



The optimization of insemination methods and techniques in sows

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RS: Conceptualization; Investigation; Data curation; Formal analysis; Visualization; Writing — original draft.
MO: Project administration; Methodology; Supervision; Validation; Writing — review & editing.

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Artificial insemination of sows in modern farms producing high-quality pork is justified both economically and technologically. The studies were implemented on a herd population of 3,300 sows of the high prolificacy hybrid (YL) of Danish selection — PIC. For artificial insemination of sows was used next methods: cervical insemination (Conventional Artificial Insemination), Intrauterine Artificial Insemination. Analyzing the fertility of sows, prolificacy and the number of live-born piglets, it was found that with the same conditions, feeding, timing and methods of weaning piglets, as well as obtaining, evaluating, processing and using the semen of boars, for all experimental and control groups, the obtained results allow to optimize the methods of artificial insemination of sows, by reducing of semen doses volume and amount, and increasing reproductive indicators, maximizing the potential of physiologically mature sows of the 4th–6th parity.

Key words: sow, fertility, artificial insemination, semen dose, optimization



Introduction

The use of artificial insemination in pig farming dates back to the 30s of the last century, however, the industrial application of this method became widespread in the 80s [2]. Currently, most pig farms have switched from the practice of natural mating of animals to artificial insemination, which is due to both the economic feasibility and technological advantages of this method [16]. In the past three to four decades, high-quality diluents for semen have emerged, enabling the attainment of the desired concentrations without loss of sperm spermatozoa viability. Moreover, these medications allowed for the prolonged preservation of the diluted semen when compared to natural conditions, which is to say, when compared to the reproductive tract of a sow [12]. The use of semen material from one boar producer to fertilize several sows using the same ejaculate has led to radical changes in pig reproduction technology.

One boar ejaculate can contain up to 10 billion sperm cells. This indicator may vary depending on

the breed of boars [9]. For successful fertilization by the classical method (cervical insemination), a diluted ejaculate in the volume of 80–100 milliliters containing up to 40 million sperm per milliliter is used [2, 5, 16]. This means that boars of highly productive breeds are able to produce 25 or more doses of sperm from one ejaculate, suitable for artificial insemination. In comparison with the natural method of reproduction, where no more than 45 sows per boar per year are recommended [8], artificial insemination is a more cost-effective method, since it significantly reduces the need to maintain a large number of breeding boars. When performing artificial insemination, the proportion of boars in the livestock should not exceed 0.5% [4].

The use of the method of artificial insemination of sows has demonstrated its practical feasibility and effectiveness. The procedure is not complicated, does not require significant time costs and is easily mastered by employees of pig farms. From the point of view of efficiency, artificial insemination demonstrates a higher level of fertilization, exceeding 90%, which is

much higher compared to natural mating [6, 7]. All this contributed to the further development of methods of artificial insemination of sows, among which three main approaches can be distinguished:

- a) Conventional Artificial Insemination (CAI),
- b) Intrauterine Artificial Insemination (IAI),
- c) Deep Intrauterine Artificial Insemination (DIAI).

Conventional Artificial Insemination

It is performed by inserting a plastic catheter with a soft tip into the cervix of the sow. A semen dose is used in a volume of 80 to 100 ml, containing 30 million spermatozoa sperm per milliliter. The catheter is not removed immediately, but after 5–7 min. Preliminary stimulation of the sow by the artificial insemination operator, establishment of contact with the boar (nose to nose) and achievement of the immobility reflex are mandatory conditions [7, 13].

The advantages of this method are as follows: it simulates the natural mating process, is easy to use, and has high efficiency. The disadvantages include the fact that it requires more time and a larger volume of sperm.

Intrauterine Artificial Insemination

The process performed by inserting a plastic catheter equipped with a soft tip into the cervix of a sow, followed by the insertion of a flexible cannula into it, which allows to reach the uterine cavity. A semen dose is used in a volume of 30 to 60 ml, containing 30 million sperm per milliliter. The specificity of this method lies in the fact that the process of stimulating sows and determining of heat is processed by artificial insemination operators in advance, at least half an hour before the start of the mating procedure. At the time of catheter insertion, the sow should be relaxed, since with reflex immobility of the sow, it is difficult or practically impossible to insert the cannula into the uterine cavity. After inserting a catheter with a cannula into the uterine cavity, the contents of dose are artificially pressed in, and the catheter is removed immediately after the procedure [7, 13].

The advantages of this method are: lower volume of semen dose; the ability to vary the concentration of sperm; fewer operators; high performance.

The disadvantages of this method include the complexity of its application for gilts and sows after the first farrowing, as well as the need for more highly qualified personnel. In addition, there is an increased risk of infection.

Deep Intrauterine Artificial Insemination

The process is carried out by inserting a plastic catheter with a soft tip into the cervical region of the sow. Then a long flexible cannula is inserted into the catheter, which allows you to reach the horns of the animal's uterus. A special feature of the method is the small volume of semen dose, up to 10 ml [10, 11, 13]. The

stimulation of sows and the detection of estrus, similar to that of post-cervical insemination, is carried out by artificial insemination technicians well in advance, ideally at least half an hour prior to the procedure. After the insertion of a catheter with a cannula, the contents of the sperm are forcibly injected into the uterus. The catheter is removed immediately after the procedure is completed.

This method has the highest efficiency, but at the same time involves considerable labor and requires the operator to have skills and experience in manipulating the catheter. In commercial pig farms, this method is usually not used because it is not practical. However, this method finds application for research purposes, and, like any other, has its advantages and disadvantages. The advantages of this method include: an extremely small amount of seed dose and high efficiency. However, this method also has a number of disadvantages: it is impractical in farms with large livestock, requires careful training of personnel, as well as expensive consumables such as a special catheter. In addition, there is a high risk of infection.

The choice of the method of artificial insemination of sows, as well as the determination of the volume and concentration of semen dose, is due to a number of factors, among which the key ones are the size of the farm, the number of sows in it, the cycle of production, the level of technological equipment, the qualification of personnel and the availability of semen material.

The research conducted in this area is aimed at determining the most effective combination of artificial insemination methods in combination with the volume and concentration of semen dose. This will improve the effectiveness of insemination and optimize the economic efficiency of using sows.

Materials and Methods

The research was carried out at the *Porco Bello* SRL pig breeding complex, located in the central zone of the Republic of Moldova (Cimisheni village, Criuleni district). The complex is a full-cycle farm for the breeding and growing of pigs. The size of the sow herd population is 3300 animals. The production potential of the complex is 100,000 piglets per year. The herd of sows at the complex is represented by a hybrid of the first generation (F1), obtained as a result of crossing sows of the Landrace breed and boars of the Yorkshire breed. This hybrid proved to be at its best in production conditions based on technology with a weekly production cycle adopted at the complex. As part of the scientific and production experiment, the entire sow population of the complex was involved, starting with the first and ending with the tenth farrowing for the period from January 1, 2020 to December 31, 2022. The conditions of keeping, diet,

as well as the timing and method of weaning piglets from sows were identical for all experimental groups of sows. As a control, the results obtained with the classical (cervical) method of insemination were used.

The main source of information on all the studied parameters of sows in the control and experimental groups was the database of a specialized herd management program used at the complex — *AgroVision (AgroSoft)*.

The object of the study was the methods of artificial insemination of sows, which are clearly shown in fig. 1. In particular, classical (1) and post-cervical (2) insemination were considered, as well as various volumes of seed material used in these methods.

Ejaculates obtained from terminal boars of the Duroc breed were taken as the studied and used semen material. The processing and preparation of ejaculates for use was carried out in the laboratory of the complex in accordance with a single standard throughout the entire study period. In the process, photocalorimetr and a microscope equipped with a high-speed digital camera were used.

To assess the economic efficiency of various methods of artificial insemination of sows and optimize the cost of semen material, an analysis of the production indicators of experimental and control groups of sows of different ages was carried out. The main evaluation criteria were the fertility level of the inseminated groups, the average number of live-born piglets per sow, as well as the volume and number of semen doses used.

The obtained digital data were analyzed using methods of variational statistics [3] and classical software tools (*Microsoft Excel*). The reliability of the differences between the study groups was determined using the Student's criterion [14].

Results and Discussion

Sows productivity

The starting point for the study was information on the reproductive ability of sows at the *Porco Bello SRL* complex, classified according to their age, determined by the number of parities [15].

In the course of studies conducted between 2020 and 2022, 23,991 sows were artificially inseminated (see table 1).

At the same time, the largest number of sows, namely 14114 heads, or 58%, were sows after 1st–3rd parity. The number of sows after 4–5 parities amounted to 5,884, or 24,5%, which represents a significant proportion of the total herd. It is also worth noting that these complex practices the effective use of sows up to the tenth parities.

During the study, the dynamics of the use of sows depending on their age was clearly presented, which is reflected in fig. 2. It shows that with increasing age of sows, their number gradually decreases, and after the fifth farrowing, this process becomes especially noticeable.

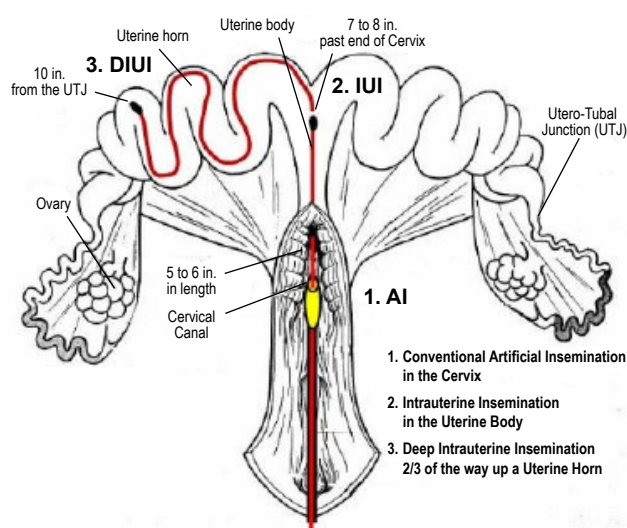


Fig. 1. Sow reproductive tract illustrating the site of semen deposition for 3 different types of artificial insemination [1]

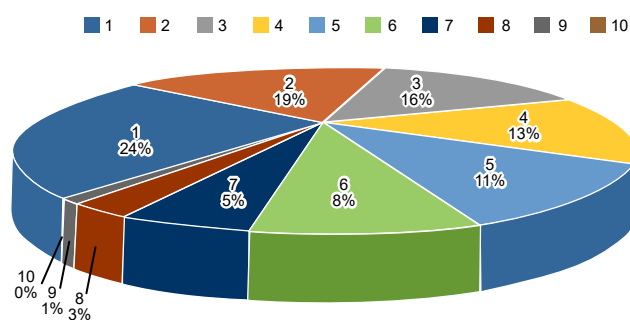


Fig. 2. Sows herd age structure by parity of investigated period 2020–2022

This is due to natural reasons — the high intensity of the use of sows in the complex (2.4 farrowing per year) leads to a faster deterioration of the animal body, which directly affects the productivity of sows. To confirm the hypothesis, an analysis of the correlation between fertility rates and the number of live-born piglets, depending on the age of the sows, was carried out. The results of this analysis are presented in the form of a diagram in fig. 2.

Table 1. Insemination structure and production results according parity number

Parity, Nr.	Sows inseminated, n	Liveborn piglets per sow, n (X±Sx)	Fertility rate, %
1	5775	13,75±0,06	85,86
2	4628	14,99±0,07	86,99
3	3711	16,09±0,07	90,73
4	3197	16,31±0,07	91,27
5	2687	16,25±0,08	92,04
6	1978	16,26±0,08	92,47
7	1221	15,65±0,11	91,4
8	564	15,50±0,16	92,38
9	184	15,16±0,26	95,65
10	46	14,50±0,53	95,65
Total	23991	X	X

Studying fig. 2, we can conclude that the farrowing carried out from the third to the sixth is the most effective. In this case, the number of live-born piglets exceeds the average value of 16 piglets per sow, and the level of actual fertility exceeds 90%. These indicators are typical for hybrid sows with Danish genetics (PIC) and can compete with the best European farms specializing in the production of high-quality pork. At the same time, the most favorable (optimal) ratios between the number of live-born piglets per sow and the level of fertility, taking into account the number of inseminated animals, are achieved in sows that have already passed the fourth and fifth farrowing.

The method of artificial insemination of sows

At this stage of the study, the effectiveness of the artificial insemination of sows was analyzed using various methods and a thorough study of their effectiveness. In each of the three cases described below, the same volume and concentration of semen dose were used.

1) *Conventional Artificial Insemination (CAI) with one repetition* — classical (cervical) artificial insemination with a single repetition 24 h after the first insemination in the presence of a immobility reflex in a sow. The volume of semen dose is 100 ml, the concentration of sperms is 30 million per milliliter.

2) *Conventional Artificial Insemination (CAI) with two repetitions* — classical (cervical) artificial insemination with a double repetition 24 and 48 h after the first insemination in the presence of a immobility reflex in a sow. The volume of semen dose is 100 ml, the concentration of sperms is 30 million per milliliter.

3) *Intrauterine Artificial Insemination* — post cervical insemination with a single repetition 24 h after the first insemination without presence of a immobility reflex in a sow. The volume of semen dose is 100 ml, the concentration of sperms is 30 million per milliliter. The results obtained during the study presented in table 2.

Table 2. Matting structure according artificial insemination type

Insemination techniques	Sows inseminated, n	Liveborn per sow, n	Fertility rate, %
CAI with one repetition	15924	15,13	88,57
CAI with two repetitions	5831	15,93	93,38
IAI with one repetition	866	15,16	87,3

Data presented in table 2 indicated that post cervical method of insemination of sows without considering the age of the animal, is not more effective than the traditional (CAI) method. In the course of our study, it was found that the fertility level and the number of live-born piglets in sows inseminated in the classical double-repeat method, all other things being equal,

were higher by 6.08 percentage points and 0.7 live-born piglets per sow, respectively, compared with the use of the post-cervical method.

However, the practical application of this method as the main one is impossible, due to variations in the duration of the estrous period (heat) in sows. This period is characterized by such a sign as the immobility reflex, which can last up to 48 h. In most sows, estrus lasts less than this period, so re-insemination is carried out only once. Regarding the post-cervical method, it should be noted that it is also effective and meets the criteria of productivity exceeding 15 live-born piglets per sow and 85% actual pregnancy. However, all other things being equal, it is inferior to cervical insemination.

As can be seen from the analysis of the data presented in table 2, the post-cervical method is a comparable alternative to the cervical method of insemination of sows. However, with equal volumes of semen dose, it is not optimal, which became the basis for conducting experiments to determine the optimal volume of semen dose with the post-cervical insemination method in order to achieve maximum results.

In accordance with our data presented in table 1 and information from the literature [15], sows of the 4th and 5th parity, which are the most productive and physiologically mature individuals, were selected and inseminated as experimental groups. During the experimental period, post-cervical insemination was performed using various volumes of semen dose: 100 ml, 60 ml, 50 ml, 40 ml and 30 ml, while the concentration of spermatozoa in each dose was 30 million/ml. The results obtained during the study of the level of actual pregnancy and the number of live-born piglets per sow were compared with each other, as well as between the corresponding age groups of sows that were inseminated using the classical (cervical) method with one or two repetitions (fig. 4).

Based on the information presented in the figure, a number of conclusions can be drawn.

Firstly, it was found that cervical insemination with two repetitions is more effective than with single repetition due to an increase in the fertilization coefficient. The difference in performance is about 3%.

Secondly, it is confirmed that in conditions when sows are at the most productive age, and the volume of semen dose is 100 ml, the most effective method of insemination is the cervical method, which can be repeated once or twice. At the same time, the effectiveness of this method is higher both in the number of liveborn piglets per sow (by 0.9–1 piglet) and in actual pregnancy (by 1–3%).

Thirdly, the most effective is the use of a group of sows that have 4th–5th parity age, while inseminated by the post-cervical method using a 40 ml semen dose and sperm concentration of 30 million/ml. In this case, the results obtained exceed the indicators of post-cervical insemination with a dose of 100 ml by 6% in terms of

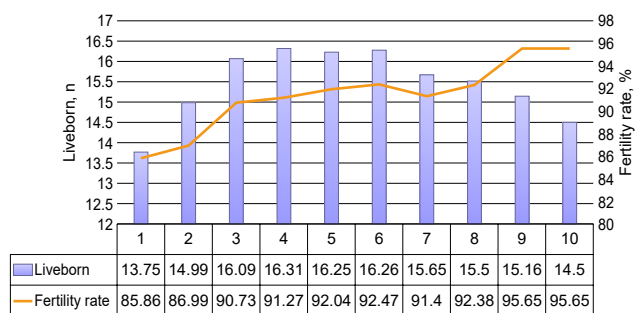


Fig. 3. Correlation of liveborn pigs vs fertility rate according to parity

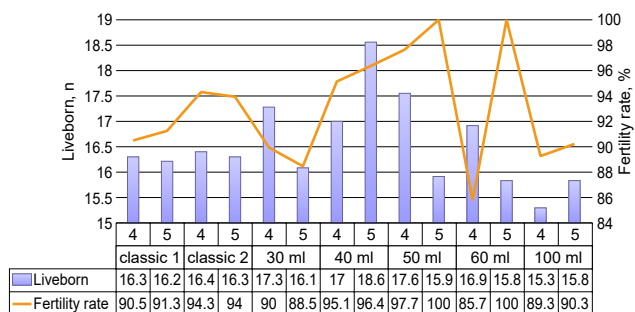


Fig. 4. Correlation between the number of live-born piglets and the fertility level of 4th–5th parity sows depending on the insemination method and the volume of semen dose

actual pregnancy and 2.7 piglets per sow in terms of the number of live births, as well as the indicators of classical (CIA) insemination with two repeats by 1–2.5% in terms of actual pregnancy and 0.6–2.2 piglets per sow.

In the course of research conducted at the *Porco Bello* SRL complex, the effectiveness of an integrated approach to the selection of the method of artificial insemination of sows was confirmed. It was found that the replacement of the traditional cervical insemination method for sows of the 4th and 5th parity with the post-cervical method leads to a significant increase in the number of piglets born while maintaining other equal conditions. This is achieved by increasing the fertility rate and prolificacy of animals.

The optimal volume of semen dose for post-cervical insemination of sows on the 4th and 5th parity is a dose of 40 ml with a concentration of 30 million sperm per milliliter. This makes it possible to significantly reduce the need for semen material and, as a result, reduce the corresponding costs for the maintenance of boars.

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Оптимізація методів і технік осіменіння свиноматок

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Штучне осіменіння свиноматок у сучасних господарствах з виробництва високоякісної свинини виправдане як економічно, так і технологічно. Дослідження проводили на поголів'ї свиноматок високопродуктивного гібрида (YL) датської селекції — PIC, яке налічувало 3300 тварин. Для штучного осіменіння свиноматок використовували такі методи: цервікальне осіменіння (звичайне штучне осіменіння), внутрішньоматкове штучне осіменіння. Аналізуючи заплідненість свиноматок, багатоплідність та кількість живонароджених поросят, встановили, що за однакових умов, годівлі, термінів і способів відлучення поросят, а також отримання, оцінки, обробки та використання сперми кнурів, для всіх дослідних і контрольних груп результати дозволяють оптимізувати методи штучного осіменіння свиноматок через зменшення об'єму та кількості доз сперми та підвищення відтворних показників, максимізуючи потенціал фізіологічно статевозрілих свиноматок 4–6-го опоросу.

Ключові слова: свиноматка, плодючість, штучне осіменіння, доза сперми, оптимізація