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SHORT COMMUNICATION

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Successful lactation induction in non-pregnant gilts

Ágatha Decroix Cordeiro[1] | Ana Júlia B. Conterato[2] | Ivan Bianchi[3] | Débora L. A. Dartora[4] | Ricardo Zanella[2] | Carlos Bondan[2] | Mariana G. Marques[4] | Bernardo G. Gasperin[1] | Thomaz Lucia Jr[1]

[1]Fibra, Faculdade de Veterinária, Universidade Federal de Pelotas, Pelotas, Brazil
[2]Universidade de Passo Fundo, Passo Fundo, Brazil
[3]Instituto Federal Catarinense, Araquari, Brazil
[4]Embrapa Suínos e Aves, Concórdia, Brazil

Correspondence
Thomaz Lucia Jr, Fibra, Faculdade de Veterinária, Universidade Federal de Pelotas, Pelotas, Brazil.
Email: thomaz.lucia@ufpel.edu.br

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Abstract
A protocol to induce lactation was applied to non-pregnant gilts. In Experiment I, five gilts with oestrus synchronized through oral supplementation of 20 mg altrenogest for 18 days received: 10 mg oestradiol cypionate (EC) on the last day of oestrous expression (D0); 10 mg EC and 300 mg long-acting progesterone (P4) on D26; and two 0.53 mg doses of a prostaglandin F2α analogue (PGF) 12 h apart on D36. Blood was collected on D12, D19, D26 and D33. Milk secretion started in all gilts 24 h after PGF administration and lasted at least 8 days. Milk samples were collected from D37 to D45. The serum P4 concentration was lower on D12 than subsequently ($p < .05$), but the oestradiol concentration was unaltered ($p > .05$). The milk produced during the induced lactation was generally richer in protein and poorer in fat compared to the milk from the lactation of a reference sow. In Experiment II, the same protocol induced lactation in two gilts, which nursed fostered piglets for 22 days. Thus, lactation was induced in all treated gilts and the milk produced was capable to nurture fostered piglets.

KEYWORDS
fostered piglets, gilts, lactation, oestradiol cypionateprogesterone

1 | INTRODUCTION

With the increase in ovulation rate and sow prolificacy over the last decades (Kemp et al., 2018), the birth of piglets with low weight and reduced viability became more frequent (Alvarenga et al., 2013). Such piglets are more likely to become runts, die during lactation or to have low weaning weight (Declerck et al., 2016). Such problems have not been mitigated by farrowing room management practices, such as intermittent suckling and split weaning (Terry et al., 2014). Nurse sows may nurture piglets fostered out of other litters, which may result in prolonged weaning-to-oestrous interval and incur negative welfare (Schmitt et al., 2019) and biosecurity (Garrido-Mantilla et al., 2021) implications.

Lactation induction has been employed for decades in the dairy industry to produce milk from non-cycling cows (Magliaro et al., 2004). Besides the economic benefit, such practice is related to the restoration of cyclicity and to reduced culling of the treated cows. Lactation induction requires administration of progestogens and oestrogens to simulate the endocrine environment observed during late gestation. Thereafter, prostaglandin F2α (PGF) is administered to promote an increase in the circulatory concentration of prolactin and glucocorticoids, as occurs physiologically prior to parturition, stimulating the growth of the mammary tissue (Loisel et al., 2015). Therefore, lactation induction in swine may be an alternative to increasing milk supply in farrowing rooms.

Mammary gland development starts at puberty as oestradiol circulatory levels increase, slows down during the two initial parts of the first gestation and accelerates in the final third of the gestation (Hurley, 2019). Even though lactation was experimentally induced in gilts through subcutaneous implants for slow release of steroids for 21 days (Shamay et al., 1992), oral progestogen supplementation is more common in pigs, to induce oestrus (Werlang et al., 2011). Parenteral treatment with steroids can induce lactation in non-pregnant sows (Noguchi et al., 2020), but, in such study, the steroids were from sources not used in livestock (Abdel-Dayem & Elge, 2009). Hormones used in ruminants to control the oestrous cycle, such as oestradiol cypionate (EC; Bó et al., 2016) and the long-acting progesterone (P4; de Lima et al., 2020) may be capable to induce lactation in non-pregnant swine females, which has not yet been tested. The objectives of this study were to test a protocol to induce lactation in non-pregnant gilts through parenteral steroid treatment, determine the serum levels of reproductive steroids during the induced lactation and evaluate whether the milk produced during the induced lactation can nourish fostered piglets.

2 | MATERIALS AND METHODS

In both experiments, the females were under similar conditions, fed a commercial diet containing 14.4% crude protein and 3100 Kcal/kg ME and had ad libitum access to water. All procedures were approved by the Committee on animal experimentation of the Universidade Federal de Pelotas (# 68/2021).

2.1 | Experiment I

This experiment was conducted at an experimental station in the Universidade de Passo Fundo, including five cycling gilts of the native breed Moura with 240 days of age and 100 kg live weight, on average, which were housed in a collective barn. The gilts had their oestrus synchronized through daily oral administration of 20 mg Altrenogest (Regumate®, MSD Saúde Animal) for 18 days. Oestrous signs were detected 2–3 days after Altrenogest withdrawal, by a trained technician, in the presence of a sexually mature boar.

The last day of oestrous expression was the D0 (Figure 1). The gilts received 10 mg EC (SincroCP®, Ourofino Saúde Animal), I.M. on D12, and 10 mg EC plus 300 mg long-acting P4 (Sincrogest® injetável, Ourofino Saúde Animal), I.M. on D26. Ten days later, two 0.53 mg doses of a PGF analogue (Cloprostenol, Ciosin®, MSD Saúde Animal) were administered, within a 12 h interval.

Blood samples were collected from the jugular vein (one per gilt per day) on D12, D19, D26 and D33, centrifuged at 2500 × g for 10 min, fractioned in 500 μL aliquots and frozen at −20°C. Serum P4 and oestradiol concentrations were determined in a commercial laboratory through chemiluminescence, with intra- and inter-assay CV inferior to 12%: Elecsys oestradiol III, Roche, Ref. 06656021119, sensitivity of 5 pg/mL; and ADVIA Centaur systems progesterone kit, Siemens, Ref. 01586287, sensitivity of 0.21 ng/mL.

When milk secretion was first observed (on D37, 24 h after the first administration of PGF), each gilt received 2 mL oxytocin I.M. Then, 80.0 mL milk samples were milked by hand per gilt daily, until the milk secretion ceased. The milk concentrations of protein, fat and lactose were analysed using the Delta LactoScope milk and dairy products analyser (PerkinElmer Ltd.).

For reference, milk samples were collected from a sow of the same genetics, which was gestating simultaneously, on the day of farrowing (D0) and D1, D2 and D7. The milk samples from that sow were analysed as described above for the treated gilts.

2.2 | Experiment II

This experiment was conducted at an experimental station in Embrapa suínos e aves, including two 250-days-old gilts from Embrapa's genetics, which received the same protocol described for Experiment I.

On D37, after milk secretion was first observed, the gilts were transferred to farrowing crates. Eight 5-day-old piglets farrowed by other sows housed in the same farrowing room, which were considered runts, were fostered to each gilt to be nursed ($n = 4$ piglets per gilt).

2.3 | Statistical analyses

Due to lack of normality, serum oestradiol and P4 levels were transformed to arcsine. Comparisons across periods of collection were done by analyses of variance, adjusted for individual effects.

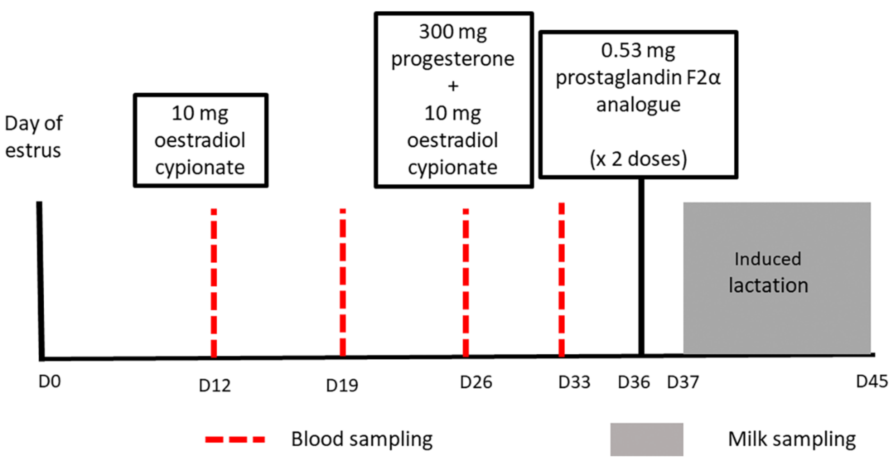

FIGURE 1 Protocol for lactation induction in non-pregnant gilts*. *D0, last day of oestrous expression after Altrenogest withdrawal.

Comparisons of means were done with the Tukey test. The analyses of the milk composition considered an 8-days period. All analyses were conducted with Statistix® (2013).

3 | RESULTS

3.1 | Experiment I

Serum P4 levels were lower on D12 than in the subsequent weeks ($p < .05$, Figure 2a) but serum oestradiol levels did not differ ($p > .05$, Figure 2b).

Milk secretion lasted 8 days for most gilts, except for one gilt that produced milk for 10 days. The fat concentration was reduced during the first 4 days of the induced lactation, achieving the greatest concentration on the 7th and 8th days ($p < .05$, Table 1). The protein concentration remained unaltered during most of the lactation ($p > .05$) but it was lowest at the 2nd and the 3rd days ($p < .05$). The lactose concentration was increased until the 2nd day but reduced from the 4th day on ($p < .05$).

3.2 | Experiment II

Milk secretion was observed for both treated gilts. The fostered piglets were nursed for 22 days (until they were 27-days-old) and were weaned with 5.0 ± 0.7 kg live weight. One of the fostered piglets died during lactation.

4 | DISCUSSION

In the present study, for the first time, lactation was induced in all gilts parenterally treated with EC and long-acting P4. In a previous study (Noguchi et al., 2020), lactation was induced in only 53.8% of the treated sows, which may have been due to the use of an oestrogen originally prescribed to treat gynaecological disorders in women (Abdel-Dayem & Elge, 2009). On the other hand, EC is commonly used to control the oestrous cycle of cows (Bó et al., 2016), but it is not frequently used in swine. As the serum P4 concentration increased during the 3 weeks after D12 concurrently with unchanged oestradiol concentration, the tested protocol promoted an endocrine environment of pseudo-gestation, with no oestrous expression during the induced lactation. Oestrous expression during lactation may occur naturally in nurse sows and lactating sows under reduced suckling frequency, for example, intermittent suckling and split weaning (Terry et al., 2014). Physiologically, oestradiol and P4 act synergically to boost mammogenesis during pregnancy, since oestradiol increases the number of P4 receptors in the mammary tissue (Hurley, 2019). As P4 supplementation stimulates endometrium vascular activity in gestating sows (Szymanska & Blitek, 2020), it may indirectly modulate a response at mammary gland level.

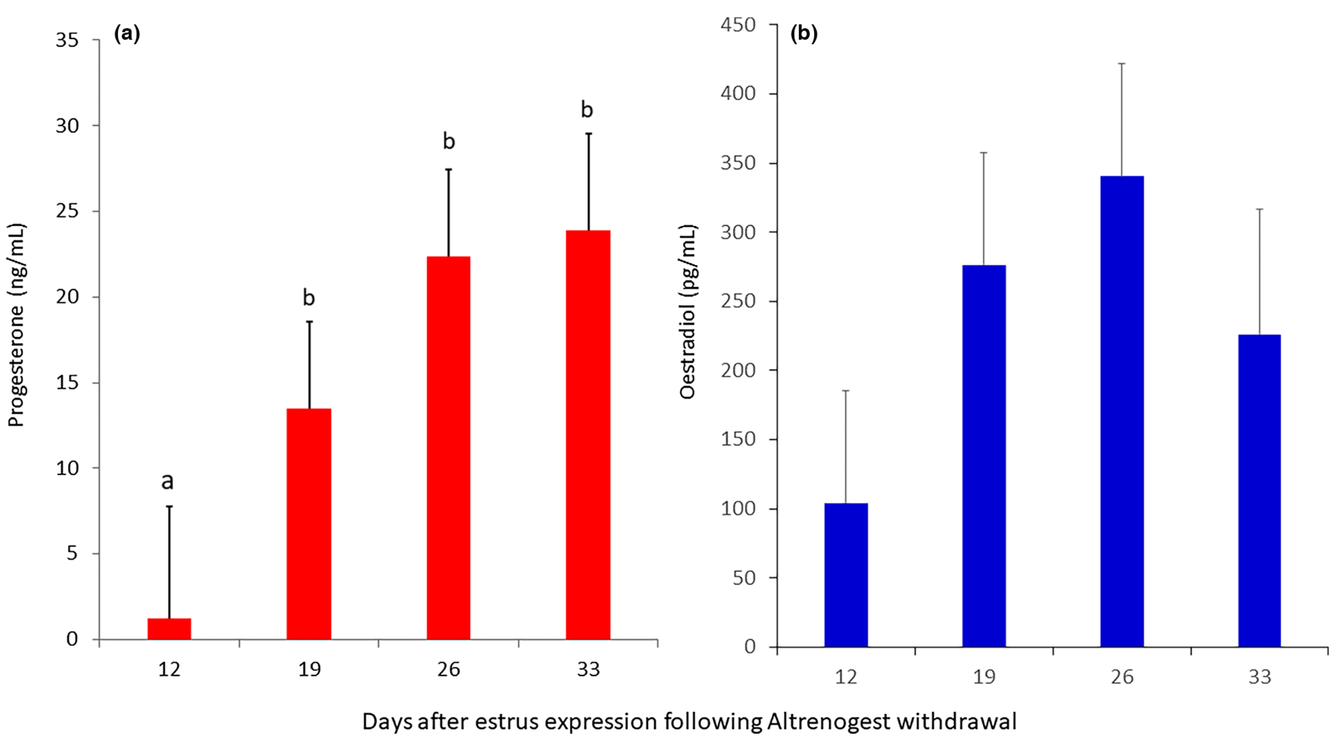

FIGURE 2 Serum concentration of progesterone (a) and oestradiol (b) in non-pregnant gilts submitted to a protocol for lactation induction ($n = 5$ gilts, one sample per gilt per day)*. *D0, last day of oestrous expression following Altrenogest withdrawal; D12, 10 mg oestradiol cypionate; D26, 10 mg oestradiol cypionate plus 300 mg long-acting P4; D36, two doses of 0.530 mg of a PGF analogue within a 12-h interval. ^{a,b}Means ± SEM having distinct superscripts differ by at least $p < .05$.

TABLE 1 Composition of the milk produced by non-pregnant gilts ($n = 5$) during an induced lactation.

Day of lactation	Protein (g/100g)	Fat (g/100g)	Lactose (g/100g)
0	15.4^{A}	3.3^{E}	3.6^{A}
1	13.4^{AB}	4.2^{DE}	3.4^{A}
2	11.7^{B}	4.3^{DE}	3.4^{A}
3	11.6^{B}	4.9^{CDE}	2.9^{AB}
4	12.5^{AB}	6.0^{CD}	2.5^{BC}
5	13.0^{AB}	6.7^{BC}	2.2^{CD}
6	12.9^{AB}	8.4^{AB}	2.1^{CD}
7	13.9^{AB}	9.5^{A}	$1.8C^{D}$
8	14.5^{AB}	9.2^{A}	1.6^{D}
SEM	0.6	0.5	0.1
Overall mean ± SD	13.2 ± 2.0	6.3 ± 2.5	2.6 ± 0.8

Note: ^{A,B} Means ± SEM having distinct superscripts differ by at least $p < .05$.

Although a previous study reported induced lactations for at most 144h (Noguchi et al., 2020), in Experiment I, milk secretion lasted at least 8days. The milk produced during the induced lactation apparently presented greater protein concentration and lower fat and lactose concentrations compared to reference values (Hurley, 2019) and to the milk produced during the lactation of the reference sow (data not shown). Nevertheless, a novel finding of the present study is the fact that, in Experiment II, the duration of the induced lactation was similar to those of natural lactations of commercial farms. Thus, the fostered piglets were nursed until weaning, likely due to the continuous stimulation of the mammary glands for 22days. However, each gilt nursed only four runt piglets. Compared to piglets of contemporary litters from other lactating sows in the same facility, such piglets were nearly 1.5kg lighter at weaning. That may have occurred because runt piglets have retarded prenatal intrauterine growth and low birth weight (Alvarenga et al., 2013), and likely have inadequate colostrum ingestion (Declerck et al., 2016). Future studies should evaluate whether litters of similar size may be nurtured during induced lactations as efficiently as in natural lactations.

Induced lactations are frequently used in the dairy industry despite the controversies related to the concern that steroid residues in the milk might lead to collateral effects on consumers of dairy products (Gamma & Sato, 2005). For pigs that is unlikely to be an issue since the milk of sows is not destined for human consumption. As the efficiency of the tested protocol for lactation induction was initially unknown, the present study was conducted in experimental units using a small number of gilts from non-commercial genetics. Thus, further research is necessary to determine whether induced lactation can be efficiently adopted in commercial farms. In Experiment II, after their allocation to farrowing crates, the treated gilts were initially refractory to the fostered piglets. Thus, during the first 24h of the induced lactation, at every 2h, the piglets were kept in the creep area of the farrowing pens while the gilts received udder massages. Their contact gradually increased as the gilts became more accustomed to the fostered piglets. That suggests that sows to be culled may be better candidates for lactation induction, as they likely developed maternal ability in previous farrowing. Additionally, that would prevent the use of gilts not selected for reproduction, which have greater market value than older sows. Furthermore, compared to nurse sows, using sows to be culled, which will no longer be part of the regular breeding inventory, may reduce the risk of transmission of infectious microorganisms (Garrido-Mantilla et al., 2021) and would not disrupt the production flow, which is important in farms using batch farrowing management. However, although treatments to induce lactation may re-establish the cyclicity of anoestrous cows, contributing to reduce culling rates (Magliaro et al., 2004), in swine breeding herds, the retention of subfertile sows would be questionable.

5 | CONCLUSIONS

Lactation was successfully induced in non-gestating gilts parenterally treated with oestradiol cypionate and long-acting progesterone. The induced lactations approached the duration of natural lactations, allowing fostered piglets to be nursed until weaning.

AUTHOR CONTRIBUTIONS

ADC, AJBC and DLAD conducted the experimental procedures. CB conducted the milk composition analyses. IB, RZ, MGM, BGG and TLJr contributed to the experimental design, logistics, data analysis, funding and manuscript review.

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CONFLICT OF INTEREST STATEMENT

None of the authors have any conflict of interest to declare.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ORCID

Ricardo Zanella https://orcid.org/0000-0003-1449-6708
Mariana G. Marques https://orcid.org/0000-0002-3110-1280
Bernardo G. Gasperin https://orcid.org/0000-0002-3715-2345

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