1% vs. 12.9%) and those with 14–17 piglets (23.9%) (Laothong *et al.*, 2024). This data suggests that in large

litters, either the sow's colostrum yield or the piglets' ability to consume colostrum needs to be improved.

Characteristics of piglets from highly prolific sows in a tropical environment

Piglet birth weight: The number of piglets born in a litter had a direct impact on their average birth weight and birthweight variance (Oliviero, 2023; Adi *et al.*, 2024a). This pattern aligns with our recent study, which observed a decrease in piglet birth weight and a rise in within-litter birth weight variability as litter size increased (Adi *et al.*, 2024a; Laothong *et al.*, 2024) (Table 1). Specifically, there was a significant decrease in piglet birth weight, from 1.67 kg in sows with ≤ 9 piglets born per litter to 1.26 kg in sows with ≥ 16 piglets born per litter (Adi *et al.*, 2024a). Additionally, within-litter birth weight variation significantly increased, from 14.9% in sows with ≤ 9 piglets born per litter to 23.4% in highly prolific sows with ≥ 16 piglets born per litter (Adi *et al.*, 2024a). The impact of litter size on piglet birth weight has also been documented in other studies (Kitkha *et al.*, 2017; Moreira *et al.*, 2020; Peltoniemi *et al.*, 2021), indicating the possibility of competition for finite nutritional resources, contributing to the observed influence of the total number of piglets born on individual piglet birth weight (Kitkha *et al.*, 2017; Moreira *et al.*, 2020). The high number of developing fetuses in highly prolific sows results in intrauterine overcrowding, leading to a higher prevalence of piglets experiencing intrauterine growth retardation (IUGR). In Thailand, approximately 11.5% to 12.1% of liveborn piglets from litters averaging 13.3 to 13.9 piglets per litter exhibited IUGR characteristics (Ngo *et al.*, 2024). However, in litters where the total number of piglets born exceeded 16, the incidence of IUGR piglets could reach as high as 17.2% (Table 1). Nonetheless, further comprehensive studies are needed to investigate the incidence of IUGR piglets in tropical climates and the associated factors. Other factors that may influence piglet birth weight in tropical environments include sow parity, the piglet's position within the uterus, and litter

size (Adi *et al.*, 2024a; Laothong *et al.*, 2024). Primiparous sows had the lowest average piglet birth weight compared to multiparous sows (1.34 kg vs. 1.46–1.47 kg) (Adi *et al.*, 2024a). It remains unclear whether the lower birth weights associated with parity are due to gilts and parity-one sows diverting nutrients towards maternal growth at the expense of fetal growth, or simply because they are smaller with reduced uterine blood supply. Interestingly, piglets born in the fourth quartile of farrowing had higher birth weights than those born in the first to third quartiles (Adi *et al.*, 2024a). This may reflect uterine position, with larger pigs gestating at the ovarian end of the uterus and smaller pigs originating towards the cervix (Jang *et al.*, 2014). Piglets born in larger litters (18 or more) had lower birth weights compared to those in smaller litters (i.e., 10–13 and 14–17 piglets), which resulted in reduced colostrum consumption among piglets from these larger litters (Laothong *et al.*, 2024). This suggests that larger litters are associated with lower birth weights, which can lead to reduced colostrum intake and an increased risk of pre-weaning mortality.

Reduced piglet birth weights are one of the primary factors linked to increased stillbirth and preweaning mortality in highly prolific sows (Cabrera *et al.*, 2012; Feldpausch *et al.*, 2019; Udomchanya *et al.*, 2019). To exemplify, piglets born with a weight of 0.9 kg exhibited a preweaning survival rate 21% lower than their 1.6 kg contemporaries (68% vs. 89%, respectively) (Cabrera *et al.*, 2012). In a separate study, piglets weighing ≤ 1.11 kg at birth were found to have a preweaning mortality rate of 34.4%, contributing to 43% of the total mortality before weaning (Feldpausch *et al.*, 2019). Additionally, Quiniou *et al.* (2002) noted that 11% of piglets with a birth weight below 1.0 kg were stillborn, and a further 17% succumbed within 24 hours. Consequently, it is evident that piglets with lower birth weights face an elevated risk of perishing during or soon after parturition compared to their heavier litter mates. Therefore, mitigating the occurrence of piglets with low birth weight is important to establish management practices aimed at reducing piglet loss.

Table 1 Piglet characteristics based on litter size in a tropical environment (least squares mean $\pm$ SEM) (modified after Adi *et al.*, 2024a).

Variables	Litter size			P value
	8 – 12	13 – 15	≥ 16	
Number of piglets	4,666	6,537	5,993	
Piglets born alive (%)	87.2	88.3	87.9	0.827
Stillborn piglet (%)	5.4 ^a	6.2 ^a	7.2 ^b	0.002
Mummified fetuses (%)	7.4 ^a	5.6 ^b	5.0 ^b	<0.001
Piglet birth weight (kg)	1.54 $\pm$ 0.01 ^a	1.35 $\pm$ 0.01 ^b	1.27 $\pm$ 0.01 ^c	<0.001
Piglets with body weight at birth ≤ 1.0 kg (%)	10.7 ^a	17.3 ^b	25.3 ^c	<0.001
Within-litter birth weight variation (CV)	16.7 $\pm$ 0.3 ^a	20.6 $\pm$ 0.3 ^b	23.5 $\pm$ 0.4 ^c	<0.001
Colostrum intake (g)	532.3 $\pm$ 27.5 ^a	435.0 $\pm$ 19.7 ^b	351.0 $\pm$ 7.6 ^c	<0.001
Intra-uterine growth restriction piglets (%) ¹	9.9 ^a	9.8 ^a	17.2 ^b	0.012

Data are presented median and interquartile ranges (IQR) unless stated otherwise

^{a,b,c} different superscripts within row differ significantly ($P < 0.05$). ¹Data sourced from Adi *et al.* (2024c).

Colostrum intake: A sow's capacity to generate sufficient colostrum to satisfy the demands of sizable litters is limited in highly prolific sows (Devillers *et al.*, 2011; Adi *et al.*, 2024c). As litter size increases, colostrum production grows, yet the average intake per piglet diminishes (Adi *et al.*, 2024c; Laothong *et al.*, 2024). This is likely due to competition among littermates and the limitation of sow colostrum yield. Recent research illustrates that piglets born to sows with 15 or more piglets per litter had an average intake of 369 g of colostrum, a quantity lower than that of piglets born to sows with fewer than 12 piglets per litter (460 g of colostrum intake) while piglets with birth weights below 1.3 kg took in less colostrum compared to piglets weighing between 1.3 and 1.79 kg (305 g vs. 425 g of colostrum, respectively) (Nuntapaitoon *et al.*, 2019). Similarly, Boonprakob *et al.* (2024) demonstrated that piglets weighing ≥ 1.3 kg at birth consumed more colostrum compared to those weighing between 1.0 and 1.29 kg, as well as those weighing less than 1.0 kg. Additionally, the incidence of insufficient colostrum intake (< 300 g) was lower among piglets weighing ≥ 1.3 kg compared to those weighing between 1.0 and 1.29 kg, and those weighing less than 1.0 kg (Boonprakob *et al.*, 2024). Furthermore, piglets with birth orders of 10 or more also exhibited reduced colostrum intake when compared with piglets with birth orders below 9 (Nuntapaitoon *et al.*, 2019). These findings emphasize that piglets born to sows with large litters face a heightened risk of not receiving sufficient colostrum. A previous study by Declerck *et al.* (2016) found that colostrum intake was positively associated with weaning, intermediate, and finishing weights, and negatively correlated with preweaning mortality. Nonetheless, it is advisable to set a minimum target of a colostrum intake of >300 g to promote a satisfactory preweaning mortality rate (i.e., 6.3%), and even better if the colostrum intake can be enhanced to >400 g to achieve a preweaning mortality rate of $\sim 1.5\%$ (Nuntapaitoon *et al.*, 2019). This means that piglets that consume more colostrum have a greater chance of surviving until weaning. Thus, ensuring adequate colostrum intake for each piglet becomes particularly critical, especially in highly prolific sows (Muns Vila and Tummaruk, 2016). Additionally, a successful strategy for enhancing piglet colostrum intake and boosting colostrum production in highly prolific sows within a tropical setting involved raising the feed level (Adi *et al.*, 2024c). Specifically, elevating the lactation feed level from 3.0 kg per day to 4.0 kg per day during the 6 days before farrowing increased piglet colostrum intake by 40.0 g and tended to boost sow colostrum production by 0.5 kg (Adi *et al.*, 2024c). This represents a promising enhancement that could potentially be implemented on a commercial scale.

Conclusion

In conclusion, the increase in litter sizes among swine breeding herds globally results from decades of practices aimed at enhancing prolificacy in the pig industry. While advancements in genetics and breeding programs have significantly increased litter sizes, particularly in European countries, this hyperprolificacy presents challenges in farrowing

performance and piglet characteristics, especially in tropical environments. Increased litter sizes have resulted in higher incidences of stillbirth, extended farrowing durations, and challenges in colostrum yield and intake. Managing these issues requires a multifaceted approach, including improved management practices, optimized nutrition, and environmental control to mitigate the adverse effects of hyperprolificacy on sow and piglet health. Implementing targeted strategies, such as increasing feed levels to enhance colostrum production, holds promise for improving outcomes in highly prolific sow production, ensuring better piglet survival and overall herd performance.

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