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Research Article

Do the Access to External Paddock in Collective Pen System Improve Sow and Piglets' Health and Performance?"

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Abstract

The use of individual gestational crates is responsible for the economic viability of swine production systems and contributes to improved productivity. However, these methods are associated with poor animal welfare. This can be improved using group housing throughout gestation and lactation. The use of collective pens has been studied, although little is known about the effects of access to external paddocks on health and performance during the reproductive and maternity phases. Therefore, the objective of this study was to compare the health and performance of lactating sows and suckling pigs housed in collective pens with and without access to external paddocks. Thirteen females were allocated to two housing treatments: collective pens with access, and collective pens without access to an external paddock. Animal health and performance were measured in pregnant and lactating sows, and sucking pigs. An independent t-test ($P < 0.05$) was used to analyze the data. For data that did not show a normal distribution, non-parametric analysis was used the Mann-Whitney test for comparison between the average pairs of treatments. The results indicated that the sows had increased weight during gestation, lost weight during lactation, and were not affected by the treatments ($P > 0.05$). The other parameters did not differ between the treatments ($P > 0.05$). In conclusion, sows housed in collective pens with access to external paddocks had proper and equivalent health indices and performance as their piglets, compared to the ones in collective pens without access to external paddocks, showing that this last system can also be a good option for the reproduction and maternity phases with no productive and health losses.

Keywords: Alternative Systems; Animal Production; Parasites; Weight Gain; Welfare

Abbreviations

BCS1: Body Condition Score at 42 Days of Gestation; BCS2: Body Condition Score at 111 Days of Gestation; BCS3: Body Condition Score at 30 Days of Lactation; BW: Birth Weight; CP: Collective Pens without Access to an External Paddock; CPE: Collective Pens with Access to an External Paddock; DW1: Daily Gain During Gestation; DW2 Daily Gain During Lactation; MT: Mortality; NM Number of Mummified Piglets; NPB: Total Number of Piglets Born; NPBW: Number of Piglets Born with Weight < 1000 kg; NS: Number of Stillborn Piglets; WW: Weaning Weight; W1: 42 Days of Gestation; W2: 111 Days of Gestation; W3: Weight at 30 Days of the Lactation;

Introduction

Pregnant sows are mostly housed in individual gestation crates in intensive farming systems during both the pregnancy and lactation periods of approximately 138 days. The individual gestation crates are ranked upside by side in corridors, with concrete partially slatted floors, with approximate dimensions of 1.32 m^2 in both pregnancy and 0.6 m wide by 2 m long in the gestation periods,

generating motion restriction [1]. The main objective of this system is to optimize economic and productive performance [2] with a high calving rate (92%) and high total number of piglets born [3]. Economic viability is dependent on the productivity indices of pregnant sows, which have a direct relationship with reproductive indices [4] and an inverse relationship with animal welfare [5,6].

The evaluation of domestic animals involves aspects related to installation, management, and the environment, such as water and food distribution, evidence of panting, possibility of movement, comfort around rest, ease of movement, relationship between animals, reproduction, temperature, ventilation, light, available space, floor type [7-9] and mortality and reproductive indices [10].

Production systems that present poor animal welfare must be redesigned as a whole, environmental enrichment tool or the system must be changed to alternative production systems [11] with feeding, sanitary management, and adequate stocking rates, providing space for animals to move freely [12].

According to previous studies, pregnant sows in industrial systems that use gestation crates because they cannot move around and do not have psychic challenges; they have a high level of stress and express stereotypical behaviour [13]. The stereotypes evaluated were sham chewing (when the sow had nothing in its mouth), tongue rolling, teeth grinding, bar/trough/drinker biting, floor licking [14], and poor welfare conditions [5,6,15,16].

In these systems, the sanitary aspects are also worrisome. A dirty pen during birth can generate a higher rate of urinary infection in sows [17]. Accumulation of excretions can cause urinary problems in sows because of the anatomical structure of the urinary tract [18,19] and the position of the vulva in relation to the source of infection [18].

Problems related to urinary infection and the participation of pathogens are the most important factors contributing to the decline in the performance of sows at this stage of production [20] (Moura., *et al*. 2018). Lactating sows with severe urinary infection reduce water and feed consumption, lose more weight, and consequently produce less milk [21]. The cost of treating urinary infections with antimicrobials for each sow is approximately US$ 4.18, but economic losses are higher, such as a higher rate of piglets born underweight and a higher rate of stillbirths [22].

The lactation phase is a critical period for sows and piglets, and new production systems that provide better welfare, such as the use of collective pens. The access to external paddocks is also important to provide similar natural environment, but require further investigation. The objective of this study was to compare the health indices and performance of sows and piglets from gestation to lactation phases housed in collective pens with and without access to an external paddock.

Materials and Methods

The study procedures were approved by the Ethics Committee on the Use of Animals, CEUA/FZEA-USP (no. 7148260116).

Local, animals and treatment

The study was carried out at pig farming of Fernando Costa Campus, Brazil (latitude 21º 57' 02"S, longitude 47º 27' 50"W). Meteorological data were obtained at the Fernando Costa Campus station, approximately 1,100 m from the pig farm (Table 1).

Months	Air temperature (°C)	Relative humidity (%)	Thermal sensation (°C)
November	24.1 ± 0,058231	56.3 ± 0,070555	24.6 ± 0,133409
December	24.0 ± 0,054791907	56.2 ± 0,073007	24.6 ± 0,131311
January	24.0 ± 0,05957	44.4 ± 0,081652	24.3 ± 0,151589
February	25.0 ± 0,063683	58 ± 0,077058	26.1 ± 0,144492
March	24.0 ± 0,058946	56.3 ± 0,085458	24.5 ± 0,133977

Table 1: Average, maximum and minimum values of meteorological variable during the study.

Eighteen sows in estrus (TopGen Afrodite® Lineage Large White x Landrace), from second calving orders, were served by natural mating, each six every two days. The pregnant sows remained in the paddocks of origin during first 39 d and then were housed in two treatments: nine in collective pens with (CPE) and nine without (CP) access to an external paddock. They were transferred according to the date of mating and kept in the same treatment until the end of the study.

The CPE treatments had three strawed pens (6.7 x 2.2 m, approximately 4.9 m^2 per sow), disregarding the feeder area. Every pen had nine individual feeders, with head barriers by 1,8 x 0,55 m, with a total area of 39,47 m^2. Water was freely available from nipples per pen. The internal part of the collective pens was kept with sugarcane bagasse bedding, 0.50 m deep, changed every 10 days, revolved, and turned daily.

The external area was 600 m^2 and surrounded by trees with vegetation and shallow mud puddles. Seven days before farrowing all bedding were removed, the collective pens were washed, and it was placed 1.0 m of sugarcane bagasse bedding and 2 kg of hay were added to the sows make their own nest.

The pens were kept with sugarcane bagasse bedding, 0.50 m deep, twisted and revolved twice a day and changed every 10 days, and three suspended iron chains as enriched object. Seven days before of farrowing all bedding was removed, the collective pens were washed, and it was placed 1.0 m of sugarcane bagasse bedding and 2 kg of hay were added as the sows could make their own nest.

The CP had three collective pens (6.0 x 5.0 m, totaling 30 m^2, with a minimum of 10 m^2 per sow), disregarding the area of the feeders. Each pen had nine individual feeders, without head barriers by 2.0 x 0.60 m, and three nipples per pen.

Pregnant sows were fed twice daily, at 5:30 a.m. and 6:30 p.m., with a commercial restricted-level feed (NRC, 2012). In addition, females housed in the paddock system had access to a pasture (*Brachiaria brizantha*). On the day after farrowing the feed was reduced to 2.5 kg/day/sow, after this the feed supply was gradually increased (0.5 kg/day/sow), so that by the 6th day after farrowing, the sow would be consuming 5 kg/day. From the 15th day after farrowing until the 30th day of maternity, the sows consumed approximately 7 kg/day of feed (Table 2). No specific rations were offered to the litters.

At 2-day old, piglets were weighed, had Australian marking identification, teeth cutting, vaccination for *Micoplasma hyopneumoniae* (RespiSure, Zoetis), iron dosages, and surgical castration of male piglets.

Health indices

The evaluation of the health indices met the criteria for the occurrence or non-occurrence of urinary infection and mastitis (Table 3). To make such an evaluation, an adaptation of the swine welfare protocols was made from the Welfare Quality and Humane Farm Animal Care [14,23]. Laboratory tests were not performed to confirm clinical signs. The scoring was based only on the occurrence of clinical signs.

	Gestation phase		Lactation phase	
Feed	**(%)**	**Quantity/kg**	**(%)**	**Quantity/kg**
Finely ground corn	59.50	148.75	64	160
Soybean meal	14	35	30	75
Soybean oil	-	-	3	7.50
Wheat bran	24	60	-	-
Commercial base mix	2.5	6.50	3	7.75
TOTAL	100	250	100	250

Table 2: Formulation of the ration offered for the sows housed in collective pen with and without access to external paddock during the gestation and lactation phases.

16.8% CP and 3.275% TDN in the gestation phase; 18.33% CP and 3,344% of TDN in the maternity phase. Mix composition gestation: Folic acid: 41.8 mg; Pantothenic acid: 482.2 mg; Biotin: 4.0 mg; Calcium: 261.2g; Copper: 4729.9 mg; Choline: 10.2g; Iron: 1155.8 mg; Gross fibre: 0,2g; Phytase20000 FTU: Phosphorus 33.9g; Iodine: 19.5 mg; Lysine: 5.0g; Manganese: 2544 mg; Mineral matter: 231g; Niacin: 803.9 MG; Brute protein: 5.9g; Selenium: 12 mg; Sodium: 63.2g; Humidity: 100g; Vitamin A: 4200000UI; Vitamin B1:101.9 mg; Vitamin B12:600 mcg; Vitamin B2:160 mg; Vitamin B6:62.7 mg; Vitamin D3:60000 IU; Vitamin E: 1200UI; Vitamin K3:61.2 mg; Zinc: 3854.7 mg. Mix composition lactation: Folic acid: 51.2 mg; Pantothenic acid: 590.6 mg; Amylase: 4800 U; Biotin: 4.9 mg; Calcium: 212.9 - 319.3 G; Copper: 4487.9 mg; Choline: 8352 mg; Iron: 1040.3 mg; Phytase 13200 FTU; Match: 41.4 G; Iodine: 17.6 mg; Lysine: 3.9 g; Manganese: 2289.6 mg; Niacin: 984 mg; Protease: 8400 U; Brute protein: 3.8 g; Selenium: 14.6 mg; Sodium: 41.2 g; Unit: 100 g; Vitamin A: 514 500 IU; Vitamin B1:124.9 mg; Vitamin B12:735 mcg; Vitamin B2:196 mg; Vitamin B6:76.9 mg; Vitamin D3:73500 iu; Vitamin E: 1470 IU; B12: Vitamin K3:75 mg;; Zinc: 3469.2 mg.

The sow's health indices were evaluated on six different dates during the study: four during gestation (42, 60, 90, and 111 days) and two during the lactation phase (15 and 30 days), at 6:30 p.m.

To evaluate the occurrence of respiratory problems, diarrhoea, and locomotor problems in suckling pigs the welfare protocols for swine was used [14,23] (Table 4). Faecal samples were collected randomly from ten piglets in each group from the rectal ampoule and the facility floor was observed. Evaluations were carried out during the lactation phase at 15 and 30 days of age, at 6:30 pm.

Rated criteria	Score
Coughing and/or sneezing	1- Half or more of piglets in the same pen are having respiratory problems.
	2 - Less than 30% of piglets in the same pen are having respiratory problems.
Diarrhea	1 - Half or more of the piglets in the same pen have diarrhoea.
	2 - Less than 30% of piglets in the same pen have diarrhoea.
Locomotor System	1 - Half or more of the piglets in the same pen have locomotor system problems.
	2 - Less than 30% of piglets in the same pen have locomotor system problems.

Table 4: Assessments of the occurrence of disease in suckling pigs housed in collective pens with and without access to external paddock.

Source: Adaptation of the Welfare Quality Protocols (2009) and Humane Farm Animal Care - HFAC (2013).

Faeces samples were packed in thermal box with ice and taken to the Multiuser Laboratory of Animal Health and Food Safety from Universidade of São Paulo (USP), Pirassununga-SP, to be carried out the parasitological analysis.

Coproparasitological examinations were carried out to detect nematode eggs (*Ascaris suum, Trichuris suis, Metastrongylus* spp., and *Strongyloides ransomi*), cysts, and oocysts of protozoa (*Eimeria* spp., *Cystoisospora suis*, and *Cryptosporidium* spp.) in the samples [24,25].

Performance measurement

Sow performance was determined using weight at 42 (W1) and 111 (W2) days of gestation, weight at 30 days of lactation (W3), daily gain during gestation (DW1) and lactation (DW2), body condition score at 42 days (BCS1) and 111 days of gestation (BCS2), and body condition score at 30 days of lactation (BCS3). Body condition score was evaluated according to the Humane Farm Animal Care protocol (HFAC) [23] (Table 5).

To the suckling pigs evaluation the parameters: total number of piglets born (NPB); Number of stillborn (NS); Number of mummified (NM); Number of piglets born with weight < 1000 kg (NPBW); Mortality (MT); Birth weight (BW); Weaning weight (WW) were determined.

Statistical analysis

A fully randomized design was used in the analysis. The system (collective pens with or without access to external paddocks) was used with a fixed effect using the t-test ($P < 0.05$) for comparison between the average pairs. When the data did not present a normal distribution, non-parametric analysis was performed using the Mann-Whitney U test for comparison between the average pairs of the two treatments. All data are presented as the mean ± SEM, and the analysis for this study was performed using SAS software, Version 2008 of the SAS System for Windows.

Score	Appearance	Condition
1	Extremely emaciated	Spine and hips quite prominent; emaciated flanks; apparent bone structure.
2	Emaciated	Rounded shape, but with emaciated flanks. Spine and hips easily perceived with pressure from the palm of the hand; A little prominent.
3	Normal	Rounded shape. Hips and spine only perceived with firm pressure from the palm of the hand; Not visible.
4	Fat	Hips and spine cannot be perceived; Base of the tail surrounded by fat. tendency to arch.
5	Obese	Spine and hips with thick layer of fat; Middle line only as a cavity between the round layers of fat.

Table 5: Evaluation of the body condition score of the pregnant and lactating sows housed in collective pens with and without access to external paddock.

Source: Humane Farm Animal Care - HFAC (2013).

Results and Discussion

There was no difference ($P > 0.05$) in the occurrence of diseases on pregnant sows (Table 6), lactating sows (Table 6), and suckling pigs (Table 7) housed in collective pens with and without access to the external paddock.

Parameters	Score	Collective pen		Probability
		CPE (%)	CP (%)	
Urinary infection	1	0.043 ± 0.042	0	0.97
	2	100 ± 0.042	100 ± 0.042	0.97
Mastitis	1	0	0	0.99
	2	100 ± 0.006	97.7 ± 0.022	0.99

Table 6: Average, standard errors of the scores of diseases of pregnant sows housed in collective pen with (CPE) and without (CP) access to the external paddock.

Performance	Collective pen		P<
	CPE	CP	
W1 (kg)	200.0 ± 28.50	210.25 ± 18.65	0.472
W2 (kg)	243.0 ± 22.73	273.25 ± 21.31	0.033
W3 (kg)	220.2 ± 37.37	249.5 ± 27.51	0.130
DW1 (kg/day)	0.59 ± 0.13	0.86 ± 0.38	0.099
DW2 (kg/day)	-0.63 ± 0.57	-0.67 ± 0.62	0.898
BCS1	3.28 ± 0.26	3.32 ± 0.19	0.739
BCS2	4.00 ± 0.22	4.01 ± 0.14	0.946
BCS3	3.54 ± 0.13	4.00 ± 0.17	0.156

Table 7: Means followed by standard error of performance in collective pen with (CPE) and without (CP) access to the external paddock.

W1: Weight at 42 days of gestation; W2: Weight to 111 days of gestation; W3: Weight at 30 days of lactation; ADG1: Daily average gain in the gestation stage; ADG2: Daily average gain in the farrowing stages phase; BCS1: Body Condition score at 42 days of gestation; BCS2: Body Condition score at 111 days of gestation and BCS 3: Body Condition score at 30 days of farrowing stages.

Variables	Average		P	Median		Maximum		Minimum	
	CPE	CP		CPE	CP	CPE	CP	CPE	CP
NPB	12.3	12.5	0.090	12	14	13	17	4	3
NS	0.8	1.0	0.642	1.0	1.0	1.0	2.0	0	0
NM	0.6	0.4	0.691	0	0	2.0	2.0	0	0
NPBW	0.2	0.4	0.668	0	0	0	2.0	0	0
MT	0.8	1.2	0.332	1.0	1.0	1.0	3.0	0	0
BWW (Kg)	1.5	1.6	0.890	1.6	1.7	2.0	2.5	0.95	1.05
WW (Kg)	9.2	9.5	0.840	9.2	10	16	12	3	5.5

Table 8: Mean, median, maximum, minimum and descriptive levels of probability of the corresponding non-parametric test Mann-Whitney for comparison between the average pairs of the performance in piglets with (CPE) and without (CP) access to external paddocks.

NPB = Total Number of Piglets Born; NS = Number of Stillborn; NM = Number of Mummified; NPBW = Number of Piglets born With Weight < 1000 kg; MT = Mortality Until Weaning; BW = Birth Weight; WW = Weaning Weight.

Sows in both treatment groups showed no signs of urinary infection or mastitis. In some cases, because of the constant contact of the pregnant or lactating sows' vulva with the faeces, confinement has a higher prevalence of urinary infection [26], and it is possible that even the sows without an external paddock were allocated to a place that did not have many pathogenic organisms, and the risk factors that could have a propensity for urinary infections in the farm were controlled.

The risk factors most related to urinary infections are: anatomical structure of the female urinary tract [17,18], vulva position in relation to the source of infection, quality and hygiene of the facilities, diseases of the locomotor system [18], quality and quantity of the ingested water [20], feed composition and management [18,27], parity order; control of pathogenic microorganisms in the pre and postpartum period and; parity duration, the possibility of urinary infections increases on farms where the frequency of prolonged births are high [19].

The non-mastitis incidence showed that the management practices adopted in the study and farm procedures were efficient control measures. The following should be highlighted as control measures against mastitis: hygiene of facilities and animals, use of

antibiotics and chemotherapy at birth, environmental corrections, and piglet teeth clipping [28].

Different results were found [29], where digestive problems and the MMA complex (mastitis, metritis, and agalactia) were the most common pathologies in outdoor sows; however, they had a lower incidence than those in the confined system.

In suckling pigs, there were no symptoms of the evaluated diseases, independent of the system applied ($P > 0.05$). The absence of signs of respiratory disease can be explained by the non-mixing of groups, small size of the lots in the group housing, low stocking of the group housing, low rates of air movement (ventilation), and ideal temperature and humidity for suckling pigs. Temperature and humidity influence other variables, such as microorganism survival and the concentration of gases and particulates in aerosols, which are influenced by differentiated sedimentation in relation to varied moisture levels [30].

The absence of diarrhoea showed a lower risk of contamination and transmission of infectious agents in group housing. The absence of locomotive problems may be correlated to the low crushing rate observed in group housing during the lactation phase. Similar results were found by [31], where suckling pigs raised in an outdoor system also showed no respiratory, locomotor, splay leg, or diarrhoea problems. In contrast, [27] a studding 663 piglets weaned from a confined system reported that only 32% of the animals did not present diarrhoea. The lower prevalence of diarrhoea in the outdoor system can be explained by the lower risk of contamination and transmission of infectious agents than in the intensive system.

No eggs of *Ascaris suum*, *Trichuris suis*, *Metastrongylus* spp., or *Strongyloides ransomi* were found in faecal samples collected from suckling pigs during the maternity phase. The conditions that favour the proliferation of these parasites are inadequate management of food and water supply, contact between animals of different ages, and lack of sanitary management [32].

As the health indices for different housing systems were similar for both sows and suckling pigs, and there was no evidence of sanitary problems, these may have not influenced the performance data.

From these results, it is possible to identify similarities in the performance of sows and suckling pigs housed in groups, regardless of access to the external paddock. Sows housed in collective pens with access to external paddocks had a lower weight at 111 d of gestation ($P < 0.05$). This difference may be related to the fact that sows lodged in the paddocks moved more than females lodged in the system without access to the paddock. However, body condition scores were similar ($P > 0.05$). Throughout pregnancy, sows should gain approximately 45 to 57 kg, and sows with a birth order ≥ 1 should gain approximately 34 to 45 kg [33-35], which was confirmed in the present study, when in the external paddock.

There were no significant differences between treatments in relation to maternal weight gain in the maternity phase ($P > 0.05$), weight gain during gestation, or weight loss from parturition to weaning ($P < 0.05$). Other studies using alternative materials have reported similar results [36,37]. It was also found that the females who gained the most weight during pregnancy had the greatest weight loss during lactation, which agrees with the results of other studies [38].

Regarding the body condition score, it was observed in both treatments that the sows at the beginning of gestation and a score of 3 and at the end of gestation the score was 4. Studies have shown that in the second and third stages of gestation, the sow body condition score ranges from 3 to 4 [23,39], and in the maternity phase, it ranges from 2 to 3 [23]. Although collective housing systems may interfere with the reproductive performance of sows owing to disputes regarding food consumption [12], in our study, the system did not interfere with reproductive or productive performance [40,41].

There were no significant differences in suckling pig performance between treatments ($P > 0.05$). In relation to other studies, it was observed that the average number of suckling pigs born was higher than in other studies [42]. The weight of suckling pigs at weaning was superior to those in studies with maternity in gestation crates with environmental improvements, such as inclusion of mats for suckling pigs and access to paddocks for the sow and its bedding [37], lateral opening and curtain management [43], or group housing during gestation [13].

The stillborn and mummified indices in this study were higher than those found in other studies of sows housed in groups [13,43]. This may be related to the fact that the sows on the farm where the experiment was performed were housed in group housing before 28 days of gestation, which may have led to an increase in physiological stress in the initial third of gestation and, consequently, some problems in reproductive management, such as increased return to oestrus and abortion rates, and reduced numbers of live-born suckling pigs [8,44].

Females housed in group housing during the first month of gestation were 3.2 times more likely to present early embryonic losses than those that remained in gestation crates during the same period. The worst reproductive performance was observed in properties where females were housed between the first and second weeks after insemination [12].

In the present study, among the registered deaths, most of the suckling pigs in the CPE system died by crushing (77.8%) or other causes (22.2%). All the CP-suckling pigs died after crushing. These results are consistent with other studies that claim that the most common causes of mortality in outdoor suckling pigs are crushing and starvation, accounting for 86% of all causes of mortality [45].

The average mortality in the present study is very promising, around 1%, when compared to a confined system, which indicates mortality of 10.1%, with a variation of 7 to 13% [29] which was lower compared to values between 7.4% and 8.5% for suckling pigs housed in open farrowing stages with access to paddock [37,46]. Furthermore, the number of born suckling pigs and weight on weaning were higher than those in other studies with cage systems and housed groups [47].

In alternative maternities with access to paddock, suckling pigs have more environmental challenges as greater contact with cold air streams and microorganisms and structural ones as absence of protective iron grids on the sides, which may favor more crushing deaths) [48], however, in the present study, mortality until weaning was very low.

Conclusion

Collective pens with and without access to the external paddocks of sows and suckling piglets can be alternative systems for the reproduction and maternity phases with no productive losses. Both had adequate and equivalent performance, with no health problems, as they did not influence the occurrence of disease or parasitic infections. Further studies are needed to assess welfare and behavior of these animals.

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Conflict of Interest

None.

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