

Article

The Effect of Different Farrowing Housing Systems on the Reproductive Performance of Sows and the Losses and Growth of Piglets

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Abstract: The aim of the experiment was to analyze the reproductive performance of sows and the losses and growth of piglets in three different systems of farrowing houses. A total of 120 sows of the Prestice Black-Pied breed were included in the study with 40 litters evaluated in each of the systems. The housing systems compared were conventional farrowing cages, pens with temporary fixation, and free farrowing pens. The housing system significantly affected the length of pregnancy ($p < 0.05$). Its effect was 0.35 days shorter in the sows in the free-farrowing system than in the cage technology and 0.6 days shorter than in the temporary fixation. Housing also influenced the onset of post-weaning oestrus ($p < 0.01$), which occurred 0.31 days earlier in the sows in a free-farrowing system and in those in pens with temporary fixation. A significant effect of housing on the overall losses of piglets ($p < 0.05$) was also found. The crushing of piglets by sows was also significantly affected by the housing system ($p < 0.05$), with the highest incidence found in the free-farrowing system. The effect of the housing system on the individual weaning weight of piglets was also found to be significant ($p < 0.001$). The piglets of the sows in the free housing system showed higher growth intensity when compared to piglets in the other housing systems. In conclusion, it can be stated that the lowest losses caused by the crushing of piglets were found in the cage systems. However, the combined system seems to be very perspective in terms of losses of piglets. The free-farrowing system has positive effects on the growth of piglets.

Keywords: housing of sows; alternative pens; losses of piglets; crushing; growth of piglets



Citation: Nevrlka, P.; Sečkář, J.; Weisbauerová, E.; Horký, P.; Knitlová, D.Č.; Lustyková, A.; Hadaš, Z.; Rozkot, M. The Effect of Different Farrowing Housing Systems on the Reproductive Performance of Sows and the Losses and Growth of Piglets. *Agriculture* **2024**, *14*, 1084. <https://doi.org/10.3390/agriculture14071084>

Academic Editor: István Egerszegi

Received: 5 June 2024

Revised: 2 July 2024

Accepted: 3 July 2024

Published: 5 July 2024



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1. Introduction

The breeding of sows is mainly aimed at the economically balanced production of piglets. The productivity of a herd is most often expressed by the number of weaned piglets per sow per year [1]. When the breeding of sows is evaluated from the economic aspect, the number of non-productive days, related to the onset of the post-weaning oestrus and, mainly, the conception rate of sows, is also taken into account. In terms of piglet prosperity, the most important time is the peripartum period and the following lactation period with the pre-weaning mortality of piglets being a crucial criterion [2]. The birth weight of a litter and the weaning weight of a litter are related to the quality of the pigs. The optimum birth weight is put in relation to viability and growth intensity in later phases of life. Lower birth and weaning weights of piglets strongly correlate with higher pre-weaning mortality and a lower growth ability after weaning [3,4]. Pre-partum, peri-partum, and pre-weaning sows

are often kept in conventional farrowing cages, introduced in the 1950s. In the conditions of the European Union, about 90% of piglets are born in these systems nowadays. Despite being considered highly economically effective (lower piglet mortality, space-saving, better animal hygiene, and efficiency of work procedures), these systems are problematic in terms of animal welfare and raise social concerns about good life conditions for sows, associated with movement restrictions and a significant reduction in the possibility of natural behavior [5–7].

Therefore, new alternatives have been developed for the housing of farrowing and lactating sows and more systems are constantly being introduced [8]. For example, Baxter et al. [9] described the PigSAFE pen, which has a nesting area with a separate heated corner creep for piglets, a dunging area, and a lockable feeding box. The nesting area enables escape from three directions, the entrance provides a view of the adjacent pen and the solid floor enables the offering of substrate for nest building. Nevertheless, a critical issue of these new alternative farrowing houses is the mortality of newborn piglets [3,8]. The pre-weaning mortality of piglets is determined by a range of parameters, such as genetics, housing system, environment, nutrition, diseases, litter size, and maternal instinct [1,4]. It has been documented that 5–20% of piglets die before weaning [10]. Marchant et al. [11] report starvation (up to 40%) and overlaying (up to 45%) as the most important causes of losses with up to 10% of losses possibly influenced by poor maternal instinct. KilBride et al. [12] consider the first days of life most critical for piglets. During the first three days, a mother can crush some piglets with her movement. The number of crushed piglets correlates with the sudden movements of sows in combination with the low birth weight of piglets. These factors increase the risk of suffocation or injury resulting in the death of piglets [13].

In the conditions of the Czech Republic, farrowing cages are used in more than 95% and only limited experience with alternative farrowing cages exists on Czech farms [14]. Therefore, the aim of this experiment was to analyze the reproductive performance of sows, losses of piglets, and pre-weaning growth of piglets in three different systems of farrowing houses. Namely, the conventional farrowing cages, free-farrowing pens with the possibility of temporary fixation of sows, and free-farrowing systems that enable nesting. Not many studies have been carried out comparing multiple farrowing systems in the equal conditions of one stable.

2. Materials and Methods

The experimental observation was carried out in the experimental stable of the Institute of Animal Science in Prague, workplace Kostelec nad Orlicí, approved by the Ministry of Agriculture of the Czech Republic (protocol No. 4124/2021-MZE-18134/1). The breeding complies to requirements of the EU directive [15].

2.1. Animals

A total of 120 Prestice Black-Pied sows from the 2nd to the 5th parity were included in the observation. This breed is a Czech national breed included in the National Program for Farm Animal Resources, which belongs to the European Regional Focal Point for Farm Animal Genetic Resources. The breed is characterized by average fertility, good longevity, strong constitution, and adaptability [16]. The sows were divided randomly into the evaluated housing systems; however, an even distribution of sows according to parity was ensured in the individual housing systems. In every housing system, each parity was represented by 10 sows; first-parity sows were not included in the study. The gilts were first inseminated at the age of 230 days. In each system, 40 sows (litters) were evaluated. Farrowing was natural, without induction.

2.2. Housing Technologies, Feeding, and Organization

During insemination and the following thirty days, the sows were stabled in individual boxes (length 2100 mm and width 650 mm) with differentiated floors (solid concrete floor

vs. slats). Each sow had her own feeding unit and drinker. The sows were fed 3–5 kg of commercial feeding mixture per animal/day according to their condition. From the 31st to the 108th day of pregnancy, the sows were transferred to group pens with floors differentiated into lying areas (concrete) and dunging areas (plastic slats). The group pens were equipped with feed dispensers and automatic drinkers according to the number of sows. The floor area was 2.40 m² per animal. The sows between the 31st and the 85th day of pregnancy were fed 2.8 kg of the commercial feed mixture per animal/day and from the 86th to the 108th day they received 3.5 kg of the commercial feed mixture per animal/day. One week before the expected farrowing, the sows were transferred to the farrowing house, where they were stabled in the tested farrowing boxes. Feeding of the sows was equal in all the tested housing systems. The sows were given a commercial feed mixture in the amount of 2.8 kg per animal/day with an addition of 0.5 kg for each live-born piglet. The feed was dosed to the troughs by individual dispensers. Three different housing technologies for farrowing and lactating sows were used in the observation, namely a conventional cage system, a combined system with temporary fixation, and a free farrowing system. The systems were manufactured by the AGE company, Czech Republic. During the experiment, 4 pens of each housing system were installed in the experimental stable. All the pens were located in one section of the stable. The observation was carried out throughout the period of one year. The utilization of individual cages and pens in the tested technologies was balanced over the course of the year. The experiment was terminated after the evaluation of 40 litters in each system.

A conventional cage (Figure 1) has an overall area of 4.5 m², of which 1.3 m² is for the sow. The cage is equipped with inner arches that protrude into the space where they direct the movement of the sow when lying down. The rear part of the cage is formed by a door for the transfer of animals. The floor is solid in the front part of the farrowing cage (2/3), while there are concrete slats in the rear part (1/3). The system does not use bedding. A trough for sows, as well as a drinker, is located in the front part of the cage. An open creep for piglets is also a part of the creep, with the floor heated by electric mats and an infra lamp attached to the plastic board covering the creep. The area of the creep for piglets is 0.4 m². Until weaning, the sows are permanently fixed in the farrowing cage.

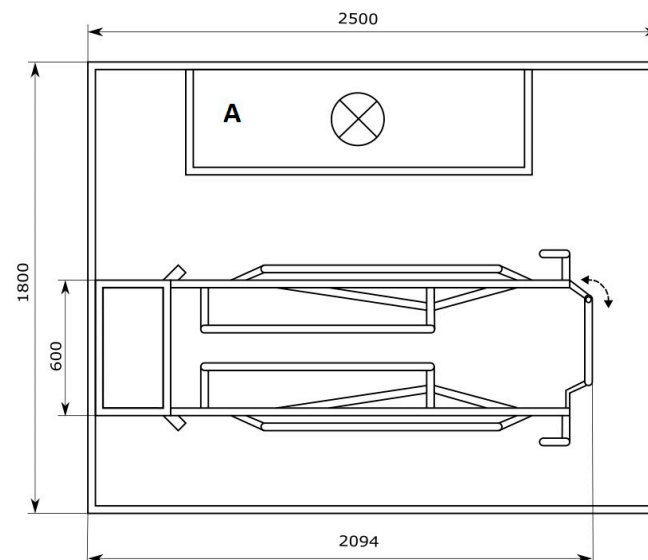


Figure 1. Conventional cage system for farrowing and lactating sows. A = creep area.

The overall area of the combined pen (Figure 2) is 6 m². The farrowing pen is designed for the improvement in the welfare of lactating sows and their piglets, through the innovative system of temporary confinement of sows, which enables opening the cage by lifting it without affecting the overall cage area. In the closed state, the area of the cage is 1.3 m². The rear part of the cage is equipped with a door, which is closed after the sow is transferred

into the cage. A trough for sows and a drinker is placed in the front part of the pen and cage stall. The wall of the cage that forms one side of the pen is equipped with a sliding board (630×1300 mm, tilt angle 18°), which helps the sow lie down more easily and carefully. The board is placed at a height of 350 mm above the ground, which allows the piglets to escape. When the cage is opened and the sows can move freely around the pen, the piglets are protected from overlaying by two metal bars located in the opposite corner of the sliding board. The pen is equipped with a creep for piglets with an area of 0.8 m^2 . A trough, as well as a drinker, are placed in the front part of the pen next to the creep. A heated lamp providing adequate temperature comfort for piglets is embedded in the openable plastic cover of the creep. In front of the creep, there are three metal bars preventing the sows from entering the creep. The creep can be closed, which enables manipulation with the piglets. The floor in the farrowing pen is solid in the front part ($2/3$) and formed by concrete slats in the rear part ($1/3$). The creep, as well as the pen, was bedded. Dirtied straw was removed daily and replaced with new stock as needed. The sows were fixed in the cage from transfer to the farrowing house until three days after farrowing. On the fourth day, the cage was opened and the sow was free to move until weaning of the piglets.

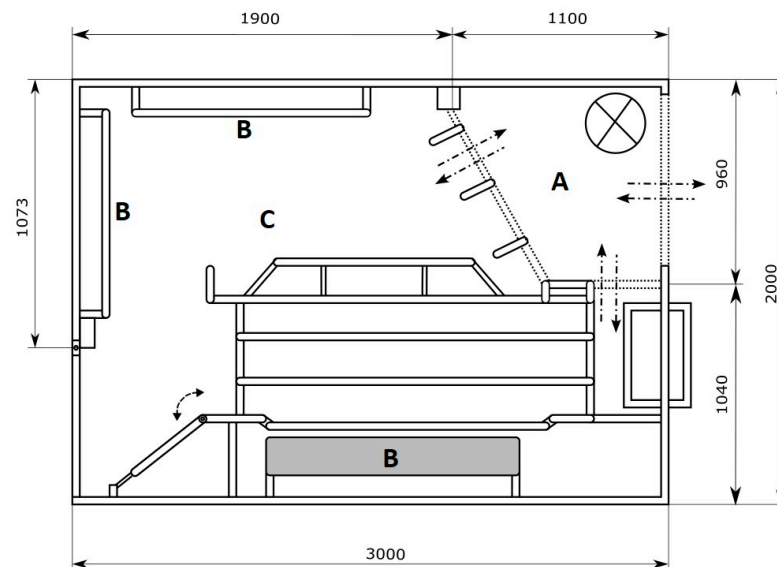


Figure 2. Combined housing system for farrowing and lactating sows. A = creep area, B = anti-crushing bars, C = common area.

The overall area of the free-farrowing pen (Figure 3) is 8.2 m^2 . It is an alternative farrowing system, where sows are free to move throughout their stay. This housing system consists of a nesting area of 4.3 m^2 . In this area, there is a creep for piglets, which is close to enabling manipulation with piglets. Over the creep, there is a plastic cover with an embedded heating lamp providing adequate thermal comfort. In front of the creep, there are two metal bars preventing the sow from entering the creep. The wall of the pen, which forms one side of the nesting area, is equipped with a sliding board (630×1800 mm, tilt angle 18°), which helps the sow lie down more easily and carefully. The board is placed at a height of 250 mm above the floor, which allows the piglets to escape. The floor of the creep and nesting area is solid (concrete). The creep and nesting areas were bedded. The dirtied straw was removed daily and replaced with new stock as needed. The area for nesting is detached from the common space used as a dunging area by a removable fence (height 200 mm) in the direction of the feed box and by a removable door in the direction of the sliding board. These features prevent the sows from entering the creep. The common area of 2.5 m^2 is slatted (dunging area). The pen includes a feeding box of 1.4 m^2 . The sow can be fixed in the feeding box. A trough for the sow as well as a drinker are in the front part of the feeding box next to the creep.

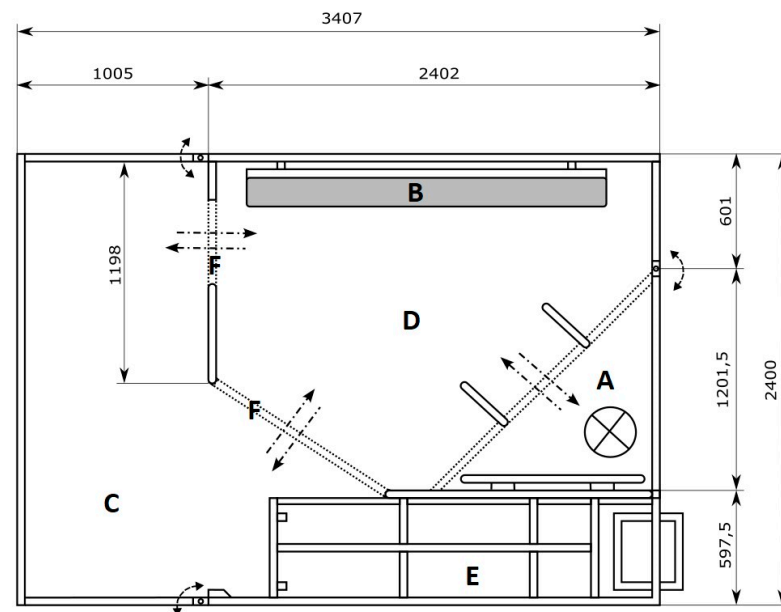


Figure 3. Free housing system for farrowing and lactating sows. A = creep area, B = anti-crushing bars, C = common area, D = nesting area, E = feeding box, F = removable fence.

In all the farrowing systems, feeding of piglets *ad libitum* with a commercial feeding mixture started on the 5th day after birth. Farrowing pens are equipped with nipple drinkers for piglets. Boars are castrated on the 5th day after birth. At the same time, a single dose of iron (Uniferon[®], Holbæk, Denmark) is applied intramuscularly into the neck muscle of all the piglets. No other vaccination or treatment procedures were carried out during the rearing of the piglets. Piglets were weaned at once at the age of 28 days.

2.3. Evaluated Parameters

After birth, the piglets were marked with individual numerical codes. In the tested farrowing systems, selected reproductive parameters were evaluated, namely the length of pregnancy, total number of piglets, number of live-born piglets, stillborn piglets, and reared piglets per litter, onset of post-weaning oestrus (days), and conception rate (%). The overall losses of piglets from birth to weaning were expressed as the difference between the number of live-born piglets and the number of reared piglets. The piglets were identified as crushed when expressing signs of traumatic injuries, bruises, and floor prints (assessed by the on-farm vet, every day at the same time). Losses marked as “others” included piglets lost due to causes different from crushing.

Evaluation of productive parameters in piglets included individual live weight (kg) from birth to weaning and subsequent assessment of their growth ability expressed as average daily gain (g/day). A digital hanging scale with an accuracy of 0.01 g was used for individual weighing of piglets carried out within 24 h after birth and then at weaning (on the 28th day). Average daily gain was calculated from initial and end weight in the monitored time interval.

2.4. Statistical Analysis

Data were analyzed in the SAS 9.1 software. The effect of the housing system was evaluated using a linear model (PROC GLM). The statistical significance of the factors was assessed based on the analysis of variance using TYPE I sum of squares.

The significance of differences ($p < 0.05$) between individual least mean squares (LMS) within the monitored housing systems was tested using the Tukey test.

The influence of monitored parameters was tested with the following model equation:

$$y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

y_{ij} —respected dependent variable;

μ —intercept;

α_i —effect of the housing i ($i = 1$: cage, $i = 2$: combined, $i = 3$: free);

ε_{ij} —residual error.

Data in tables are expressed as LSM and standard error of the mean (SEM).

3. Results

The results of the reproductive performance are presented in Table 1. In the cage technology, a total of 427 live-born piglets, 24 stillborn, and 396 reared piglets were found. In the pens with temporary confinement, 413 live-born, 35 stillborn, and 369 reared piglets were recorded. In the free housing system, 420 live-born, 28 stillborn, and 358 reared piglets were found. The housing system had a significant effect on the length of pregnancy ($p < 0.05$). Pregnancy of the sows housed in the free-farrowing system was 0.35 days shorter when compared to the cage technology and 0.6 days shorter when compared to the temporary confinement. The housing system also influenced the onset of post-weaning oestrus ($p < 0.01$); the sows stabled in free-farrowing technology and in pens with temporary confinement showed 0.31 days earlier onset of the estrus. A tendency of the highest conception rate was observed in the free-farrowing system, the lowest in the cage technology. Other reproductive parameters were not affected by the housing system.

Table 1. Effect of housing on selected reproductive parameters of sows.

Item	Cage	Combined	Free	SEM	<i>p</i> -Value
n litters	40	40	40		
Length of pregnancy (days)	115.10 ^a	115.35 ^a	114.75 ^b	0.10	0.044
Total number of piglets (pcs/litter)	11.28	11.20	11.20	0.27	0.991
Live-born piglets (pcs/litter)	10.68	10.33	10.50	0.24	0.845
Stillborn piglets (pcs/litter)	0.60	0.88	0.70	0.09	0.449
Reared piglets (pcs/litter)	9.90	9.23	8.95	0.24	0.249
Onset of oestrus (days)	5.15 ^b	4.83 ^a	4.84 ^a	0.05	0.008
Conception rate (%)	87.50	95.00	97.50	2.29	0.179

^{a,b} Mean values in the same line marked with a different superscript indicate statistical significance ($p \leq 0.05$). Mean values with no superscript are not significantly different from any other values. SEM, standard error of means.

Losses of piglets are presented in Table 2. A significant effect of housing on total losses of piglets ($p < 0.05$) was proven. The highest losses from the live-born piglets were recorded in the free-farrowing system, 13.57% (62 piglets). In the pens with temporary confinement, the losses reached 10.75% (44 piglets) and the lowest losses were found in cages, 7.54% (31 piglets). Crushing represented the most important cause of losses. The housing system was assessed as a statistically significant factor in losses of piglets due to crushing ($p < 0.05$), with the highest rate found in the free-farrowing system (54 piglets); 35 piglets were crushed in the temporary confinement system and the lowest rate of crushing was observed in the cage system (27 piglets). The results clearly show that most piglets are crushed during the first two days after birth. Differences between the technologies on individual days until weaning were not statistically significant.

Table 2. The effect of housing on losses of piglets.

Item	Cage	Combined	Free	SEM	<i>p</i> -Value
n litters	40	40	40		
Total losses	0.78 ^a	1.10 ^{ab}	1.55 ^b	0.12	0.036
Crushed					
Total	0.68 ^a	0.88 ^{ab}	1.35 ^b	0.10	0.020
Day 1	0.35	0.35	0.48	0.06	0.659
Day 2	0.15	0.30	0.38	0.04	0.106
Day 3	0.08	0.13	0.15	0.03	0.574
Day 4	0.05	0.03	0.10	0.02	0.352
Day 5	0.03	0.10	0.10	0.02	0.345
Day 6 and later	0.00	0.03	0.08	0.02	0.167
Losses—others	0.10	0.18	0.20	0.04	0.492

^{a,b} Mean values in the same line marked with a different superscript indicate statistical significance ($p \leq 0.05$). Mean values with no superscript are not significantly different from any other values. SEM, standard error of means.

Table 3 shows the growth parameters of piglets. The effect of housing of sows on individual weaning weight of piglets and average daily gain was statistically significant ($p < 0.001$). The piglets of sows housed in the free-farrowing system showed higher growth intensity when compared to the piglets in the other housing systems. The individual birth weight and birth weight of litter and weaning weight of litter were not affected by the housing system.

Table 3. Effect of housing on the growth ability of piglets.

Item	Cage	Combined	Free	SEM	<i>p</i> -Value
Individual birth weight (kg)	1.39	1.41	1.40	0.01	0.129
Birth weight of litter (kg)	14.79	14.58	14.74	0.35	0.968
Individual weaning weight (kg)	6.03 ^b	5.99 ^b	6.14 ^a	0.02	0.001
Weaning weight of litter (kg)	59.08	55.09	55.12	1.40	0.413
Average daily gain (g)	178.68 ^b	176.18 ^b	182.45 ^a	0.70	0.001

^{a,b} Mean values in the same line marked with a different superscript indicate statistical significance ($p \leq 0.05$). Mean values with no superscript are not significantly different from any other values. SEM, standard error of means.

4. Discussion

From the economical point of view, the most important reproductive parameters are the number of live-born piglets and, mainly, the number of reared piglets. The values of 15–16 live-born and 13–14 reared piglets per litter can be considered optimal in terms of competitiveness. However, such values are achieved in modern hybrid pig genotypes [4]. The numbers of live-born and reared piglets recorded in our study are lower since sows of purebred sows of the original Prestice Black-Pied breed were used for the evaluation. Lower values of the reproductive parameters correspond to the results of other authors who report worse results of reproductive performance in original breeds. Nevertheless, differences in the onset of post-weaning estrus or conception rate were not reported between original breeds and hybrid sows [17].

The housing system influenced some of the reproductive parameters. This study proved that the length of gravidity was shorter in the sows housed in a free-farrowing system in comparison with the fixed sows. Choi et al. [18] also found a tendency of shorter pregnancy in sows in free housing, specifically by 0.36 days in comparison with sows fixed in a cage. At the same time, these authors proved a significantly ($p < 0.05$) shorter duration of farrowing in sows in free housing, by 175 min. They attribute this trend to the possibility of moving freely and choose a place for farrowing, which may reduce the duration of farrowing. Calderón Díaz et al. [19] state that sows that were not fixed before and during farrowing showed higher physical activity, which can indirectly influence the length of pregnancy or farrowing duration. The use of straw in free-farrowing pens can also be

identified as a realistic possibility that could shorten the pregnancy length in sows since the material for nest building can stimulate the sow to earlier farrowing and thus shorten the pregnancy [20]. The results of our study indicate that parameters such as the number of live-born, stillborn, and reared piglets were not significantly affected by the housing system. The recorded values show that permanently fixed sows and temporarily fixed sows (5 days prior to 3 days after farrowing) reached a similar reproductive performance, which corresponds to the findings of other authors [21–23]. However, a tendential difference of 0.95 piglets was found in the number of reared piglets between the permanently fixed and freely housed sows, which shows that free movement shortly after farrowing can decrease the survival of piglets [11]. In the present study, a significantly faster onset of post-weaning oestrus was recorded in sows in the free-housing system and in temporarily fixed sows and, therefore, in sows that were free to move in the course of lactation. It implies that increased physical activity, which is higher in free housing systems than in permanent confinement [24,25], could cause faster onset of oestrus. It is known that the suckling of piglets has a strong inhibitory influence on ovarian activity; however, some studies state that the feeding system, season, and effect of boar as well as increased physical activity can influence the inhibitory effect [26,27]. Nevertheless, further studies need to be performed. It is worth noting that sows that were not permanently confined during lactation also showed a tendentially higher conception rate, which is difficult to explain, since it is known that the conception rate can be influenced among others by housing during early pregnancy, not during lactation [28].

The present study showed that crushing contributes the most to the losses of piglets. It was proven that the risk of losses due to crushing was the highest in the free housing system, which corresponds to most studies [9,11,13,26]. Higher losses found in the free housing system can be associated with free movement of the sows but also with larger nest space in general, where the sow can lie down unsupported and crush piglets [13]. For example, Hales et al. [21] reported that sows in a free-farrowing system showed more rolling activity. Rolling was identified as dangerous in relation to the crushing of piglets, mainly rolling from the ventral to the lateral lying position [26]. Another risk in the free-farrowing systems is a larger nesting area for piglets to wander while their temperature decreases when they are distant from heat sources [9]. That is why the nesting area of the free-farrowing pens in our study was equipped with a protective board at a height of 20 cm covering the nest so that the piglets could not move around the whole pen. It can be assumed that besides construction features preventing the overlaying of piglets, attention will also need to be focused on the selection of sows since maternal behavior was proven to be based genetically [29]. It will be necessary to pay more attention to temperament aggression but also behavior while lying down, the ability to respond to the sounds of piglets, and also to the mobility of sows [30,31]. The conclusions of this study also imply that the highest losses caused by crushing occur during the first two days of life and are the highest in the free-farrowing system, which is in accordance with most studies [32–34]. In general, piglets are considered to stay in close vicinity to the udder during the first 2–3 days after farrowing [33]. Being close to the udder provides piglets with warmth as well as attachment to individual teats, which can lead to better colostrum and subsequent milk intake, but also increases the risk of crushing by the sow [32,35]. This can be more pronounced when sows move freely.

As expected, the housing system did not influence the birth weight of piglets but piglets born in free housing reached a higher weaning weight as well as average daily gain. Similar differences, although not statistically significant, were presented by Choi et al. [16], who recorded a weaning weight of 8.71 kg (7.82 weaned piglets) in sows in a free-farrowing system and a weaning weight of 8.28 kg (8.09 weaned piglets) in fixed sows. The findings of the present study can be related to the fact that there were higher losses of piglets immediately after birth in the free-farrowing system, which led to an increased amount of milk for further growth of the surviving piglets. This trend was confirmed by Škorjanc et al. [36], who found a statistically significant ($p < 0.01$) negative correlation

between the number of live-born piglets and weaning weight of piglets and also between the number of weaned piglets and their weaning weight.

5. Conclusions

In conclusion, the housing of sows during farrowing and lactation influences some reproductive parameters, losses of piglets, and their growth intensity. The lowest losses of piglets due to crushing were found in the cage system. However, the combined system that enables confinement of the sow for as long as necessary, seems to be very perspective in terms of losses of piglets. It can be stated that the cage system was associated with the lowest losses caused by overlaying. Free housing of sows during farrowing increased the losses of piglets; however, this system was beneficial in terms of their pre-weaning growth.

Author Contributions: P.N. and E.W. conceived, designed, and performed the experiments; P.N., J.S., P.H., Z.H., A.L. and E.W. analyzed the data; P.N., E.W., M.R., A.L. and D.Č.K. contributed to analysis tools; P.N. wrote the paper. All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by the project of the MENDELU internal grant agency, Faculty of AgriSciences No. IGA24-AF-IP-052, and the NAZV Project No. QK23020085 of the Ministry of Agriculture of the Czech Republic.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available to preserve the privacy of the data.

Conflicts of Interest: The authors declare no conflicts of interest.

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