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SHORT COMMUNICATION



Effects of three different designed farrowing crates on neonatal piglets crushing: preliminary study

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ABSTRACT

In swine production, the economic gain in the farrowing room corresponds to the number of weaned piglets/sow per year. Pre-weaning mortality is at least 11–13% of total losses within one herd, considering a previous 7–8% of the stillbirths. Piglet crushing by the sow contributes significantly to the overall piglet mortality. It is caused by multiple factors related to the sow, the piglet and due to modern swine husbandry along the last 50 years. This study aimed to compare three different designs of farrowing crates during the first three days of life in relation to piglet-crushing mortality in intensive herd. One hundred fifty-eight sows with spontaneous deliveries were housed in the following farrowing crates groups: group A ($n = 51$) farrowing within conventional crates, group B ($n = 47$) farrowing within the slide cage and group C ($n = 60$) in the up and down designed, for a total of 2487 live born piglets. In the first three days of life, group C reported the lower crushing mortality rate (0.54%), while groups B and A reported 2.37% and 5.46%, respectively. The comparison between the group C value compared with group A values ($p < .001$; Chi-square = 36.90) and B ($p = .003$; Chi-square = 8.81) were statistically significant. In conclusion, the approach to create more space for both mother and litter within an acceptable size of farrowing crates (slide cage and up & down designed) allowed a significant reduction in mortality crushing rate of the piglets during the first three days of life.

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Piglet crushing; farrowing crate; neonatal mortality; sow

Introduction and materials and methods

The challenge in reducing piglets' mortality is a worldwide concern. It is a primary cause of decrease in productivity resulting in economic losses. Moreover, it certainly represents a growing welfare issue. Pre-weaning mortality is highest during farrowing and in the first days of the piglet's life (Marchant et al. 2000; Andersen et al. 2009). Pre-weaning mortality rate is strictly related to the management level of the considered farm and it is ranging between 11% and 13%, when including a previous 7–8% of losses due to stillbirths (Kirkden et al. 2013); these figures have been apparently stable during the last 20 years (Weary et al. 1998). As reported by previous studies, piglet crushing and starvation caused 50–80% of total piglet mortality in the farrowing room (Jarvis et al. 2005). The crushing usually occurs when the sow changes its position from up standing to the lying position, from a sternal decubitus to a lateral one and during rolling movements (Danholt et al. 2011). Sow restlessness is

an additional risk factor for piglets poorly viable and smaller, which are less reactive to the changes in position of the sow. High stress conditions for the sow are caused by natural behaviour suppression (Damm and Pedersen 2000) related to both the sow spatial/mobility restriction due to the farrowing crate and to the disturbance by workers in the farrowing units (Fangman and Amass 2007). The farrowing crate, which is widely use in modern pig husbandry, inhibits the sow's innate behaviour to build a nest before parturition. These restrictions generate a decrease in maternal endogenous hormones that could in turn lead to detrimental effects on farrowing and lactating performances (Jarvis et al. 2001). Nevertheless, crushing risk is due to piglets attempts to reach the teats, an instinct which is necessary for their survival, ensuring colostrum assumption and a heat source. Moreover, literature reported that the piglets' crushing rate is correlated with other reasons, such as the sow's age and parity or prolonged farrowing. The sow's

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temperament is important to evaluate and a high 'crushing attitude' is a reason for culling (Jarvis et al. 2005). Piglets born from long duration farrowing might be poorly viable within the first hours and therefore exposed to higher risks of crushing (Lay 2002). Even though the farrowing crates can include artificial nests with a comfort zone created by a red-light lamp, piglets spend the first days of life and especially the first 24 h closely to the sow (Danholt et al. 2011), attracted by tactile, thermal and olfactory stimuli (Vasdal et al. 2010). Pre-weaning mortality has continued to stand at around 10% for many years because of these complex interactions. Research focussed in the last years on innovative farrowing crates and new technologies to improve animal welfare and productivity with the mean target to reduce crushing rate and consequently piglets' mortality. This study aimed to compare the effects of three different designs of farrowing crates on piglet crushing-related mortality assessed during the first three days of piglets' life in intensive herd.

The study involved 158 pregnant sows (gilts were excluded from the study) and 2487 born alive piglets, all belonging to an intensive farrowing unit located in the Po Valley (Italy) within a commercial herd. The overall herd health status was classified as 'conventional' on the basis of the presence of *Mycoplasma hyopneumoniae* and *Porcine reproductive and respiratory syndrome virus* (PRRSV). The herd size was 2000 sows (Danish Breed genetics, Dan Bred International®, Denmark) in site one and it used a modern multisite production strategy ('one week batch farrowing system'), where weaned piglets moved to site two, 5 km apart from the site one. The herd management followed standard operating procedures (SOPs) for animal husbandry, vaccination, housing, cleaning and waste management and biosecurity measures. The farm was selected since it provided three types of farrowing crates in the farrowing rooms: conventional, slide cage (*Pig Evoslide*®-Evotek, Cremona-Italy) and an up and down (*Elevotek*®-Evotek, Cremona-Italy). Automatic and semiautomatic liquid feeding were administered to the sows during gestation and lactation, respectively. Room temperature was kept between 18 and 20 °C, with a negative pressure ventilation and the sows were housed on paper strips bedding. Except for the farrowing crate, all the animals were reared in the same condition. The study was performed between December 2016 and February 2017. After mating, sows were loose-housed on deep sawdust bedding in groups of 8–10 sows. During the observation period, five days before the expected farrowing date, each sow moved from the

pregnancy area to the farrowing unit in one of the three crate models, on the base of their parity, in order to obtain three homogeneous groups for this trait at the end of the trial. In this farm 10 conventional crates, eight slide cage crates and 10 up and down crates were available. The costs of the slide cage and up and down crates were increased by 15% and 50% respectively, in comparison to the conventional one. If the dam showed any sign of illness or behavioural problems during the observing period, the farrowing data were excluded from the study. Sows in group A ($n=51$) farrowed in the conventional crates, those in group B ($n=47$) in the slide cage crates, while those in group C ($n=60$) used up and down crates. Moreover, each sow and its litter could be moved to other crates at 5–7 days of lactation to allow the farrowing crate rotations, since according to the aim of the study data were recorded only during the first three days after farrowing. The three selected farrowing rooms within a barn contained 10 conventional crates, eight slide cage crates and 10 up and down, in each room the crates were positioned as two rows, faced each other from across an aisle of 1.25 m in wide. A negative pressure ventilation system in each room continuously removed air to the outside of the building at 6.8 m³/min. The conventional crates box (2700 × 1700 mm) contained a sow area (2100 × 600 mm) surrounded by solid metal dividers. The movements of the sow were limited by lateral anticrushing bars. The bars were intended to prevent the sow rolling suddenly onto her side (Figure 1). In each crate, a 0.5 × 1.5 m 'creep area' was present in front of the sow stall, floors was made by plastic-coated wire mesh. Heat lamps were placed either in the creep area at the right front corner of the crate or in the area on the right of the sow stall and consisted of a 250-W heat lamp suspended 69 cm above the crate floor. The slide cage box (2600 × 1800 mm) provided a sow area (1810 × 585 mm) equipped with a nest represented by a steel box of (400 × 500 mm) at a lower level and positioned behind the sow (Figure 2). In this crate, immediately after birth, the piglets can slide on an inclined plane, dropping in the nest. The inclined plane allowed the vital piglets to rise up and come back to the upper side immediately after farrowing and the lesser viable piglets are allowed to lie under the red lamp to warm themselves. The up and down crate (2700 × 1700 mm) was composed of a central area (2100 × 630 × 500 mm) for the sow and two lateral sides for the piglets (Figure 3), with anticrushing bars resembling those of a conventional crate. Through a mechanic sensor activated by the change of sow position from laying down to the four legs

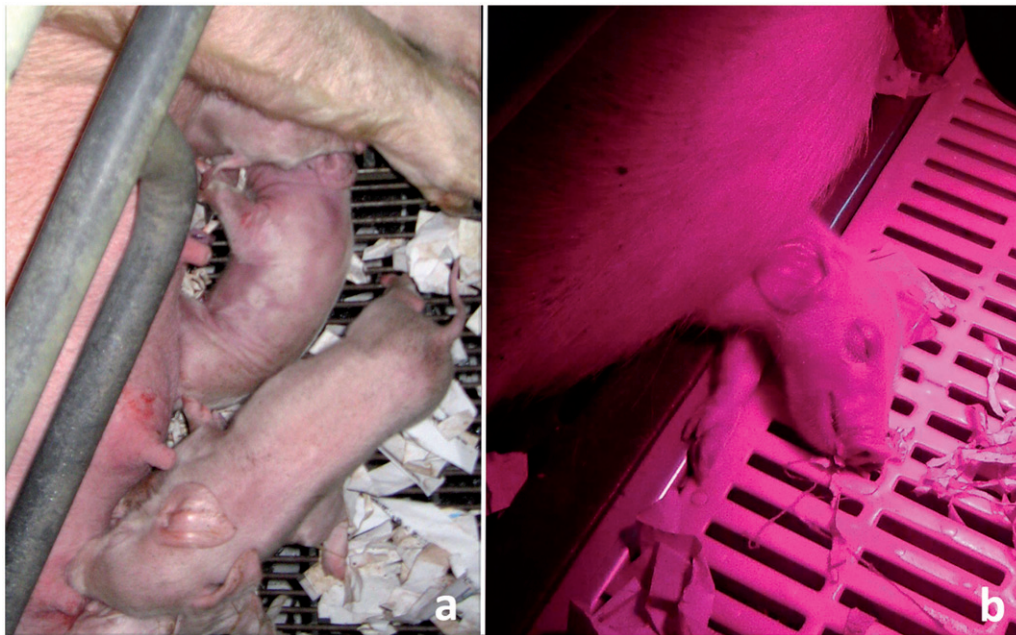


Figure 1. (a,b) Piglets found dead beneath the sow, within a conventional farrowing crate.

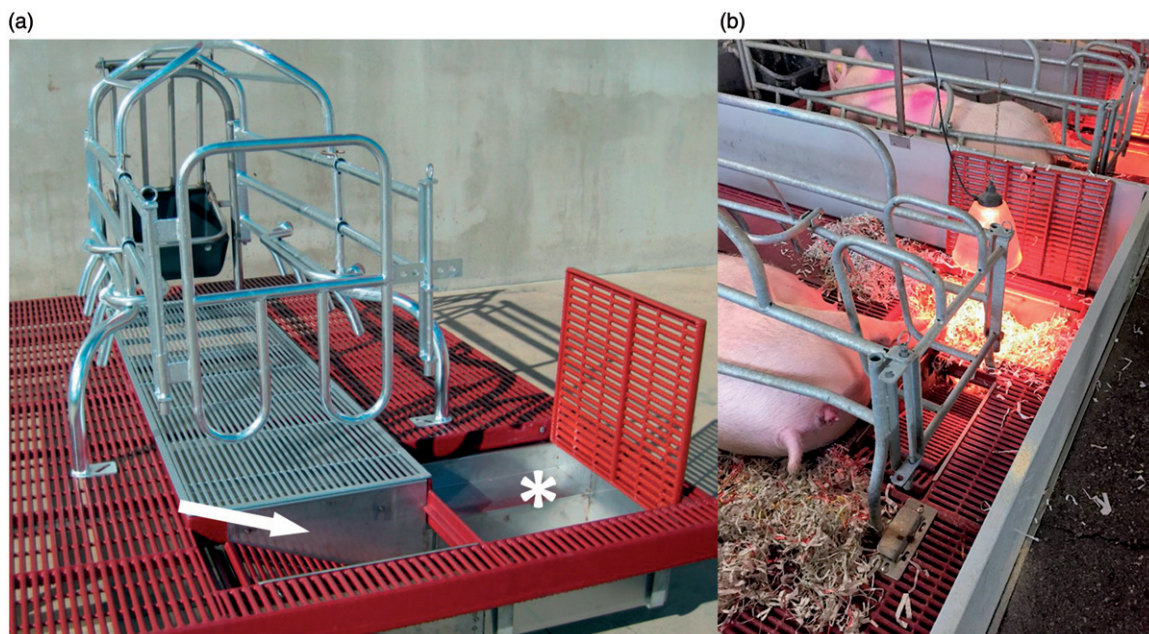


Figure 2. (a) An empty slide cage farrowing crate: the slide (white arrow) that allows the newborn piglets to outflow from the nest (asterisk), once is ready to suckling (b) farrowing unit: a pregnant sow housed in a slide cage farrowing crate with paper strips bedding.

standing, the central sow area raised up from the floor to a 20 cm higher plane using a motorised technology. The raising of the sow area allows piglets to stay in a lower level, with the impossibility to reach the mother. Conversely, when the sow from a standing position tries to lay down, reaching a safe position for the piglets, the mechanic sensor causes the sow platform to lower, letting the piglets to reach the teats. An individual data sheet including the farrowing date, parity,

number of live born, stillbirths and mummified piglets was collected for each sow. Trained veterinarians performed the post-mortem examination of each dead piglet to confirm the cause of death. Crushed piglets, stillbirths and mummified were identified as reported by Weary et al. (1998). During the three days after farrowing, the number and the cause of piglet death (crushing, starvation, diarrhoea, cannibalism or malformations) were recorded. Farrowing induction was not

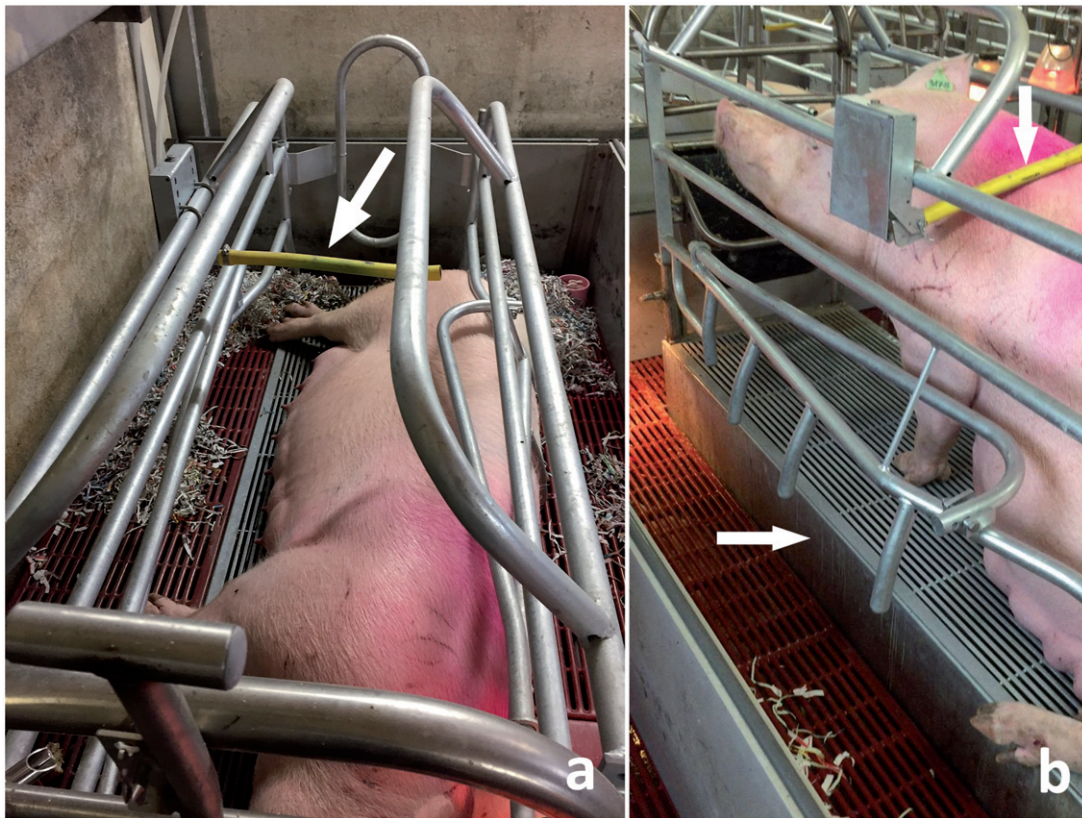


Figure 3. The up and down strategy: (a) when the sow lying down the yellow sensor (white arrow) is not active, the sow level is the floor level (b) when the sow standing up the yellow sensor is active and the sow is gently pushed up (20 cm) from the floor level.

adopted in accordance to the farm management and during the trial only spontaneous farrowing took place.

Statistical analysis

The statistical analyses were performed using the statistical software package SPSS for Windows Version 21 (IBM SPSS Inc., Chicago, IL). The differences between the parity order, the average number of live born piglets among groups were evaluated using the ANOVA procedure; the Bonferroni *post hoc* test was applied. To compare the differences and frequencies in piglet crushing mortality among the three groups of crate type, a Chi-square test with Yates correction was performed.

Results and discussion

Table 1 reports the number of dead piglets due to sow crushing in the groups. Stillbirths and mummified foetus were excluded from the statistical analysis. The group parity orders were not significantly different (Table 1). The average number of piglets born alive did not statistically differ between groups and the

overall average amount of piglets born alive was 15.74 ± 4.2 . In group A, 48 (5.46%) deaths out of 879 piglets born alive were caused by crushing, that was statistically different ($p = .003$; Chi-square = 8.50) compared to B (676 born alive piglets and 16 deaths, equal to 2.37%) and C groups (932 born alive piglets and 5 deaths). During the study, the conventional crates showed the worst performances in comparison to the up and down and the slide cage designed ones. In the litters within groups B and C, an important decrease in crushing rate during the observation period was registered. Considering the first three days of the piglet life, mortality by crushing was 0.54% in the litters delivered in up and down crates (group B). As reported in Table 1, also the slide cage reported a lower crushing rate than the conventional crate. Finally, the piglets crushing percentage observed in group C was statistically significantly lower in comparison with the one observed both in conventional (group A: 5.56%; $p < .001$, Chi-square = 36.90) and in the slide cage crates (group B: 2.37% $p = .03$; chi-square = 8.81). The results of the present study showed a decreased piglet crushing mortality within the first three days after birth if the farrowing room was equipped with modern farrowing crates (groups B

Table 1. Farrowing and piglet crushing mortality results obtained from delivery within three different types of farrowing crate during three days after farrowing.

	Group A (conventional) (n = 51)	Group B (slide cage) (n = 47)	Group C (up & down) (n = 60)	Overall (n = 158)
Sow parity order	3.39 ± 1.98	4.00 ± 2.05	4.08 ± 1.79	3.83 ± 1.94
Live born piglets (n.)	879	676	932	2487
Live born piglets/farrowing average ± SD	17.2 ± 2.5	14.4 ± 4.8	15.5 ± 4.5	15.74 ± 4.2
Crushing % (crushed piglets n.)	5.46 ^a (48)	2.37 ^b (16)	0.54 ^c (5)	2.79 (69)

^{a,b,c}The percentages differ significantly.

and C). This comparison demonstrated that the slide cage or up and down models could represent the optimal choice in a modern farrowing unit, without changing other managerial conditions. Considering our study design, we would underline that the parity among the groups did not differ statistically, and the data regarding gilts, that may be inexperienced mothers were not included in the study. In fact, literature is not univocal about sow parity related to piglet crushing (Ostovic et al. 2012). The gilts might crush less, since they are thin and short; otherwise, they change posture quickly and they could be not so good as mother. While, increasing with the parity, the sow could be more experienced but larger and heavier than piglets (250–300 kg vs. 500–800 g). Moreover, the individual behaviour is more related to the phenomena of piglet crushing than the parity order of the sow and the *Danish breed genetics* are notorious to show 'good' mothering. The choice to attempt the reduction of the piglet crushing by limiting the sow's postural movement occurred during 1960s by the conversion from free-range pens to conventional crates, which determined at first a decrease in the number of crushed piglets among the single litters (Jarvis et al. 2005; Ostovic et al. 2012). However, the crushing rate continued to contribute to the overall piglet mortality (Weary et al. 1998). Based on a commercial perspective, the advances in reproductive efficiency of semen doses, studies in innovative semen extender (Bresciani et al. 2012, 2014) and sow selection reaching elevate standards allow an elevated delivery number of piglets born alive, till 15–20 live born piglets as consequence of the potential reproductive efficiency of the sow (Bresciani et al. 2017). As reported in Table 1, the average density of the piglets (litter size) was slightly higher in the group A than others, but not statistically different among groups. Furthermore, overall average of piglets born alive was high (15.74), considering commonly ranges, which is also due to the sow genetic line chosen by the farmer. In our opinion, this feature represented an advantage to evaluate the rate of piglet crushing related to the different farrowing crates design. Otherwise, Pedersen et al. (2006) reported that

the increasing in total born/litter size determine only a minimal part (1.2%) of the total variation in the crushing percentage. The number of delivery considered in this study is not great, but the approach proposed in this trial might lead to improved sow performances, focussing on increasing farm productivity within pre-weaning period, which is considered very critical. The process of birth is the first area of concern in trying to decrease pre-weaning mortality and therefore the economic losses in the farrowing room. The first three days of observation were chosen in accordance with international literature, because approximately 50% of these pre-weaning death losses occur in this time (Lay 2002; Danholt et al. 2011). Since crushing mainly results from failure of the piglets to avoid the sow, it seems important to add data in a longer time of observation that takes also in account the lameness in the newborn piglets caused by incomplete crushing, the bearing injuries and their correlation with splay leg, congenital tremors, that reduce the ability to escape for physical reason. Moreover, the data about the sow length, the frequency of sow postural changes and piglet weight values should be considered. Further studies are necessary to improve the value of our consideration. The awareness on the losses caused by piglets crushing is rising again, both for economic reasons and animal welfare concerns, thus stimulating interests in development of new strategies for farrowing pens. Although the swine species has a peri-partum mortality dependent on its own native physiologic and ethologic features, certainly the use of a cage represent a stress factor that could increase stillbirth rate and episodes of aggressiveness towards the litter (Danholt et al. 2011). For these reasons, the projecting phase of new structures must consider both mother's and piglets' needs. The modern designed farrowing crates investigated in this study are designed to create a comfort area within an acceptable size for modern swine industry. Within the slide cage, considered as non-conventional crates, two steps let more vital piglets to come back on the upper side, immediately after farrowing. In this specific case, poorly viable piglets, which are warmed by red light lamps

positioned over the nest, have the possibility to restore after falling in the lower plane nest. Moreover, the heat loss taking place until the farm staff will move them back closer to the mother is prevented. In fact, less vital piglets delivered during not assisted farrows can wait up to 3 h before the first colostrum assumption (Andersen et al. 2009). During this elapsed time, heat loss with the consequent drop in body temperature can lead to death, considering also the energy consumption for competition within the litter (Andersen et al. 2009). While, smaller piglets, more susceptible to cold, will lie more closely to their dam to obtain warmth. Over the 24 hours from farrowing the sow postural changes – responsible for crushing – become more frequent. Thus, the process which leads to the attachment of piglets to the teats to obtain milk becomes more difficult (Lay 2002). The adoption of a facility that can quickly detect changes in position of the sow, permitting the piglets to stay in contact with the mother only when she is lying in lateral or sternal decubitus, revealed to be very effective in preventing the risk of crushing and lead in turn to a decrease in absolute and percentage death values compared to traditional crates.

Conclusions

In conclusion, the two types of tested crates represent an improvement compared to the conventional ones. Although it is impossible to fully eliminate this problem, modern structures in farrowing rooms with innovative technology can offer satisfactory solutions creating more comfortable space for the litter (the slide cage) or for the sow (up & down farrowing crate). Further studies focussing on the economic benefits related to the use of the described crates are addressed.

Disclosure statement

No potential conflict of interest was reported by the authors.

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