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THE IMPACT OF PRODUCTION SCALE ON PIGLET BIRTHWEIGHT AND SURVIVAL UNTIL WEANING: INSIGHTS FROM A ROMANIAN FIELD TRIAL

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Abstract

Piglet birth weight plays a vital role in determining their growth performance and productivity of the farming systems. Moreover, piglet birth weight could be also a predictor for piglet survival and subsequent growth. A negative impact of litter size on piglet birth weight has been acknowledged, as large litters have reduced average piglet birth weights and increased within-litter birth weight variation. Consequently, comprehending the elements that influence piglet birth weight can have substantial financial effects on swine farming. A large scale trial was performed in several Romania commercial farms in order to identify the implications of the size of the production system on the piglet birth weight, survival and growth to weaning. Analysis of the records seems to suggest that there is a high variability in this respect among farms with similar rearing conditions and genetics. However, the survival rate to weaning of the low birth weight piglets (LW <1.3 kg) is low irrespective of the size of the farm. In contrast the high birth weight piglets (HW >1.3 kg) seems to thrive in both large, small or medium size units.

Key words: *birth weight, commercial, farms, piglets, variability*

INTRODUCTION

Low birth weight piglets are associated, by farmers, with increased mortality, reduced weaned pig quality, and slower growth rates thus compromising kilograms marketed (Houben et al., 2017). The subject was investigated in a wide range of farming systems worldwide, of different unit sizes, genetics and environmental conditions. However, defining an ideal or optimum birth weight is still widely debated, mainly as this becomes an issue of animal welfare. It is known that the growth of piglets relies on their weight at birth and access to maternal milk during their initial weeks of existence (Feldpausch et al, 2021; Jankowiak et al., 2020). Evidence suggests that piglets characterized by lower birth weights commonly display diminished vitality, encounter delays in accessing the initial intake of colostrum, and face difficulties in competing against stronger littermates for suckling (Devillers et al., 2011). Moreover, piglet birth weight could be also a significant predictor for piglet survival during lactation and subsequent growth (Houben et al., 2017). A negative impact of litter size on piglet birth weight has been acknowledged, as large litters generally have reduced average piglet birth weights and increased within-litter birth weight variation (Milligan et al., 2002; Kobek-Kjeldager et al., 2020).

A potential approach in order to increase piglet birth weight or decrease variability in piglet birth weights within litters is by adjusting feeding strategies of the sow, both before ovulation and during gestation (Campos et al., 2012; Jin et al., 2018). By optimizing the nutrition of pregnant sows, particularly in terms of protein and energy content, farmers can increase the birth weights of piglets and potentially improve their growth performances. In addition to genetic and nutritional factors, the timing of farrowing can also influence piglet birth weight. Furthermore, low birth weight piglets generally show poor growth performance and have a lower lean percentage of pig carcass at slaughter compared to piglets with higher birth weights (Fix et al., 2010; Zhang et al., 2014; Lujka et al., 2021; Rehfeldt and Kuhn, 2006).

Evidence from various studies supports the assumption that birth weight is a heritable trait and can be selectively bred for. For example, it was found a positive relationship between birth weight and mortality during the first three days after birth in large litters (Muhizi et al., 2022). This implies that selecting sows with higher birth weight piglets could potentially reduce early mortality rates in litters despite that the heritability of this trait is rather low (Damgaard et al., 2003).

Piglet birth weight can also be heavily influenced by the parity of the dam. Sows at parities 3-4 tend to give birth to the most balanced litter weight while parity 1 and 5-6 sows are expected to deliver lighter piglets (Lavery et al., 2019).

Piglets with higher birth weights have been found to exhibit better overall growth performance, nutrient utilization, and muscle development compared to those with lower birth weights (Lanferdini et al., 2018).

Piglets born later in the farrowing process tend to have higher birth weights compared to those born earlier. Furthermore, the variability in birth weight within a litter can also impact piglet growth performances (Zindove et al., 2014). Research has shown that larger litter sizes are associated with lower birth weights, likely due to limited uterine space and competition for nutrients among the developing piglets (Riddersholm et al.,2021).

Studies have consistently shown that birth weight is a reliable indicator of piglet growth and development (Zhang et al., 2014). Thus the economic implications of piglet birth weight should not be overlooked. Consequently, comprehending the elements that influence piglet birth weight and executing suitable tactics to maximize it can have substantial financial effects on swine farming (Opschoor, 2015).

Despite the overwhelming evidence that birthweight is an important trait for commercial pig farming systems, there is limited data investigating the issue concerning the size of the farming operation. It is widely accepted that as the size of the farm routine management practices can become more complex mainly due to the individual skills and professionalism of the caretakers in charge of the activities in the farrowing departments.

The main aim of this study was to assess the various potential implications of the farm size on the piglet birthweight and their subsequent survival and growth until weaning.

MATERIALS AND METHODS

Data collection was performed in 16 Romanian commercial farms divided into two groups based on the herd size. The first group consisted of 7 farms with an average of 2400 sow herd, ranging between 1600 and 4000 heads while the second group consisted of 9 farms with an average sow herd of 600 sows, with limits between 150 and 900 females. All considered farms have a farrow to finish a continuous production system. Farrowing departments have standard commercial housing, ventilation, lighting, feeding, and watering equipment. Farrowing pens in all units have been provided by major EU equipment producers with an average overall surface ranging between 4.6 m^2 and 5.6 m^2 depending on the timing of farm construction or refurbishment. The genetic makeup of the herds was similar in terms of the dam (Large White x Landrace F1 sows) and sire lines (Pietrain). All farrowing was recorded in the same week of June, while the weaning data was recorded in July. No overnight assistance was provided to sows at the time of farrowing. Weaning weight recording was performed individually on the day designated by the farm manager according to each unit's internal protocol. Age at weaning in all units was in line with the legal minimum requirements for pigs as found in the European legislation (Council directive 2008/120/EEC). Concerning nutrition, nursing sows were provided a standard lactation diet based on the genetics and nutrition providers' recommendations, while piglets were provided solid food (commercially available pre-starter) commencing on day 7 after birth. Despite possible and probable differences among farms regarding management, standard internal operating procedures, and health status (respiratory and

digestive pathology) at the time of the data gathering no acute symptomatology was signaled by the unit veterinarians, and internal vaccination protocols were strictly followed.
In order to perform the recordings a pack of materials was provided to each unit to designated farm staff containing the followings:
•Weighing plastic bags with the recommenddation to use one bag per litter to help maintain hygiene;
•Digital weigh balance - scaling from 0 to 3 kg;
•Two spray markers - red and green;
•Cards for recording litter details and individual piglet birthweights;
•Button tags - red and green plus pliers to tag pigs at processing (Day 2).

Weighing and data collection protocol. Weighing piglets individually was performed after the sow has finished farrowing and prior to cross-fostering occurring on Day 2 after piglet processing. There were three categories of scaled piglets: a) total born (TB), born alive (BA) and stillborn (SB). Litter cards were completed with individual piglet birth weights and allocated to the following categories: a) piglets with 1.3 kg and above were marked with one spot of green marker (G); b) piglets less than 1.3 kg were marked with one spot of red marker (R) just behind the head. Any preweaning death was recorded on the litter cards. Button tags with the same color as the markers were applied the following day, at the time of processing based on the spray markings. Condition score (CS) and parity (P) of the lactating sows were assessed at the time of scaling the birthweight of the piglets and recorded on the litter card. Subsequently, all sow and litter data were transferred from the recording cards onto the spreadsheet provided on a data stick.

Statistical Analysis
Data was statistically analyzed using GraphPad Prism (Version 9.3.1). An unpaired t-test was performed in order to compare the differences in terms of birth weight and weaning weight between the two types of farms. Also, a Pearson's correlation was performed to analyze the linear relationship between birth weight and weaning weight, in both types of units.

RESULTS AND DISCUSSIONS

Farrowing records
A summary of the data recorded at farrowing is represented in Table 1, showing the overall comparison between the Small/Medium (S-M) size and Large (L) size unit groups. When analysing the sow parity score it is evident that there is an important difference between the unit groups of 0.6 more parities in the S-M units meaning that the age of the sows is higher as well (Lavery et al., 2019). A lower average parity score in the L units suggests better management of the parity structure and a consistent policy related to the voluntary replacement rate. Evaluating the average body condition score (BCS) of the sows is leading to similar conclusions as this trait can be closely related to the age of the sows in the herds. Although the differences between the unit groups are minimal, it is worth mentioning that the values are higher in both unit groups than the generally accepted optimal BCS (2.5 to 3.0). However, it must be noted the limited number of sows were assessed in this experiment in comparison to the actual size of the entire herd in these units. Therefore, this sample status might not reflect the overall image of the parity and condition score of all females of the sow herd.
All these might suggest that the nutrition during gestation leads to heavier sows at the time of farrowing and possible effects on the piglet birth weight (BW) as well. The total number of piglets born per litter (TB) is higher in S-M units (+0.57). The same pattern is valid for the piglets born alive (BA) while the difference is slightly lower (+0.52). The average number of stillborn piglets (SB) is similar in both unit groups suggesting that relevant reproductive diseases are controlled efficiently through appropriate vaccination protocols. When compared to averages reported in other industries (Ketchem et al., 2018) the SB in the analyzed units is lower thus confirming at least a sound health control.

Table 1. Summary of farrowing data in the analysed units

Item	Small/Medium Farms (154 litters)		Large Farms (171 litters)	
	n	Mean ± SEM	n	Mean ± SEM
Sow parity score	154	4.4 ± 0.162	171	3.8 ± 0.173
Sow condition score		3.8 ± 0.046		3.4 ± 0.055
Total born/litter	2015	13.08 ± 0.2	2139	12.51 ± 0.161
Born alive/litter	1879	12.23 ± 0.182	2000	11.71 ± 0.141
Still born/litter	119	0.78 ± 0.089	136	0.80 ± 0.095
Litter weigth at birth (kg)		19.51 ± 0.345		18.32 ± 0.258
Born alive piglet birth weight (kg)		1.61 ± 0.021		1.59 ± 0.022
Light piglets/litter (< 1.3 kg)	421	2.73 ± 0.250	458	2.68 ± 0.216
Heavy piglets/litter (> 1.3 kg)	1469	9.54 ± 0.251	1559	9.12 ± 0.221

The situation is highly variable when we are analyze the differences among farms belonging to the same unit size group. In L units (Figure 1) the recorded farrowing parameters are the lowest in Unit 1 while the highest in Unit 4 at least in that specific moment in time when the sampling was performed. The wide difference between Unit 3 and Unit 6 regarding the SB piglets could be attributed either to nutrition practices during gestation or to the specific health status of the herd in the respective farm at the time of the trial. In S-M units, farrowing parameters differences between units are present as well (Figure 2).

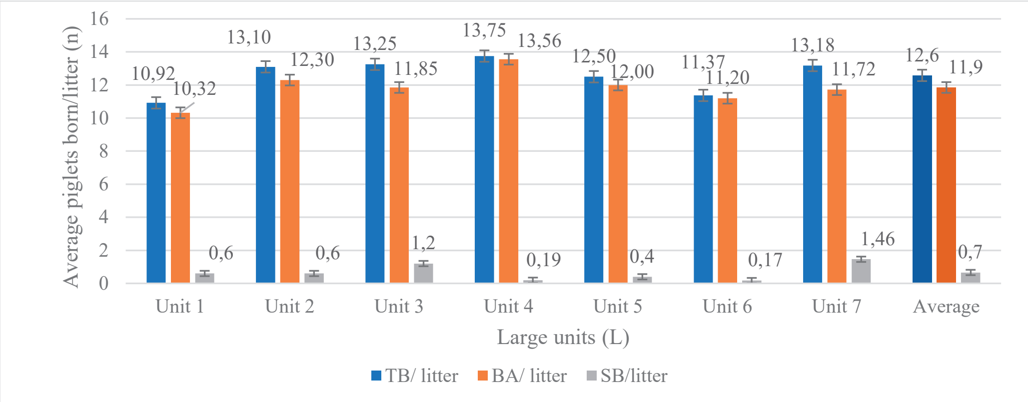

Figure 1. Differences between L units regarding the main recorded farrowing parameters (average and SEM)

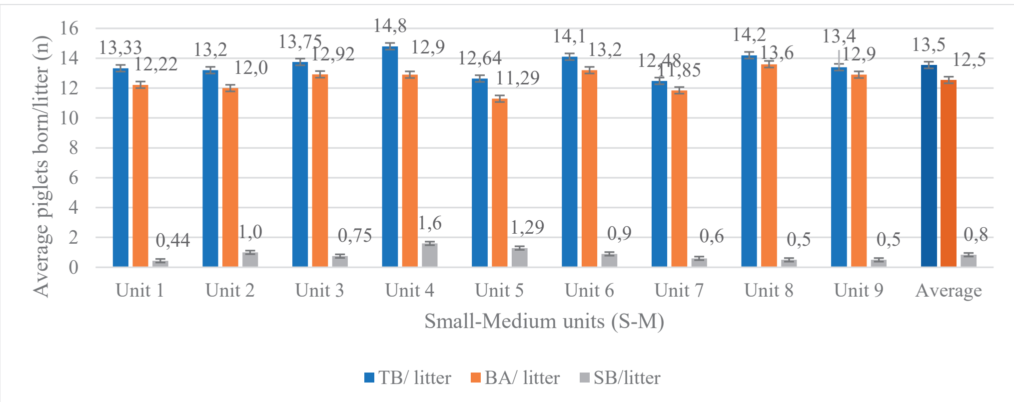

Figure 2. Differences between S-M units regarding the main recorded farrowing parameters (average and SEM)

The wider difference seems to be between Unit 4 and Unit 7 in terms of TB, BA or SB piglets. Reasons for the situation can be multiple and complex as well. However, the main one could be the quality of the sows within the sample at the time of the experiment. As the average parity in Unit 4 (3.8) is much lower than the one in Unit 6 (5.4) this might probably be the main source of variation. This would also mean that Unit 4 sows were younger on average and therefore most probably had a higher genetic index simply due to their age advantage. The same comment would be valid for the differences related to SB piglets. Alternatively, in Unit 4 the recorded condition score (CS) was 3.5 while in Unit 6 the value was 3.8. Therefore it is highly unlikely that this trait had influence over the farrowing traits. All these differences are not unusual even in the situation when the units use the same genetics. This could point out that despite similar operation size there are several other management and/or environmental factors that can influence all the farrowing parameters.

A wider difference between S-M and L unit groups was recorded on the total litter weight at birth with an advantage for the S-M units of 1.19 kg/litter (Table 2).

Table 2. Summary of piglets weights at farrowing in the analysed farms

Item	Small/Medium Farms (154 litters)		Large Farms (171 litters)	
	n	Mean ± SEM	n	Mean ± SEM
Litter weigth at birth (kg)		19.51 ± 0.345		18.32 ± 0.258
Born alive piglet birth weight (kg)		1.61 ± 0.021		1.59 ± 0.022
Light piglets / litter (< 1.3 kg)	421	2.73 ± 0.250	458	2.68 ± 0.216
Heavy piglets / litter (> 1.3 kg)	1469	9.54 ± 0.251	1559	9.12 ± 0.221

This surplus can be attributed to a higher number of BA piglets in these units. These differences favoring the S-M units might be due to better protocols for farrowing assistance and gilt development. Across both group of units the average BW of the piglets was surprisingly similar (1.61 kg/ piglet in S-M farms and 1.59 kg/ piglet in L farms) which could be related rather to the use of same genetics and less to management or the environmental conditions. The same pattern seems to be valid for the number of light (LP under 1.3 kg) versus heavy (HP over 1.3 kg) piglets within litters irrespective of the unit size and it could be attributed probably to genetics. The light and heavy litters average percentages out of the total piglets BA seems to be in the same range in both types of units (22% LP litters vs. 78% HP litters). However, a large variation of this parameter was noted between the units of the same group, ranging from 65.8% to 89.9% (heavy piglet litters) and 11.9% to 29.5% in L units (Figure 3).

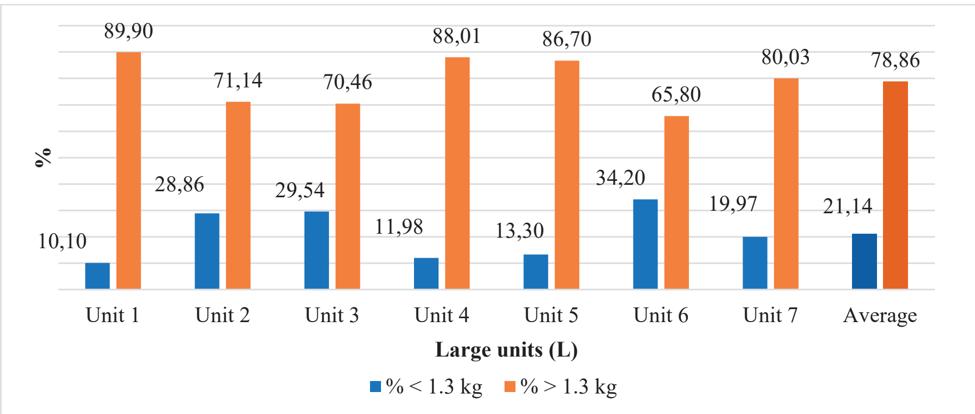

Figure 3. Variation of the ratio of light piglets (LP) and heavy piglets (HP) among the large units (L)

Stating the reasons for the high difference between Unit 1 and Unit 6 might be speculative as it could be related once again to the quality and quantity of the gestation feed or to the actual sow body fat reserves at the time of farrowing. The minimum percentage of light piglets in Unit 1 can be related to the TB and BA, which have the lowest value among examined farms. It is well documented that sows with lower prolificacy tend to have more uniform piglets at birth.
In S-M units the variation of the piglets within litters was even higher ranging between 7.6% and 33.8% (LP litters) and between 66.2% and 92.4% in heavy piglet litters (HP litters) (Figure 4). According to the recorded data, Unit 5 seems to have the most desirable ratio between light and heavy piglets at birth, with the least favorable situation in Unit 2. These differences can be attributed once again to nutrition during gestation and to the quality of the sows in the sample at the time of the experiment mainly from the age perspective (recorded average parity was 4.0 for Unit 5 and 4.7 in Unit 2, respectively). An other explanation of the low number of light piglets in Unit 5 seems to be the correlation with the lowest TB and BA in the entire group of S-M analyzed farms.

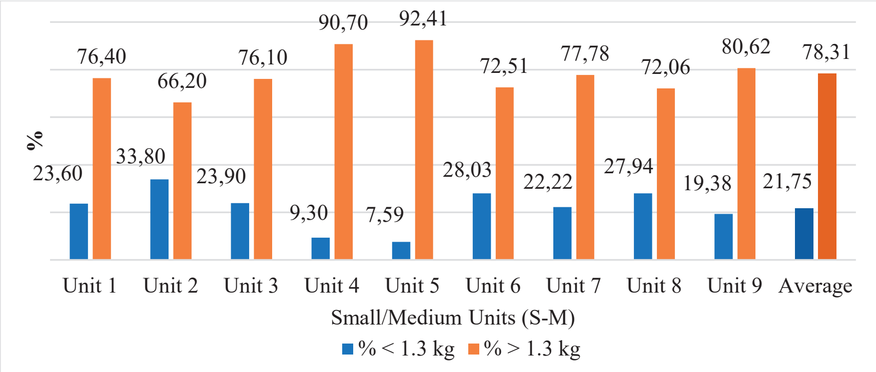

Figure 4. Variation of the ratio of light piglets (LP) and heavy piglets (HP) among (S-M) units

Weaning records
Analysing the records at the time of weaning and comparing the two groups of farms reveals that out of the 3443 piglets weaned of the 3879 BA, there is a clear balance between unit groups not only from the overall piglet number perspective but from the one of the average of piglets weaned/litter as well (Table 3). Thus, this could suggest that the farm size might not have a large impact on this trait after all. There is however a difference related to the piglet age at weaning with one day less in S-M farms suggesting that the litter weaning weight could of been in the favor of the piglets raised in the L farms group. On the contrary, records are showing that weaned litters in L farms are on average 1.53 kg lighter than the ones in S-M group units. This might indicate that S-M units managed to take an overall better care of the piglets in the farrowing house, something possible due to a lower workload and thus a higher attention to details by the caretakers. It is also valid to observe that the average litter weight at birth was 1.19 kg higher in the same S-M units, therefore a clear advantage from the start. This disadvantage for the L units could not be offset however by the extra 1 day spent by the piglets in the farrowing house if we look at the irrelevant difference between unit groups from the perspective of the average piglet weight at weaning. Further analysis of the differences between farm groups regarding the light piglets (LP < 1.3 kg at birth) reveals that the number of weaned litter is lower by 0.26 piglets / litter in S-M units. Similarly, the number of heavy piglets at weaning is higher in S-M units by 0.4 piglets/ litter (Table 3). All these findings might be relevant as the birth weight (BW) was similar in both groups of units (Table 2).

Table 3. Summary of weaning data in the sampled units

Item	Small/Medium Farms (158 litters)*		Large Farms (172 litters)*	
	n	Mean ± SEM	n	Mean ± SEM
Weaned pigs/litter	1667	10.55 ± 0.847	1776	10.33 ± 0.130
Weaning age (days)		27.90 ± 2.241		28.92 ± 0.181
Litter weight at weaning (kg)		75.25 ± 6.045		73.72 ± 1.123
Weigth at weaning (kg/head)		7.18 ± 0.577		7.14 ± 0.079
Light weaners (< 1.3 kg)/litter	298	1.89 ± 0.151	367	2.15 ± 0.206
Heavy weaners (> 1.3 kg)/litter	1339	8.37 ± 0.672	1403	8.16 ± 0.237

*More litters weaned than farrowed due to cross-fostering

Average pre-weaning survival in both groups of units is alike, with a difference of less than 1%.
However, the variation of this trait inside the groups is quite high mainly in one of the large units (66.8 % in Unit 4 to 96.3% in Unit 2). This 30% gap might be attributed primarily to differences in piglet management during lactation or even to the sow nutrition after farrowing (Figure 5).

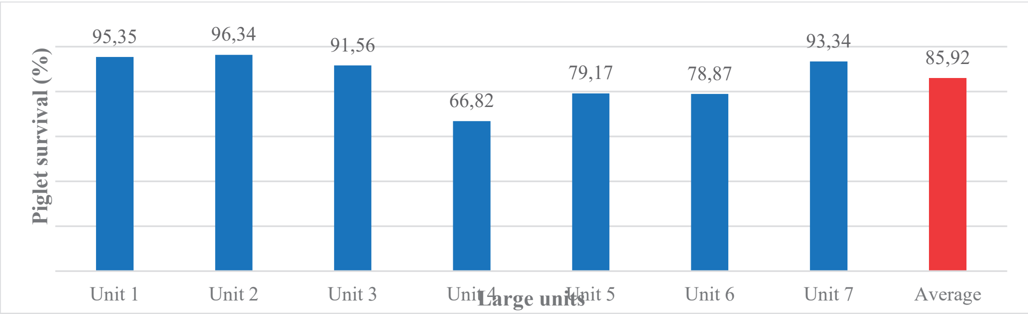

Figure 5. Overall pre-waning piglet survival in the L units group

However, similar pattern can be noticed in the S-M unit group as well with survivability to weaning of only 66.7% in Unit 1 for the same possible reasons (Figure 6).

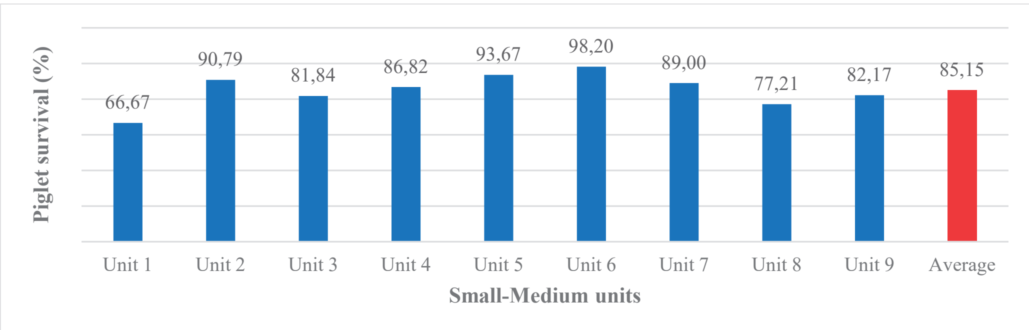

Figure 6. Overall pre-waning piglet survival in the S-M units group

LP survival in the L units is higher than the one in S-M with an average advantage of about 3% (Figures 7 and 8). The explanation could be related to the average sow parity profile and age in these units (3.8) in comparison with 4.4 in S-M units. Having younger sows in the sample would mean an advantage from the quantity of milk available to piglets. It should be also highlighted that the duration of lactation in L units was in average 1 day longer and this can be important for the survival of the lighter piglets.

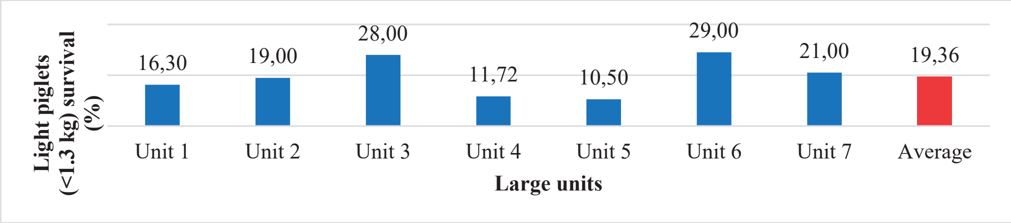

Figure 7. Pre-waning survival of the LP in the L units group

Looking at the variation of the light piglet survival inside the L unit group it can be observed that the highest percentage of weaned animals was in Unit 6 while the lowest in Unit 5 (Figure 7). This might be explained through differences in farrowing house management procedures and /or the effects of sow average parity which is the lowest in Unit 5 (2.2). When it comes to differences in LP survivability in S-M units the variation is more extreme with only 2.7% in Unit 4 up to 30% in Unit 2. This situation can be attributed once again to management and/or to average sow parity which was the highest (5.4) in Unit 4, leading probably to a lower lactating capacity. The same arguments are valid for the best survivability recorded in Unit 2.

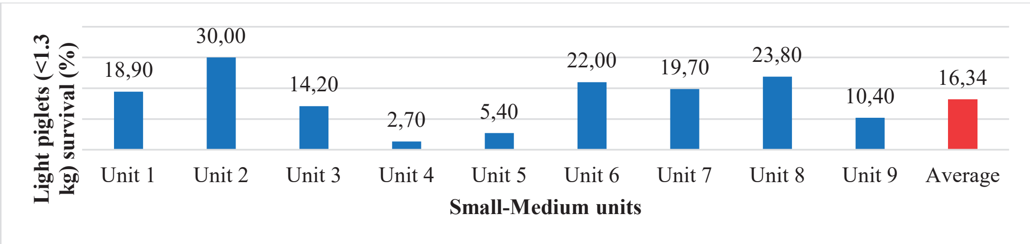

Figure 8. Pre-waning survival of the LP in the S-M units group

Analysing the overall average survival rates of the HP in both L and S-M unit groups shows a difference of only 1.4%. Within the L unit group, the variation is rather limited with the leader being Unit 4, which might be due to the fact that this unit recorded had one of the lowest number of LP at birth (Figure 9).

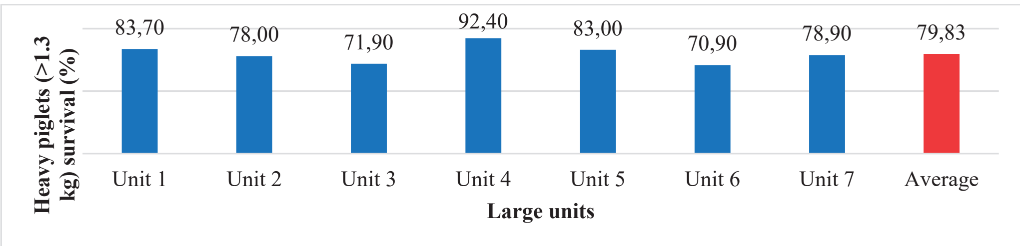

Figure 9. Pre-waning survival of the HP in the L units group

In contrast the variation of survivability of HP in the S-M units is much higher (30%) with a leading unit weaning over 95.5% of the piglets explainable by the low number of light piglets at the time of farrowing. The most unfavorable situation was found in Unit 8, where probably caretakers were not able to apply effective management practices to keep more heavy piglets alive up to weaning (Figure 10).

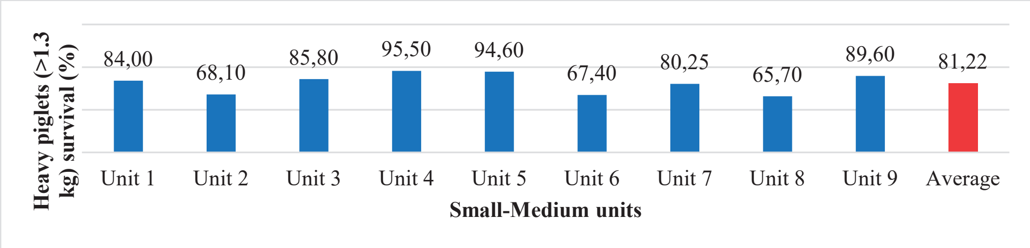

Figure 10. Pre-waning survival of the HP in the S-M units group

In terms of growth performance of the piglets, data seem to suggest that on average results were better in S-M Units than in the L ones. However, the differences are limited (8 g/day). The advantage for the S-M units is 24 g/day in the LP category a value which is more relevant and important for the further ADG in nursery and finishing stages. Also, it might suggest a closer piglet care by the caretakers up to weaning is needed. This difference between unit groups shrinks down to only 6 g/day when HP are considered suggesting that this category of piglets thrive quite the same irrespective of the unit size (Table 4).

Table 4. Summary of growth to weaning data in the sampled units

Item	Small/Medium Farms (158 litters)		Large Farms (172 litters)	
	n	Mean ± SEM	n	Mean ± SEM
ADG to weaning (kg)	1667	0.204 ± 0.016	1776	0.196 ± 0.001
ADG – Light piglets (< 1.3 kg)	298	0.168 ± 0.013	367	0.145 ± 0.005
ADG - Heavy piglets (> 1.3 kg)	1339	0.214 ± 0.017	1403	0.208 ± 0.002

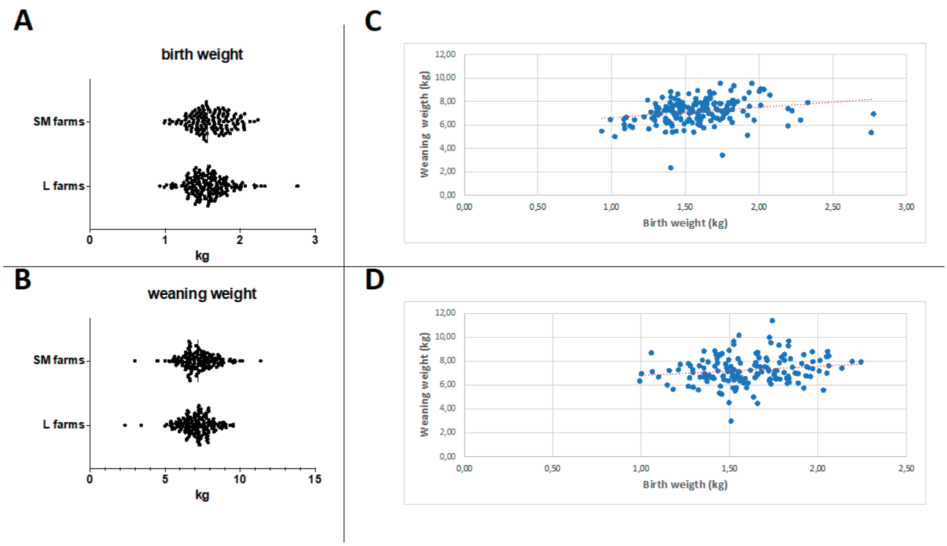

Figure 11. (**A**) Unpaired t-test graph comparing birth weight recorded in the two types of farms; (**B**) unpaired t-test graph comparing weaning weight from the two types of units; (**C**) Pearson's correlation between individual piglet birth weight and weaning weight in Large units; (**D**) Pearson's correlation between individual piglet birth weight and weaning weight in Small-Medium units

The unpaired t-test comparing the results from the two types of farms showed that there were no significant differences neither between the birth weight ($p>0.05$; Figure 11A) nor between the weaning weight ($p>0.05$; Figure 11B). These findings suggest that, despite potential variations in management practices or environmental factors between L farms and SM farms, these factors did not have a substantial impact on the weights of piglets at birth or weaning. Pearson's correlations showed that in L farms birth weight and weaning weight were highly significantly correlated ($p<0.01$; Figure 11C) and in SM farms significantly correlated ($p<0.05$; figure 11D). In L farms, we observed a highly significant positive correlation between birth weight and weaning weight ($p<0.01$). This robust correlation indicates that piglets born heavier tend to have, as well higher weights at weaning in L farms. Conversely, in SM farms, while still significant, the correlation between birth weight and weaning weight was comparatively weaker ($p<0.05$). These findings underscore the importance of considering farm-specific factors when evaluating the relationship between birth weight and weaning weight in livestock. The strong correlation observed in L farms suggests a significant influence of farm-specific factors on piglets growth and development from birth to weaning. In contrast, the weaker correlation observed in SM farms may indicate additional complexities in piglet growth dynamics within this farm type.

CONCLUSIONS

The birth weight of piglets is, undoubtedly influenced by various factors, including genetics, nutrition, litter size, pre-farrowing, management and many others. All these factors might act differently according to the size of the farms for multiple reasons. In the current trial records are suggesting that average litter BW was higher in S-M units mainly due to the extra BA piglets. However, the individual average BW of the piglets was all most the same probably due to the similar genetic makeup both from the sire and dam perspective. Despite this common genetic ground a wide variability among units of the same size was noticed, both in the LW and HW piglets categories suggesting that other influencing factors can play a significant role on the birth weight.

At the time of weaning a clear balance between unit groups was found not only from the overall piglet number perspective but from the one of the average of piglets weaned / litter as well. Therefore, this could suggest that the farm size might not have a large impact on these trait after all. There is however a difference related to the piglet age at weaning suggesting that the litter weaning weight could of been in the favor of the piglets raised in the L farms group. On the contrary records are showing that weaned litters in L farms are on average lighter than the ones in S-M group units. This might indicate that S-M units managed to take a better care of the piglets in the farrowing house, something possible due to lower workload and thus a higher attention to details by the caretakers.

In regard of the growth performance of the piglets from birth to weaning data seem to suggest that results were better in S-M Units than in the L ones. This advantage is more relevant for the LW piglets than in HW ones leading to the conclusion that in S-M units the caretakers allocate more time to the disadvantaged piglets.

Considering the importance of birth weight for piglet survival and growth, it seems essential to implement strategies that optimize birth weight to ensure their further healthy development irrespective of the size unit. Furthermore, our findings highlight that the birth weight is significantly correlated with weaning weigh. While all biological factors influencing the BW of piglets are important, there is a large number of management variables, including as gilt pool control, gestation housing and feeding, prostaglandin induced farrowing and farm hygiene, which all can have their role in boosting piglet weight at birth.

ACKNOWLEDGMENTS

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actual unit location, size and personal names were agreed to be confidential.

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