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Article

Improved farrowing rate using intrauterine insemination in sows

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Abstract:

Intrauterine insemination (IUI), a technique that uses a lower number of spermatozoa than conventional artificial insemination (CAI), could contribute to improve reproductive efficiency of boars. However, since some field trial reports show suboptimal performance for IUI, it is necessary to continue evaluating and standardizing this technique. In this work, the use of fixed reduced sperm amounts and doses volumes for IUI respect to CAI using the same semen samples was assessed. The results show an increase in the farrowing rate using IUI *vs* CAI (84.80 ± 0.36 *vs* 71.44 ± 2.63, P<0.05). Parameters such as litter size, live piglets/litter, stillborn or mummified fetuses were analyzed as well and showed non-significant differences between techniques. Statistical positive correlation analyses showed a positive correlation between live piglets/litter and stillborn piglets and between stillborn and total number of piglets, only for CAI. In addition, the economic analysis showed a positive impact on the productivity of the farm, and possibly of the region, by lowering costs using IUI instead of CAI. In conclusion, the intrauterine insemination had a positive impact on the reproductive performance and on the economic parameters of porcine production.

Key words: Porcine production, Intrauterine insemination, Artificial insemination.

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Introduction

In the early twentieth century, Ivanow reported the use of the artificial insemination technique (AI) in pig(1,2). However, the commercial application of AI began at the 1980s(3). Its success can be attributed to improvement in the boar:sow ratio, increase of the impact of individual boars in both genetic progress and reproductive efficiency; and limited spread of venereal diseases. Improvement in animal management and quality controls of semen doses and their commercial use have increased the reproductive performance(4). Conventional artificial insemination (CAI) usually employs 2.5 to 4 billion spermatozoa per insemination in a 70 to 100 ml volume of extender, which is deposited through the cervix into the uterus two or three times during the oestrous period(5). Boars used for AI can produce 20 to 40 CAI doses containing 2.5 to 3.0 billion motile sperm in 70 to 100 ml of extender. A reduction in the number of sperm per dose would result in a higher number of doses produced per boar with considerable economic saving, thus new strategies towards lowering the number of spermatozoa per dose in AI are constantly under study(6). Intrauterine insemination (IUI) is an insemination technique that uses a reduced number of sperm per insemination dose respect to CAI(7). However, data reported about the application of this technique show some discrepancy in the number of sperm cells per dose (which is not yet standardized). Moreover, most of the literature comparing treatments does not include groups with similar sperm number per dose, making it difficult to state whether the results are due to sperm number per dose or to the technique itself(4).

Boar exposure to sows before insemination is considered to induce myometrial contractions which aid sperm transport; however, there is some uncertainty as to whether boar exposure before IUI catheter insertion is detrimental to the catheter insertion and to whether boar exposure has beneficial effects in CAI. To date, there is not enough information to suggest detrimental or beneficial effects for any approach[8]. Still other matters of discussion arise when considering the advantages and disadvantages of the application of IUI *vs* CAI. These are the time consumed to insert the catheters for IUI, which is lower for CAI; backflow due to higher volume in CAI; bleeding at the time of inserting the catheters in IUI; and implementation of fixed-time ovulation induction and insemination.

There is information about the use of IUI technology which shows variations not only among countries, but also within each country[9]. In spite of considerable variation among countries and farms, AI can be monitored for success using key measures for quality control and reproductive performance[8]. Thus, a study was performed comparing the reproductive parameters: farrowing rate, litter size, live piglets/litter, stillborn and mummified fetuses between CAI and IUI. Furthermore, it has been analyzed the economic impact on the studied farm and the possible impact on the region.

Material and methods

Semen collection

Semen samples were collected from adult fertile boars by the glove-hand method in Medax (Chañar Ladeado, Santa Fe, Argentina). Sperm rich fraction was diluted in Vitasem (Magapor®, Zaragoza, Spain), and conserved at 16 ºC until use for no more than 2 d. Viability was measured through eosin exclusion test and the average for the three boars was 92.6 %. Motility was measured subjectively and the average was 91.26 % motile sperm. Morphology was assessed as previously reported[10] and normal sperm in samples were 89 % for boar B, 91 % for boar C and 93 % for boar A.

Experimental design

The study was conducted at a commercial farm located in Monte Maíz, Córdoba, Argentina (GPS coordinates: -33.206561, -62.600330). Three mature boars, two 415 PIC® (Pig Improvement Company, Pasig City Philippines) (A and B) and one Landrance (C) from Topigs (Topigs Norsvin, Burnsville, USA) were used as semen donors. Boar A showed 91.9 ± 2.13 motile sperm. Boar B showed 91.4 ± 3.2 motile sperm and boar C 90.5 ± 4.0. The inseminations were conducted between February and December of 2015. Five hundred and sixty (560) multiparous housed sows were separated in two groups of 280 sows. The criteria of selection for experimental design were: sows produced by breeding of Large-White female x Landrance boar, age between 190 and 200 d with at least 130 kg and four cycles detected, parity 3.9. A total of 560 inseminations were done. One group was inseminated by conventional artificial insemination (CAI) (280 inseminations) and the other group by intrauterine insemination (IUI) (280 inseminations) using the same boars as donors for each technique. In order to avoid variations on seminal quality due to different factors (individuality of boar, seasonality, physical and sanitary conditions, etc.), distribution of the same ejaculate to practice the inseminations of the two groups was performed. Oestrus detection was performed twice daily by experienced workers. Personnel for insemination procedures were carefully trained and evaluation of return to oestrus before proceeding to new inseminations was done. Sows from the two groups were contemporaneously inseminated by the two techniques. The sows were exposed to the same environment, fed with the same commercial diet and water was provided *ad libitum*.

Conventional artificial insemination

CAI was performed using spiral catheter (Magapor®, Zaragoza, Spain) and 3×10^9 sperm in 100 ml/dose. All sows were inseminated twice in standing heat in the presence of a boar. CAI was performed with 3×10^9 spermatozoa in 100 ml.

Intrauterine insemination

IUI was performed according to Hancock[11] using 1.5 x 10^9 sperm in 50 ml/dose and in the absence of boars, as recommended for better cannula introduction for IUI (foam catheter M. Magapor®, Zaragoza, Spain). Neither bleeding occurrence nor semen backflow were detected. IUI used 1.5x10^9 spermatozoa in 50 ml doses.

Analyses of the economic impact

Comparison between the economic parameters obtained with each technique was analyzed by the software “Análisis productivo y económico de granjas porcinas”[12] (Productive and economic analysis of porcine farms, APEC). In this computationally modeled analysis, standard catheter cost, labor cost, labor time, price of kilogram of meat and non-productive days (NPD), were the parameters used. NPD were calculated on the base of a sow productive cycle of 136 d (115 gestational days + 21 lactations days). The techniques and processes were approved for ethics by Servicio de Sanidad y Calidad Agroalimentaria (Agroalimentary sanity and quality service, SENASA, Argentina), resolution 63/2011.

Statistical analysis

Statistical analysis was performed using InfoStat (Universidad Nacional de Córdoba, Córdoba, Argentina). Normality test was performed by Shapiro-Wilks and Wilcoxon signed-rank test for non-parametric statistical hypothesis was applied.

Results

Analyses of reproductive parameters

When IUI and CAI were compared using the same boar semen samples, statistical data showed an increase in farrowing rate using IUI respect to CAI. The farrowing rate was 71.44 ± 2.63 for CAI, while for IUI it was 84.80 ± 0.36 (Table 1). The other parameters analyzed, live piglets/litter, stillborn or mummified fetuses showed no statistical differences. However, it is to note that a slight non-significant increase in litter size in IUI respect to CAI (14.61 ± 0.06 *vs* 13.72 ± 0.52) was observed. Since the same boars were used to perform the inseminations and the inseminations of sows were carried out contemporaneously using the two techniques, Pearson correlation coefficient could be applied to give insight into the observed differences. A statistically positive correlation was found between live piglets/litter and stillborn piglets (r= 1; P= 0.0074), and between stillborn and total number of piglets (r= 1; P= 0.0569) only for CAI (Table 2). The analysis for IUI showed no correlation between the studied parameters.

Table 1: Data of farrowing rate, born alive piglets, stillborn piglets, mummified fetuses and litter size obtained using CAI and IUI

Boar	Number of inseminations	Farrowing rate %	Live piglets/litter	Stillborn	Mummified fetuses	Total number of piglets/litter
		Conventional artificial Insemination				
A	74	72.72	13.13	1.22	0.41	14.75
B	79	75.5	12.25	0.93	0.15	13.33
C	127	66.6	11.96	0.84	0.29	13.08
Mean		71.44 ± 2.63[a]	12.45 ± 0.61	1.00 ± 0.11	0.28 ± 0.08	13.72 ± 0.52
		Intrauterine insemination				
A	84	84.62	12.96	0.88	0.88	14.71
B	70	84.28	12.97	1.15	0.47	14.60
C	126	85.5	12.81	1.27	0.42	14.51
Mean		84.80 ± 0.36[b]	12.21 ± 0.05	1.10 ± 0.12	0.59 ± 0.15	14.61 ± 0.06

[a,b] Different superscripts indicate significant differences (P<0.05). Means ± standard errors.

Table 2: Pearson correlation coefficient estimations for the reproductive variables study using IUI and CAI

Variable	Variable	Pearson	*P*-value
Conventional artificial insemination			
Farrowing rate	Live piglets/litter	0.44	0.7112
Farrowing rate	Stillborn	0.43	0.7186
Farrowing rate	Mummified fetuses	-0.35	0.7742
Farrowing rate	Total number of piglets	0.35	0.7755
Live piglets/litter	Stillborn	1.00	0.0074[a]
Live piglets/litter	Mummified fetuses	0.69	0.5146
Live piglets/litter	Total number of piglets	0.99	0.0643
Stillborn	Mummified fetuses	0.70	0.5071
Stillborn	Total number of piglets	1.00	0.0569[a]
Mummified fetuses	Total number of piglets	0.76	0.4502
Intrauterine insemination			
Farrowing rate	Live piglets/litter	-0.98	0.1385
Farrowing rate	Stillborn	0.53	0.6465
Farrowing rate	Mummified fetuses	-0.34	0.7776
Farrowing rate	Total number of piglets	-0.66	0.5441
Live piglets/litter	Stillborn	-0.70	0.5080
Live piglets/litter	Mummified fetuses	0.54	0.6390
Live piglets/litter	Total number of piglets	0.80	0.4056
Stillborn	Mummified fetuses	-0.98	0.1311
Stillborn	Total number of piglets	-0.99	0.1024
Mummified fetuses	Total number of piglets	0.93	0.2335

[a] Superscripts indicate significant difference (P<0.05)

Analysis of economic impact

The economic impact of using each insemination technique was analyzed, showing an increase on profits using IUI *vs* CAI in a one-year period, for a farm with 560 sows (Table 3). Based on these data, the potential reproductive performance per sow would be 2.59 farrowing/sow/year, considering 5 d between weaning and further insemination for IUI. This value is above the average for this region of Argentina, which ranges 2.21 to 2.35 farrowing/sow/yr. These results also showed an increase from 2.32 to 2.36 conceptions/sow/yr in favor of IUI. Considering the increase in litter size in 0.89 (14.61 to 13.72) and a mortality percentage of the farm of 6 %, the profit can be calculated as:

0.89 x 2.36 (conceptions/sow/yr) x 280 (sows) = 573.16 – 6% (mortality) = 538.77. Then, 538.77 x 112 kg (weigh of sale per pig) = 60,342 kg. Contemplating a price of U$S 1.09 per kg of pig, there is a calculated benefit of U$S 65,773 using IUI instead of CAI for the studied farm. Taking into account the prize of the catheter for IUI, which is more expensive than CAI, in the computational modeled economic study, there is a net income of U$S 3,428 in favor of IUI. That is, the difference between the net income for IUI and the net income for CAI is U$S 37,008 – U$S 33,580. Contemplating an average of 3,000 pig per farm of a similar size in the region, the profit would be of great benefit for the local economy.

Table 3: Economic impact of implementation of IUI and CAI in a farm from the middle region of Argentina

Variable	CAI	IUI
Sows	280	280
Farrowing rate (%)	71.44	84.08
NPD/failure/cycle	10	7,38
Farrowing/sow/year	2.32	2.36
pig Kg/sow/year	2,784	2,832
U$S annual net income	33,580	37,008

Dollar values were calculated according to kg of pig prices in Argentina in 2015.

Discussion

Artificial insemination is widely used and there is constant search for new strategies to achieve higher efficiency. Fixed-time AI, use of high genetic merit boars or changing the site of semen deposition are examples of these attempts to improve efficiency. Watson and Behan(7) reported farrowing rates of 91.1, 91.8 and 65.8 % for CAI whereas the IUI technique showed rates of 90.5, 90.5 and 86.9, using 3, 2 and 1 billion spermatozoa in 80 ml, respectively. The mean of the litter sizes with CAI were 12.5, 12.6 and 10.6 and with IUI they were 12.3, 12.3 and 12.1, respectively. They demonstrated that only the 1 billion spermatozoa dose with CAI technique showed a significantly lower farrowing rate and litter size. Rozeboom *et al*(13), showed that insemination at the beginning of the uterine horn with conventional volumes and spermatozoa numbers (1 billion spermatozoa) produced results similar to insemination in the cervical cavity (4 billion spermatozoa).

However, litter size and live piglets/litter were lower in IUI than CAI with those amounts of sperm per dose. Moreover, when 0.5 billion spermatozoa were used for IUI, the farrowing rate decreased approximately 10 % in comparison with the CAI group (78 *vs* 88.2 %, respectively) and, also, the differences in litter size between both techniques favored CAI (9.4 *vs* 11.6, respectively). Levis[14] reported similar results. Other work[15] established that the farrowing rate did not differ between CAI using 3.5 x 10^9 spermatozoa in 100 ml and IUI using 2, 1, or 0.5 x 10^9 spermatozoa in 50 ml. Peltoniemi *et al*[16] concluded that uterine insemination did not have a significant effect on live piglets/litter and farrowing rate. The results from those studies do not necessarily reflect the data from similar procedures on other farms. In whole, summarized information about pig reproductive technologies with emphasis in field application suggests that high farrowing rates and litter size are becoming common when using standard AI with only 1.5 billion spermatozoa per insemination[17].

In the present experimental design, all sows were in the same farm, and were inseminated with the same batches of seminal doses; CAI and IUI were equally distributed in the same day and performed with semen from all the three boars. These controlled parameters make it possible to perform a better comparison between the two techniques. Differences in farrowing rates were found using 3 x 10^9 spermatozoa in 100 ml for CAI and 1.5 x 10^9 sperm in 50 ml for IUI, that support the change from CAI to IUI in the studied farm. Moreover, although non-statistically significant, the increase in 0.89 on litter size makes the application of IUI more convenient than CAI. To get higher efficiency, AI must be accomplished reducing the number of spermatozoa, in this work the number of spermatozoa and volume of extender used in each dose were reduced to a half.

IUI with reduction in the number of spermatozoa in a fixed volume has already been analyzed[18]; however in such work IUI was not contrasted with CAI. They suggested that 0.5 x 10^9 spermatozoa in 20 ml are sufficient to perform successful IUI, however in this work tested that volume and, the difficulty of handling a 20 ml dose counteracted the possible improvement. The reduction in sperm and doses volume is highly profitable for artificial insemination centers, as the use of superior boars renders twice the doses for IUI than for CAI, thus this feature must be included in future economic impact analyses.

In addition, in the presented experiments, a boar was present when developing CAI and absent for IUI. The presence of a boar for IUI is not recommended due to difficulty to introduce de cannula. Instead, it is recommended for CAI to help in standing and to induce myometrial contractions which aid sperm transport, but additional labor for boar movement is required[8]. Despite the extra aid for sperm transit due to the presence of the boar, farrowing rate did not improve for CAI. This work agrees with the idea of the additional benefit of IUI on the necessity of less boar handling for its application. Since Steverink *et al*[19], reported that excessive backflow of semen upon CAI has a negative effect on fertilization results when 1 x 10^9 spermatozoa in 80 ml are used, it was hypothesized that a reduction in volume would improve the efficiency of the technique by reducing the backflow. In this work, no backflow was observed using 50 ml doses, which seems to be an appropriated volume, easy to handle during the procedure. The main obstacle to apply IUI is the complex anatomy of the sow's genital tract composed by cervical folds and the length and coiled nature of the uterine horns. This obstacle was saved by employing well-trained personnel, who were systematically evaluated throughout the experiment. This may be one of the reasons for the success of IUI in this work. The fact that IUI is time-consuming and requires professional trainers must be included in future economic studies.

To our knowledge, no statistical correlation analysis was made in the precedent works. Interestingly, a statistically positive correlation between live piglets/litter and stillborn was determined in CAI and such correlation was not observed in IUI (Table 2). The Pearson´s correlation coefficient is a measure of the linear correlation between two quantitative variables, so the results presented here may be interpreted as that more services are necessary to obtain more live piglets/litter when using CAI. It is to note that this correlation could be attributed to boar, sow or environmental effects, but results from IUI, which was performed in the same conditions rules out this possibility. With recent data demonstrating the possibility to perform IUI in primiparous sows(20), it seems that the use of fewer boars in AI centers and production of more AI doses with reduced number of sperm, per boar, is an interesting aspect to consider to improve the efficiency in swine production.

Considering that 30 minimal doses could be generated by using one single boar and taking into account health, feed, installations and handling costs, the overall costs could be reduced using IUI instead of CAI. As was demonstrated, the change of CAI to IUI using 1.5 x10^9 spermatozoa in 50 ml doses would be more profitable.

Conclusions and implications

Using 1.5 x 10^9 sperm in 50 ml, without the presence of boar and inseminating at heat standing with well-trained personal, IUI had a positive impact on the reproductive performance and on the economic parameters of porcine production.

Literature cited

1. Ivanow E. De la fécondation artificielle chez les mamiféres. Arch Sci Biol 1907;(12):377-511.

2. Ivanow E. On the use of artificial insemination for zootechnical purpose in Rusia. J Agric Sci 1922;(12):244-256.

3. Reed HCB. Artificial insemination. In: Cole DJA, Foxcroft GR, editors. Control of pig reproduction. London: Butterworth Scientific; 1982:65–90.

4. Bortolozzo F, Menegat M, Mellagi A, Bernardi M, Wentz I. New artificial insemination technologies for swine. Reprod Domest Anim 2015;(50):80–84.

5. Roca J, Parrilla I, Bolarin A, Martinez EA, Rodriguez-Martinez H. Will AI in pigs become more efficient? Theriogenology 2016;(86):187-913.

6. Hernández-Caravaca I, Izquierdo-Rico MJ, Matás C, Carvajal JL. Vieira L, Abril D, Soriano-úbeda C, García-Vázquez FA. Reproductive performance and backflow study in cervical and post-cervical artificial insemination in sows. Anim Reprod Sci 2012;(136):14–22.

7. Watson P, Behan J. Intrauterine insemination of sows with reduced sperm numbers: Results of a commercially based field trial. Theriogenology 2002;(57):1683–1693.

8. Knox RV. Artificial insemination in pigs today. Theriogenology 2016;(85):83–93.

9. Vázquez JM, Roca J, Gil MA, Cuello C, Parrilla I, Vazquez JL, Martínez EA. New developments in low-dose insemination technology. Theriogenology 2008;(70):1216-1224.

10. Teijeiro JM, Cabada M, Marini PE. Sperm binding glycoprotein (SBG) produces calcium and bicarbonate dependent alteration of acrosome morphology and protein tyrosine phosphorylation on boar sperm. J Cell Biochem 2008;(103):1413–1423.

11. Hancock J. Pig insemination technique. Vet Rec 1959;(71):527.

12. Drab S. APEC. Software para análisis productivo-económico en granjas porcinas. Cátedra Producción Porcina. Facultad de Ciencias Veterinarias. Universidad Nacional de Rosario. 2012.

13. Rozeboom K, Reicks D, Wilson M. The reproductive performance and factors affecting on-farm application of low-dose intrauterine deposit of semen in sows. J Anim Sci 2004;(82):2164-2168.

14. Levis D. Liquid boar semen production: current extender technology and where do we go from here. In: Johnson LA, Guthrie HD editors. Boar semen preservation IV. Lawrence, KS, USA: Allen Press Inc; 2000:121–128.

15. Serret C, Alvarenga M, Cória A, Dias C, Corcini C, Corrêa M, Deschamps J, Bianchi I, Lucia Jr. T. Intrauterine artificial insemination of swine with different sperm concentrations, parities, and methods for prediction of ovulation. Anim Reprod 2005;(2):250-256.

16. Peltoniemi OA, Alm K, Andersson M. Uterine insemination with a standard AI dose in a sow pool system. Reprod Domest Anim 2009;(44):414-841.

17. Martinez EA, Vazquez JM, Roca J, Cuello C, Gil MA, Parrilla I, Vazquez JL. An update on reproductive technologies with potential short-term application in pig production. Reprod Domest Anim 2005;(40):300-309.

18. Mezalira A, Dallanora D, Bernardi MI, Wentz I, Bortolozzo FP. Influence of sperm cell dose and post-insemination backflow on reproductive performance of intrauterine inseminated sows. Reprod Domest Anim 2005;(40):1-5.

19. Steverink D, Soede N, Bouwman E, Kemp B. Semen backflow after insemination and its effect on fertilisation results in sows. Anim Reprod Sci 1998;(54):109-119.

20. Sbardella P, Ulguim R, Fontana D, Ferrari C, Bernardi M, Wentz I, Bortolozzo F. The post-cervical insemination does not impair the reproductive performance of primiparous sows. Reprod Domest Anim 2014;(49):59–64.