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Original article

EFFECT OF INCIDENTS ASSOCIATED TO POST-CERVICAL ARTIFICIAL INSEMINATION ON REPRODUCTIVE PERFORMANCE OF SOWS

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Summary

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Different issues associated to post-cervical artificial insemination (PCAI) in sows such as bleeding, suppuration, or semen backflow and their impact on the farm reproductive parameters were evaluated. PCAI of 1991 Large White × Landrace multiparous sows were realised in a commercial pig farm in Tauste (Zaragoza, Spain). The parameters studied were: the cycle of the sow (parity); need to perform three or more inseminations per cycle; presence of bleeding or suppurations after insemination, semen backflow; abortions; farrowing rate; returns on heat, total alive, dead and weaned piglets per litter. The results showed that the cycle of the sow was significantly associated with the need to perform three or more inseminations per cycle, a lower farrowing rate, more abortions, lower number of total, alive and weaned born piglets per litter. Furthermore, bleeding was related to a lower total and alive born piglets per litter as well as to the sow cycle number.

Key words: farm economic performance, post-cervical insemination, predictive factors, reproductive parameters, sows

INTRODUCTION

Although artificial insemination (AI) emerged as a technique designed to accelerate genetic progress in animals and solve sanitary problems, it has also contributed to improve significantly productive and economical aspects. AI is a common practice in countries with an intensive pig farming industry (Gerrits *et al.*, 2005; Vyt *et al.*, 2007). It allows improving efficiently sow genetics in farms with minimum risk of spreading diseases (Maes *et al.*, 2008). Technological advance led to the development of post-cervical AI, which inserts the semen dose directly into the cranial portion of the cervix, the uterine body, or the start of the uterine horn

by means of a special catheter, rather than placing the dose in the cervix, as with conventional AI (Martinez *et al.*, 2006). In this sense, post-cervical AI reduces the number of spermatozoa and the volume of the semen dose required without negatively affecting reproductive efficiency (Vazquez *et al.*, 2008; Mozo-Martin *et al.*, 2012).

On the other hand, post-cervical AI requires highly precise control of the factors that determine its success. Thus, specialised training of staff or the use of flexible catheters are key aspects for optimising post-cervical AI in farms. Traditional AI requires one boar per each 150–200 sows, whereas with post-cervical AI a male can serve up to 400 females. Thus, the technique reduces the cost of the semen doses necessary to inseminate each sow without influencing reproductive success (Bennemann *et al.*, 2005). Apart from such direct economic savings, post-cervical AI improves the genetic selection of sows, thanks to the use of higher quality and more homogeneous semen doses. Genetic potential is also spread more quickly and widely to piglets.

The application of post-cervical AI in the porcine species entails certain difficulties. It is not possible to touch the uterine neck, as with cows, or pull out the vagina, as with sheep and goats. Nevertheless, correct training of the staff and the usage of appropriate materials reduce considerably the percentage of sows that resist the insertion of post-cervical catheters (Araújo *et al.*, 2009). In parallel, backflow or blood stains have been observed on the catheter but there is little information on the effect of such incidents with respect to application of post-cervical AI. The objective of the present research was to evaluate the effect of different incidents during post-cervical AI and their impact on the reproductive parameters at farm.

MATERIALS AND METHODS

Animals and insemination technique

For the present study, 1991 crossbred Landrace×Large White sows from a commercial pig farm located in the town of Tauste (Zaragoza, Spain) were inseminated using the post-cervical technique and evaluated. The distribution of the animals included in the test was typical of a commercial farm (higher number of sows in first cycles of parity and lower number of animals with more than 5 cycles) (Table 1).

Table 1. Distribution of animals per cycle of parity

Parity cycle	Number of animals
2	531
3	445
4	328
5	209
6	203
7	153
8	113
9	9
Total	1991

A sow is deemed to be in estrus if it stands immobile to the back pressure test in front of the boar. Sows in a weaning-mating interval of 4 to 5 days were inseminated for the first time 24 hours after estrus detection and then every 24 hours with up to 4 doses per estrus. Sows with a weaning-mating interval of 6 days or more were inseminated at moment 0 and at every 12 hours. Sperm concentration per dose of 45 mL was 1,500 million. A series of factors related to the process of post-cervical AI were analysed, namely: cycle

of the sow (parity); need of 3 or more inseminations; bleeding or suppuration after insemination; semen backflow after insemination and incidence of mixed inseminations (sows inseminated with post-cervical and traditional techniques in the same estrus). For the analysis of the results inseminations composed of 2 doses inserted with post-cervical insemination were considered as "normal". On the other hand, incidents ("out of the norm" animals) included: mixed inseminations, cervical insemination, 3 or more doses with post-cervical AI, bleeding, backflow and/or pus (metritis). Finally, these factors were correlated to the reproductive parameters of the farm: farrowing rate, abortions; born piglets (total, alive and dead).

Statistical analysis

The results of the quantitative parameters were represented as means ± SD (standard deviation) and analysed through ANOVA 2×2 and Fisher PLSD test, checking the normality of each group according to the Kolmogorov Smirnov test. Normal or categorical parameters were represented as percentages and analysed using the post-hoc and Chi-square methods. Differences among parameters were considered significant when $P<0.05$. All statistical tests were performed using the specific software StatView 5.0, SAS Institute Inc.

RESULTS

Animals distribution and fertility parameters

The first general analysis of the information was performed after compiling the farrowing data of the sows in the study (Table 2). The fertility of the sows was 83.58% and the means of total born piglets was 13.2 ± 3.5 (Table 3). Out of the total 1991 sows mated, 39 sows (2.0%) were inseminated using the traditional technique after repeated failure to pass the cervix. The group denominated "mixed" comprised 43 sows (2.2%), and the 1909 left (95.8%) received 2 or more post-cervical doses.

Table 2. Farrowing rate in inseminated sows

	Number	Farrowing rate
Abortions	27	0.35%
Not farrowed	300	15.06%
Farrowed	1664	83.58%
Total	1991	

Table 3. Average litter size (mean±SD) per sow at parturition

	Piglet number
Total born	13.2 ± 3.5
Born alive	12.0 ± 3.2
Born dead	0.29 ± 0.7
Mummified	0.3 ± 0.8

Considering the number of inseminations, from the 1909 sows inseminated with the post-cervical system without incidents, 36 (1.8%) received 3 or more doses and 1873 (94.0%) received 2 doses, composing the group denominated "normal". From the 39 traditional sows, 19 received 2 inseminations (84.2% fertility, 11.87 total born). One of them bled and repeated. Twenty animals received 3 inseminations (65% fertility, 12.5 total born). No incidents were observed. From the 43 sows (2.2%) with "mixed" insemination, 29 received 2 doses (96.5% fertility and 13.6 total born) and 14 sows, 3 or more (78.6% and 13.5 total born). The 36 post-cervical inseminations with 3 or more doses presented an average fertility of 83% with 13 total born and no incidents.

According to insemination type, the 1873 (94%) inseminated sows classified as "normal" had an average fertility of 83.6%, 13.2 total piglets born (12 born alive) and 2.5% presented incidents (0.26% metritis, 1.06% backflow and 1.17% blood stains). From the 43 sows (2.2%) with "mixed" insemination (any of the attempts fails), average fertility was 90.6% with 13.5 total born. Twenty-nine of them received 2 doses (96.5% fertility and 13.6 total born) and 14 sows, 3 or more (78.6% and 13.5 total born) (Table 4).

With regards to the occurrence of failures to pass the cervix, from the 29 mixed inseminations with 2 inseminations, in 4 (13.8%) of them the failed attempt was the first one and in 25 (86.2%), the second. Out of the 14 sows with 3 or more mixed inseminations, in 4 (28.6%) of them the failure occurred in the first attempt; in other 4, neither the first nor the second were successful (28.6%); in 4 (28.6%) the third attempt failed and in 2 (14.3%) both the second and third failed. There were no mixed inseminations with failure in the first and third and insertion in the second attempt.

Bleeding, suppuration and backflow per treatment

From the total number of inseminations, bleeding was detected in 27 (1.3%) cases. Although such percentage is low, the analysis of the parameter per cycles showed a statistically significant occurrence (P=0.0068) of bleeding in sows of 2nd and 8th cycle during insemination with the post-cervical technique (48.15% and 18.5% respectively). From the sows with bleeding problems, 25 (95.3%) farrowed a litter with an average number of 11.7 total born piglets, with 2 cases of backflow and one that did not farrow. The analysis of the distribution of total piglets born and total born alive between sows that bled and those which did not, revealed an important reduction of such parameters (P=0.03 and 0.01 respectively) in sows that bled (Table 5).

Backflow was observed in 20 inseminations, either during insertion of the dose or immediately after insemination. Also in this case, sows of second cycle were the most affected (40% of the 20 cases detected), followed by those of 4th cycle. From sows with backflow, 15 (75%) farrowed with a means of 12.1 total born, 4 repeated and one aborted.

The evaluation of suppurations showed 5 inseminations which led to posterior suppuration. Once again, it mostly affected sows of 2nd cycle (60% of the total); followed by sows of 4th and 6th cycle (20% of the total). From the animals that suppurated, 4 farrowed (80%) with a means of 12.5 total piglets born alive.

Table 4. Fertility data and incidents

	Mixed AI		Cervical AI		Post-cervical AI	
	2 AIs	3 AIs	2 AIs	3 AIs	2 AIs	3 AIs
	n=29	n=14	n=19	n=20	n=1873	n=36
Fertility	96.5%	78.6%	84.2%	65%	83.60%	83%
Total born piglets	13.6	13.5	11.87	12	13.2	13
Bleeding	3	1	1	0	22	0
Metritis	0	0	0	0	5	0
Backflow	0	0	0	0	20	0

Table 5. Distribution of total born and born alive piglets between the groups of sows that bled and those which did not. Values are expressed in means ± standard deviation

Parity cycles	Bleeding	Total born	Born alive
1	no (n=531)	12.84±2.96	11.50±3.01
2	no (n=519)	12.82±3.17	11.95±3.09
	yes (n=13)	11.15±2.73	10.38±2.50
3	no (n=440)	13.62±3.12	12.69±2.86
	yes (n=5)	13.50±3.32	11.50±2.65
4	no (n=326)	14.16±3.36	12.76±3.18
	yes (n=2)	15.50±3.54	12.00±7.07
5	no (n=209)	13.61±3.92	11.96±3.32
6	no (n=200)	12.57±4.10	11.03±3.62
	yes (n=2)	9.50±4.95	9.50±4.95
7	no (n=152)	12.61±3.82	11.06±3.32
8	no (n=108)	11.70±3.82	10.36±3.64
	yes (n=5)	11.00±3.83	9.25±3.95
9	no (n=9)	11.43±2.51	10.43±1.72

Table 6. Distribution of the number of piglets weaned, born alive and total born (means ± standard deviation), and % of fertility and groups with 3 AIs or more among sows of different cycles

Parity cycles	Number	Weaned piglets	Total born	Born alive	Fertility	3 AIs or more
2	454	11.07±0.4	12.80±0.16	11.90±0.1	84.77%	45.7%*
3	394	11.30±0.05	13.60±0.11	12.80±0.9	88.09%	20.0%
4	283	10.80±0.6	14.17±0.4	12.70±0.2	85.36%	18.57%
5	186	10.15±0.1*	13.60±0.9	11.90±0.3	88.04%	8.57%
6	157	9.70±3.9*	12.50±0.1*	11.02±0.6*	75.86%*	4.28%
7	111	9.10±4.01*	12.60±0.1*	11.03±0.3*	71.24%*	0%
8	90	8.60±4.1*	11.70±0.8*	10.30±0.6*	77.87%	2.85%
	P	<0.0001	<0.0001	<0.0001	<0.0001	0.0059

* P<0.05.

Effect of the sow cycle

The statistical analysis of the reproductive results depending on the cycle of the sow showed a significant relationship (P<0.05) between the parameter and the need to make two or more inseminations per cycle, a lower percentage of parturitions, a higher number of abortions, a lower number of total born, alive and weaned piglets per litter. The group of second cycle females comprised 45.7% (32/70) of total sows that required 3 or more AIs (P=0.0056). The farrowing rate decreased significantly from the group of sows of 6th cycle (75.8%) and 7th cycle (71.2%) onward (P<0.0001), accompanied by a higher abortion rates (2% and 2.6% respectively). Likewise, the number of weaned piglets started to decrease significantly from the group with five farrowings (P<0.0001), just as the number of total

born and born alive was reduced from cycle 6 onward (Table 6).

DISCUSSION

During the study, the most frequently observed abnormality was the necessity to perform a mixed insemination (2.25%), followed by 1.95% of the sows that could not be mated using the post-cervical method and 1.75% that needed 3 post-cervical inseminations. Araújo *et al.* (2009) reported similar results, with 4.6% of sows presenting problems during insemination. Also, Watson & Behan (2002) concluded that more than 95% of the sows could be easily inseminated and Sbardella *et al.* (2013) observed that in 86.8% of the cases studied, the post-cervical probe passed through the cervix without problem.

In parallel, parity number of females influenced the farrowing rate, total born and born alive piglets, as well as weaned animals. From the 6th cycle, these parameters were reduced, as already described in previous studies (Dagorn & Aumaitre, 1979; Kroes & Van Male, 1979).

Regarding bleeding, this problem had an incidence of 1.35%, which affected posterior reproductive results. From the sows that bled during insemination, over 90% farrowed, but the number of total born and born alive piglets was lower than that of sows which did not bleed. Sows of 2nd and 8th parturition presented more bleeding problems than the rest of the animals. Other authors have reported similar results. Sbardella *et al.* (2013) observed that although bleeding did not affect the farrowing rate, litter size was smaller in sows inseminated with the post-cervical system and presence of blood during insemination. On the other hand, Araújo *et al.* (2009) compared the traditional to post-cervical insemination techniques and found out a higher incidence of bleeding in sows inseminated with PCAI which did not influence the rate of returns to estrus or litter size. Although this problem is not largely spread in the population, it would be recommendable to choose the less aggressive insemination inner catheter for the animal rather than that which guarantees the higher number of insertions. The high fertility of bleeding sows allowed us hypothesising that blood resulted from injuries during the insemination process, probably in the vagina that recovered spontaneously due to the fact that no other clinical signs were seen. The reduction in prolificacy could be related to the local inmune reaction to such injuries added to the acute post insemination inmune response, that will affect the number of spermatozoa ready to reach the infundibulum.

Another anomaly studied was backflow. Similarly to bleeding, this parameter had lower incidence, but in the cases observed, sows presented considerably lower fertility rates. In our research, 1% of the sows had backflow with a fertility of 60%. Steverink *et al.* (1998) observed that backflow after insemination did not affect reproductive results except when more than 5 mL were expelled during insemination in first-cycle sows. In our study, backflow during insemination had a negative effect, so we believe that it may be caused by an incorrect application of the insemination related to a torsion of the inner catheter or to the difference between the ratio of the inner catheter and the exit of the cervical catheter that allows semen backflow in case of excessive pressure immediately after or during insemination that will be related to a reduction in the available sperm for fecundation and thus, to the reduction in fertility rate and/or total born piglets. With regards to inci-

dence, Mezalira *et al.* (2005) observed that the percentage of backflow reached 95% in animals in the first 8 hours after insemination, which can be considered a natural effect. They also demonstrated backflow during insemination in sows serviced with 1×10^9 sperm and negative effects on fertilisation. Our research agrees with the negative effect, even though we only compiled data during insemination. Backflow during insemination is a mechanical problem that can be related to an inadequate technique and negative consequences on the results at an extent such that, if backflow cannot be prevented, it would be advisable to inseminate the animal again using the cervical system. Concerning the discharge of purulent exudates, 4 out of 5 cases ended in normal farrowing, which eliminated metritis as a possible cause and suggested that the origin of the problem could be an urinary tract infection.

According to our results, post-cervical insemination is a safe system that can reach the reproductive objectives of cervical (traditional) insemination using a lower amount of sperm. In this study, 94% of the sows were inseminated without any problem.

The sow as individual factor is important with regard to the possibility of inserting the catheter through the cervix at a determined moment. Fertility in "abnormal" sows was 83%. A thorough analysis showed that mixed inseminations were more fertile than those performed using the traditional system in all the occasions (91% and 74% respectively), similarly to the total number of piglets born (13.24 and 12.56 respectively). The estimation of the fertilisation rate of such animals showed that sows inseminated with the traditional technique were 22.8% less productive than mixed abnormal ones.

The timing of estrus and its correct detection were also determinant factors. It has been observed that animals presenting problems when inserting the probe in the first or third insemination, did not have them in the second. It could be thought that the ideal moment for inseminating such sows was the second dose, so the first and third attempts could have been saved. In this sense, sows of second cycle required 3 or more inseminations, being the group with more problems.

The present study proved that animals with bleeding problems had poorer productive results. In general, difficult insertions, resulting in bleeding or mixed inseminations, lead to lower fertility and/or prolificacy data.

Further study is needed for the posterior weaning mating interval of the sows inseminated $\geq$3 times or of sows with inseminations out of the norm. It could be important to determine if failures are related to a "non-ideal" estrus moment; or sows with $\geq$3 inseminations present long estrus not related to the weaning mating interval, which could be thus potentially pathological.

In conclusion, reproductive failures related to the insemination process play an important role in the economic performance of the pig farm. This work permitted to evaluate the effect of different incidents during post-cervical artificial insemination and their impact on the farm reproductive parameters. It was shown that, in addition to the importance of the sow's cycle in reproductive success, sows inseminated more than two times had lower fertility and prolificacy. Reproductive results obtained highlighted the importance of applying the post-cervical insemination technique correctly, using a suitable probe of easy insertion that does not injure the reproductive tract of the sows.

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