Suckling hierarchy and performance of piglets in the farrowing phase with artificial ventilation and roof sprinkles

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Abstract

The hierarchy between pigs occurs in the first days after birth and can be influenced by the sequence in which piglets breastfeed on teats. This study aimed to evaluate whether the artificial ventilation and roof sprinklers causes hierarchical changes in feeding and weight gain of piglets. The study was conducted at a farrowing unit with 26 individual stalls, half of them with fans and roof sprinklers. Twenty-six females and 281 piglets, of second birth order, with weaning at 21 days were evaluated. The piglets were numbered and distributed in weight categories. The teats were delimited on the left and right sides, forming classes. The recording of the teats where the piglets breastfed and the disputes were carried out from the second day of birth to weaning, three times a week, in two daily evaluations. The imposition of the hierarchy was attributed to the registration of agonistic behaviors among the piglets, identifying the sender, receiver, the type of behavior performed by the aggressor and the counter-reaction of the victim. Higher means of seeking teats were found in the intermediate, upper and lower classifications, with no statistical difference between environments and periods of the day. In the establishment of the hierarchy, no strictly dominant, intermediate or subordinate animal was found. Piglets classified as heavier at birth were heavier at weaning in both environments evaluated. It was concluded that the sequence of piglets in the mammary gland influences the weight gain of pigs at the end of the farrowing phase.

Introduction

The swine species has its thermal and social comfort impaired by intensive confinement, determined by the restriction of movement and interactions resulting from the reduction of available space (PUTTEN, 1989). In heat stress, pigs use physiological mechanisms as panting to reduce body temperature (SARUBBI, 2009), presenting changes in maternal posture and conduct, together with feeding behavior, responsible for reducing the performance of female pigs and their litters (QUINIOU and NOBLET, 1999; RENAUDEAU and NOBLET, 2001; RENAUDEAU et al., 2003).

According to Martins (2006) at high temperatures, the sow in the farrowing unit changes its suckling behavior, which remains decreased, as a result of the increase in the prone and sitting positions, reducing the milk production by the female due to less stimulation by the piglets and the feeding time. According to Ferreira (2005), breeders exposed to 32°C present a 25% reduction in their milk production, with lower weight results of their litters. For Cabrera (2001), female food consumption can be reduced by 40%, generating a reduction in the thickness of the backfat, an increase in the weaning and heat interval, with a loss of 30% of milk production, reducing the size of the litter and the lactation period.

The farrowing phase presents specific thermal needs for piglets and sows, since piglets need higher temperatures when compared to sows, becoming a challenge for production (TOLON and NAAS, 2005). Seeking to improve the ambience of the facilities, the use of physical environmental enrichments such as ventilation and nebulization reduces stress, increasing reproductive rates, restricting behavioral disorders and pig mortality (CARLSTEAD and SHEPHERDSON, 2000).

Sows have a characteristic behavior in relation to their piglets, marked, especially, by suckling that occurs at regular intervals of 45 to 50 minutes, with initial and successive vocalizations emitted by the breeders and massages of the mammary gland by the piglets after milk ejection (ALGERS, 1993). In the first minutes after birth, piglets go to the teats to ingest the colostrum, generating aggressive initial disputes by hierarchy. Within one week, piglets choose one or two teats in the mammary gland, where new disputes will hardly be observed (HARTSOCK and GRAVES, 1976; ROSILLON-WARNIER and PAQUAY, 1984).

Studies involving the formation of order by the teats in the mammary gland were conducted in order to evaluate its stability and determine its relationship with weight gain and dominance hierarchy. Harstock and Graves (1976) and Scheel et al. (1977), who stated that since birth, disputes were observed to obtain the front teats. Harstock et al. (1977) indicated the time for the definition of the teat on the mammary gland. However, it is necessary to evaluate whether these particularities change in environments with air conditioning from fans and water sprinklers, with temperatures close to the thermal comfort of the pigs and determine the relationship of these changes with the weight gain of the animals.

Therefore, this study was conducted in order to evaluate whether there are hierarchical changes in the feeding of piglets housed in environments with access to artificial ventilation and roof sprinkles in tropical conditions and the interference of these changes in the weight gain of the animals.

Material And Methods

The study was conducted at the farrowing facilities of the Swine Sector of the Fernando Costa campus city hall, at the University of São Paulo, Fernando Costa Campus, in Pirassununga, São Paulo. The site is at an altitude of 340 meters, south latitude of 21°80'00" and west longitude of 47°25'42", a Cwa climate with average annual temperatures of at least 13 and at most 31°C, according to Koppen (2011). This study was approved by the Ethics Committee on the Use of Animals CEUA Nº. 3758260116 of FZEA/USP.

The system used was semi-confinement in individual stalls for females and their litter, measuring 1.80 m wide, 4.20 m long, without cages, cemented floor with bed of sugarcane bagasse, an anti-crushing grid measuring 3.20 m long, drinking fountains for females and piglets and trough-type feeder for piglets and concrete ones for females. The 26 stalls included pens with a lamp to heat the piglets, separated from the stall by a 1.65 m high wall that allows access only to the piglets from an opening of 0.5 m high and 0.3 wide. In the stalls there were two hanging chains used as environmental enrichment for both ages (females and piglets).

The installation had a ceiling height of 2.70 m, a roof consisting of Marseille tiles and wood and concrete floor. The farrowing unit was divided into fan + sprinklers and control areas. In half of the experimental stalls three-propeller fans of the brand Ventisol of 60 cm were installed, with power of 1/5CV – 147W; and a maximum 1200 rpm. A fan was used for each two females and their respective litters at a height of 1.80 m from the floor, fixed on the pillar and a sprinkler/pulse irrigator with a TRAPP - DY-1013 rod for

irrigation of water on the roof, fixed on the wall so that the water covered the entire roof, with one sprinkler used for each three females (stalls). The equipment was turned on at 6 am and turned off at 5 pm, remaining on continuously throughout the day. The control area consisted of stalls with a bed of sugarcane bagasse, environmental enrichments and the same physical structure of the fan + sprinklers area, but without the presence of fans and water sprinklers on the roof. Both environments had pens where the lamps remained on for the piglets throughout the day experimental period.

The facilities were separated by plastic canvas as a way to separate the environments, with a distance of 1.5 meters between treatments, preventing the circulation of air from the fans and humidity for the control treatment. The internal temperature in the control environment at 7 am was 23.7°C ± 0.64 with humidity of 74% ±1.64 and 26.2°C ± 1.23 at 1 pm with humidity of 70.4%± 1.68. In the fan + sprinklers environment, at 7 am the ambient temperature found was 21.1°C ± 0.66 with humidity of 81.9%±1.66 and at 23.5°C ± 0.85 at 1 pm with humidity of 85.7%±1.34.

Twenty-six females, F1, Landrace x Large White, of second birth order and their respective litters were used, totaling 281 piglets, 154 females and 127 males, with weaning at twenty-one days.

Nutritional management was performed in the morning and afternoon for females and piglets, with 7 kg per day for females and with progressive increase for piglets, starting with 200 grams in the first week and 500 g in the week of weaning.

On the second day after birth, piglets conventionally undergo routine practices, such as castration of males, tooth grinding, docking, Australian massaging and iron application. At this moment, the piglets were numbered with Arabic numerals using a non-toxic pen, in order of sex and weight, always starting with the heaviest males, followed by the lightest males, heaviest females and finally the lightest females. The animals were distributed in the following classes according to the average weight of the piglets at birth: light (≤ 1.36kg); medium (1.37 to 2.13kg) and heavy (> 2.14kg). Piglets were weighed at birth and three times a week until weaning and females at the entry of the farrowing phase (7 days before delivery) and at 21 days postpartum.

The litters were organized with 14 piglets. For the analysis of the hierarchy of piglets in the mammary gland, the total number of teats of each sow was obtained first. The minimum number of pairs found were seven and a maximum of nine. Sequentially, a classification was established for the location of the teats in the gland, in the craniocaudal direction, always initiated by the left side followed by the right side. The teats were numbered from 1 to 9 on the left side and from 10 to 18 on the right side. If there were no teats to follow the numbering, the digits remained in the sequence, following the classification described for the side of the gland (Fig. 1).

The registration of the teats where the piglets breastfed and the dispute for hierarchy was carried out from the second day of birth to weaning, three times a week, with one observation in the morning and another in the afternoon, by direct focal observation, in a strategic position, seeking less interference in suckling, performed by two observers previously trained for this function. The indication of the location of

the teat where the piglet breastfed and the presentation of the behaviors were evaluated according to the side that the female remained in lateral decubitus position for suckling. Therefore, if she was lying on the left side, the observation and marking of the teat began at 1, if she was on the left side, it began at 10, always following the classification.

The classification into dominant, intermediate and subordinate was carried out by sow, aggregating different nomenclatures for males and females in relation to the weight category. Male piglets were defined by Arabic numerals, starting with the heaviest to the lightest, and females by capital letters, in the same order of weight. The imposition of the hierarchy was attributed to the registration of the occurrences of agonistic behaviors among the piglets, by direct observation with a sampling route of the behavior (MARTIN and BATESON, 1993), in a specific ethogram for the registration. For each agonistic interaction, the sender, receiver, the type of behavior performed by the aggressor and the counter-reaction of the victim were identified.

The record of the behavior performed during the imposition and definition of the suckling hierarchy was obtained concomitantly with the observation of the location of the animal to the classified teat, using collection routes by the direct focal method and continuous or instantaneous recording, according to the observed behavior (MARTIN and BATESON, 1993).

The evaluation of the hierarchy of piglets in the mammary gland was based on the occurrences of agonistic interactions observed between the piglets during the first stage of the study. The binary matrix of dominance was constructed based on the occurrences of agonistic interactions identifying the individuals of the lines that dominate individuals of the columns (DE VRIES, 1995). Based on the number of circular triads (d), the Kendall consistency coefficient (K) was used to test the linearity of the dominance relationships, which should be significantly stronger than expected, in an attempt to organize individuals into a linear hierarchy (APPLEBY, 1983; DE VRIES, 1998). For the division into three levels of hierarchy, a methodology adapted from (ECCLES and SHACKLETON, 1986 adapted from SOARES, 2015) three levels of hierarchy (dominant, intermediate, subordinate) was used, using fourteen animals per litter. Data were analyzed by variance with fixed effects of treatment (fan + sprinklers or control), time of day (morning or afternoon), sex (male and female), weight category and their interactions. For the significant effects, the means were compared by t test at 5%.

Results

The period was included as a fixed effect, but as there was no effect on any parameter, it was removed from the analysis. Among the parameters evaluated, none interacted ($P > 0.05$).

Regarding the disputes over the position in the teats available in the mammary gland, 127 occurrences were observed in the control environment and 85 in the fan + sprinklers environment over the three weeks of evaluations ($P \geq 0.05$). However, even with the greater number of fights in the control environment, the number of fights did not differ between environment, week and periods of the day ($P \geq 0.05$).

The continuity of fights for preferred teats over the weeks until weaning is related to the dispute for the same class of teats for piglets. The teats classified as superior, usually preferred by piglets with higher weight, in this study, were less disputed by piglets classified as heavy than piglets considered as medium and light ($P \leq 0.05$). Medium and light piglets were in the upper teats at similar frequencies ($P \geq 0.05$), Table 1.

Table 1
Preferences for the teats in the mammary gland for the piglets according to the weight category

Teat Class	Piglet weight category								
	Light			Medium			Heavy		
	Event	EL	%	Event	EL	%	Event	EL	%
Upper	74.5Ab	5.3	27	65.5Ab	4.6	27.8	26Bb	1.8	21.1
Median	144Aa	10.2	52.4	129.5Aa	9.2	53.9	75Ba	5.3	60.3
Lower	56Ab	3.9	20.4	44Ac	2.1	18.2	23Bb	1.6	18.5

*EL- Event per piglet. [a,b,c A,B] Different capital letters in the row and different lowercase letters in the column, for the same characteristic, differ by Student's T test at 5%

In relation to the hierarchy of piglets in relation to the classification as dominant, intermediate and subordinate, sex had no influence on the definition ($P \geq 0.05$), with females found among the dominant and suckling on teats demarcated as superior. However, the weight of the piglets was the hierarchical determination factor, since there was variation in the weight range of males and females ($P \leq 0.05$), Table 2.

Table 2
Demonstration of piglets classified as dominant, intermediate and subordinate in relation to sex and average birth weight in the competition for teats in the mammary gland

Classification	Piglet	Sex	Average weight (SD)	Weight
Dominant	1	Male	2.07	0.29
	3	Male	1.71	0.29
	D	Female	1.68	0.29
	4	Male	1.61	0.32
	B	Female	1.9	0.30
Intermediate	C	Female	1.71	0.34
	G	Female	1.14	0.24
	5	Male	1.49	0.40
	E	Female	1.55	0.32
	F	Female	1.33	0.22
	2	Male	1.9	0.35
Subordinate	A	Female	2.08	0.34
	6	Male	1.38	0.28
	7	Male	1.27	0.10
SD* Standard Deviation; Letters represent females and numbers represent males.				

In this study, it was observed that piglets classified as heavy competed for dominance, allowing medium and light animals to have access to teats classified as superior. Thus, heavy piglets were found in the intermediate and subordinate categories, and this number is related to the number of dominants within each litter. However, at weaning, heavy animals were animals with higher weight, compared to intermediate and subordinate animals, indicating that over the course of the twenty-one days, the largest returned to the teats initially breastfed, removing the smallest from the upper teats.

In the comparison between the control and fan + sprinklers environments, for light and heavy piglets, statistical differences were found between the treatments ($P \leq 0.05$).

In the fan + sprinklers environment, average piglets presented higher average weight in relation to light and heavy one higher average weight in relation to medium and light ones ($P \geq 0.01$). In the control environment, piglets of the light, medium and heavy categories gained different weights over the twenty-one days, where the heaviest were found in the heavy category ($P \geq 0.01$), Table 3.

Table 3
Weaning weight according to the categories defined at birth in the evaluated environments

Environment	Weight category in Kg		
	Light	Medium	Heavy
Control	4.21 ± 0.087Aa	5.32 ± 0.055Ba	6.56 ± 0.090Cb
fan + sprinklers	3.87 ± 0.089Bb	5.68 ± 0.058Ba	7.22 ± 0.103Ca

f[a,b A,B,C] Different uppercase letters in the row and different lowercase letters in the column differ from each other by Test t at 5%.

Light piglets presented lower weight at weaning in the fan + sprinklers environment when compared to the control environment ($P \leq 0.05$).

Discussion

During suckling, piglets have a preference for pectoral mammary glands, especially because their milk contains higher protein contents, especially colostrum immunoglobulins, which contribute to higher quality passive immunity, in addition to other proteins that improve the intestinal development of piglets (WU et al. 2010), as well as sugars and fat. They also have more flaccid and longer teats, which assist in suckling, followed by the abdominal teats and finally the teats of the inguinal region of the mammary gland (CASTRO and MURGAS, 2015). Also, the upper teats provide a more comfortable position for suckling in relation to the posterior glands, making them more disputed (GILL and THOMSON, 1956; HEMSWORTH et al. 1976).

According to Mores et al. (1998), because they are smarter and stronger, heavier piglets naturally fixate on the pectoral mammary glands, the intermediate piglets remain in the abdominal teats, and the smaller and weaker piglets are located at teats in the inguinal region of the mammary gland. In this study, the upper teats were disputed by dominant, intermediate and subordinate piglets, however, the median and lower teats were constantly disputed, especially in the first days, before the imposition of the hierarchy.

The teats classified as medians were widely disputed by piglets of all weights and this may be related to the occupation of the upper and lower teats, the type of teat (flaccid) available and the high number of disputes between the heavy animals. In their study, Furtado et al. (2009), found that the first three pairs of teats (upper) were the most sought after, with 18.6%, 17.7% and 18.2% for pair one, two and three, respectively and 70.7% of piglets breastfed in the first four pairs, corroborating the results of Kim et al. (2000) who described that 60% of piglets suckled on these teats. According to Algers (1993), in an attempt to breastfeed on another teat, the piglet may lose its place in the mammary gland, starting new fights due to the territorial behavior of the piglets before the teats (HARTSOCK and GRAVES, 1976).

In this study, females and males presented as dominant, intermediate and subordinate, indicating that sex had no influence during the disputes by hierarchy. Ishiwata et al. (2002) stated that the number of aggressions in weaned piglets of the same sex at 28 days is higher in relation to the opposite sex, and thus it can be observed that animals of the same sex have a higher frequency of fights when housed in groups. Colson et al. (2006a) observed the same correlation. However, they described that there is an increase in agonistic events, possibly determined by social instability caused by the presence of the opposite sex at weaning.

Weaker (light) piglets are more susceptible, representing around 65% of the total losses of the farrowing phase (FERREIRA et al. 2005). The order in which piglets breastfeed in the mammary gland interferes with the development of piglets, due to the variation in the milk production of each mammary gland, as the main condition that contributes to the variation in weight at weaning of piglets (FRASER et al. 1979; FRASER and JONES, 1975; HARTSOCK et al. 1976; ROSILLON-WARNIER and PAQUAY, 1984). In their study, Furtado et al. (2009), found that piglets at birth with average weight at (1.59 ± 0.17 kg) and high weight (1.93 ± 0.21 kg) that suckled in pairs classified as five, six and seven exhibited lower weight (5420 ± 1130 g, 5900 ± 1110 g, respectively) at weaning, at 21 days of age, compared to piglets that suckled in pairs one (6660 ± 1100 g, 7400 ± 1130 g, respectively), two, three and four (6140 ± 1120, 6600 ± 1200 g, respectively). In this study, heavier animals remained larger at weaning compared to intermediate and light animals, respectively. It is indicated that the time breastfed in the upper teats by the intermediate and light piglets was not enough to make them heavier at weaning or that there is an influence of the development of the piglets throughout pregnancy, in relation to piglets born with higher weights. Piglets that are born larger tend to be heavier at weaning since in the dispute for teats they have greater ability and possibility of suckling in teats where milk production is higher, as well as their intake.

The temperature of the thermal comfort zone of the female pig is between 16 and 24°C and that of the neonate piglet in the farrowing phase between 32 and 34°C (BORTOLOZZO et al. 2011). In this study, the pen was used with an exclusive area for the piglets. However, probably due to the presence sugarcane bagasse bedding in the cemented stall where the female remained and the presence of the mother, it was observed that the piglets settled close to her, which may have brought colder to the light piglets in the fan + sprinklers environment and increased mortality due to crushing by the sows Hypothermia is among the main causes of mortality in newborn piglets (ENGLISH, 1998). In thermal stress caused by cold, even when suckling, piglets may have hypoglycemia and the use of pens is essential to maintain heat for this stage of creation. In this study, light piglets had lower weight at weaning in the fan + sprinklers environment when compared to the control environment, which is related to the greater body surface area of piglets exposed to comfort temperature for females, which is lower for medium and heavy piglets, which have less body surface area exposed to the environment, maintaining their body temperature.

The insertion of fans and roof sprinklers are simple and practical techniques that provide comfort to pigs, even in facilities that do not meet minimum thermal comfort requirements for the species. Dela Ricci et al. (2018) evaluated the behavior of female pigs of different birth orders in the farrowing phase in environments enriched with fans and water sprinklers in the summer concluded that this type of physical

environmental enrichment brings important benefits to welfare due to the reduction of negative behaviors improving the quality of life in the farrowing phase. In this study, environments enriched with fans and water sprinklers on the roof improved the comfort of females due to the lower temperature and the presence of water in the environment, which became an attraction in the hottest times of the day. In the control environment, an important factor of heat loss was the wet area resulting from the cleaning of waste and water from the drinking fountains. These factors allowed the exchange of heat by females by evaporation and mainly by conduction, causing similar weight loss in both environments.

It was demonstrated that larger piglets spent part of the suckling period disputing their position in the mammary gland with other piglets of the same classification, allowing intermediate and medium animals to breastfeed in upper teats. However, heavy piglets returned to the upper teats, presenting greater weight at weaning, in relation to the intermediate and subordinate ones. Regarding air conditioning, in the control environment, higher rates of fighting were observed, indicating that the comfort temperature of the piglets may have interfered with the greater activity among the piglets in relation to the lower temperature in the fan + sprinklers environment.

Conclusion

Fans and water sprinklers on the roof are an efficient mechanism to reduce the temperature of the facilities and improve the welfare of pigs in the farrowing phase, mainly by allowing the expression of innate behaviors to the species.

The definition of the pig hierarchy in the first phase of life presents important changes in view of the literature found, which may be related to the breeding system, the lineages studied and the type of enrichment included, but was not influenced by fans and roof sprinkles.

Declarations

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Author contribution All authors contributed equally to the study conception and design.

Data availability The datasets generated in the current study are available from the corresponding author.

Code availability Not applicable

Ethical approval/statement of animal ethics The animals used for the research were housed, managed and handled according to the ethical guideline/rules on animal handling by the ethics committee of University São Paulo standards and approval (No. 3758260116 of FZEA/USP) was obtained.

Consent to participate The authors have permission to participate.

Consent for publication The authors have permission for publication.

Competing interests The authors declare no competing interests.

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Figures

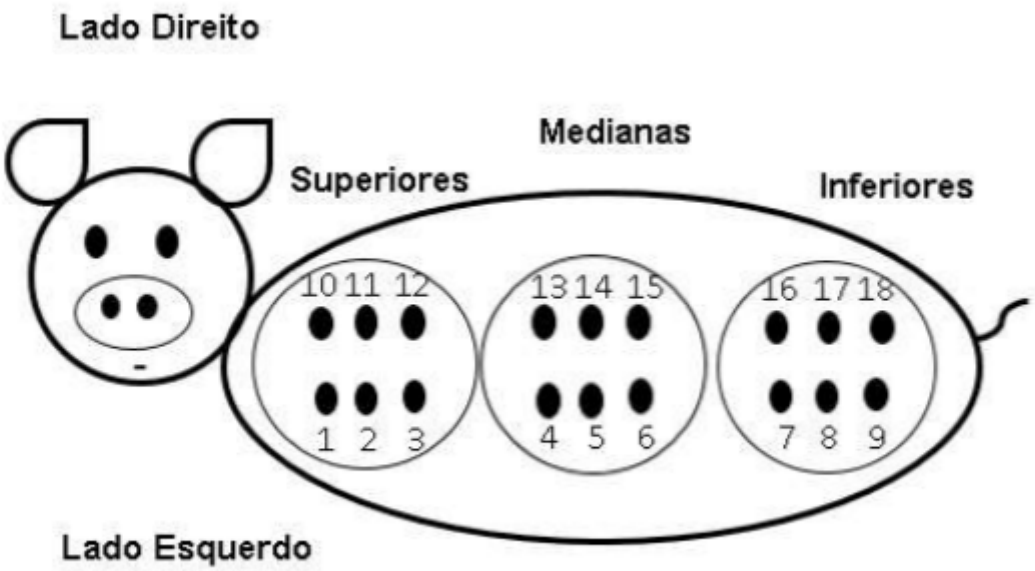

Figure 1

Classification of the teats into upper, middle and lower in relation to the right and left sides of the mammary gland