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Review Article

IMPROVING REPRODUCTIVE EFFICACY IN SWINE HUSBANDRY THROUGH ARTIFICIAL INSEMINATION

Arokia Robert M[1]*, Shibu Simon[2], E.D. Benjamin[3] and Aravinda Ghosh K.N[4]

[1]Research Scholar, [4]Professor and Head,
Department of Animal Reproduction, Gynaecology & Obstetrics
College of Veterinary and Animal Sciences, Mannuthy
[2]Assistant Professor & Head, Livestock Research Station, Thiruvazhamkunnu
[3]Assistant Professor, Centre for Pig Production and Research, Mannuthy
Kerala Veterinary and Animal Sciences University
E-mail: arokiarobert@gmail.com (**Corresponding Author*)

Abstract: Artificial insemination (AI) in swine when compared to natural service has got several advantages such as reducing cost of boar replacement, disease control, breeding stock improvement, improving conception rate and litter size. AI is being widely used for breeding pigs and has been instrumental for facilitating global improvements in fertility, genetics and herd health. The satisfactory collection of boar semen could be normally achieved using the gloved hand technique. Sows that were inseminated 24 to 0 h before ovulation and 0 to 5 h after ovulation did not influence the percentage of normally developed embryos. Recently, new AI methods in which the deposition of the semen is accomplished in uterus or in the uterine tube have been recommended. The standard techniques are intra-cervical artificial insemination (ICAI), intra-uterine artificial insemination (IUAI), deep intra-uterine artificial insemination (DIUAI) and the intra-tubal artificial insemination (ITAI) through laparoscopy. Fertility success depends to a greater extent on proper timing of semen deposition relative to ovulation rather than on the site and number of sperms deposited. Using appropriate insemination procedures, it is now feasible to attain high fertility rates with chilled, freeze–thawed or sex-sorted semen for improving the efficiency and sustainability of global pork production.

Keywords: Boar, Sow, Artificial insemination, Sperm dose, Fertility.

INTRODUCTION

AI remains as the most worldwide breeding biotechnology applied under commercial conditions in domestically farmed species. According to the first reports, the artificial insemination of the pig was first performed by Ivanov in Russia at the beginning of 1900s (Roca *et al*., 2006). Historically, the swine industry adopted the use of AI at a slower pace compared to dairy industry.

Today, it is still possible to observe less technified farms that use the natural mating, which requires higher number of males in a herd. The purpose of artificial insemination is to

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guarantee that a sufficient quantity of spermatozoa reaches the utero-tubal junction. A reduction in the number of sperms per dose would result in a more number of doses produced per boar with considerable economic savings (Rozeboom *et al*., 2004).

SEMEN COLLECTION

Gloved Hand technique

The satisfactory collection of boar semen could be normally achieved using the gloved hand technique because the gloved hand readily adapts to the corkscrew shape of the boar's penis and provides the constant pressure necessary during the stimulatory and ejaculatory phase of the collection process and provides adequate stimulus to achieve optimum sperm output than artificial vagina (Gordon, 1997).

Semen ejaculation

The semen volume of boars ranged from 125 to 500 ml with a mean of 250 ml with a total sperm concentration of 10 to 100 billion sperm cells per ejaculate (Noakes *et al*., 2002). Boar ejaculate in three fractions. The first fraction is termed as pre-sperm fraction which is transparent fluid and does not contain sperm (~25 ml). The second fraction is called as sperm-rich fraction which is normally whitish in colour, contains 80-90% of all sperm cells in the ejaculate, and ranging from 40 to 100 ml. The third or post-sperm fraction is normally clear, gel containing portion, ranging from 70 to 300 ml and it should not be collected. The gel constitutes 20–25 per cent of the total volume of ejaculate. After collection, the gel portion should be filtered and discarded. Because, the gel portion comes from the cowper's gland, which coagulate the seminal plasma. The collection container should be kept in warm water. The semen should be processed within 15 min after collection. The ejaculation may continue up to 15 min (Milad, 2011). Sreekumaran (1974) found the mean per cent of motile sperms in the ejaculate ranged from 40 to 80 with a mean of 65.7. Gibson and Johnson (1980) stated that young boars of 8 to 12 months of age had more than 85 per cent sperm motility in the ejaculate.

Frequency of collection

Swierstra and Dyck (1976) reported that frequency of collection influenced motility (Higher percentage motility at 3 day interval Vs 1 day interval) and pregnancy rates (83 per cent at 3 day interval Vs 1 day interval).

SEMEN EXTENDERS

Boar spermatozoa are extremely sensitive to cold shock which alter sperm viability (Pursel *et al*., 1973). Specifically, this sensitivity seems to be related to the lipid content of the sperm

cell membranes. Thus, when the temperature declines, sideways movement of membrane phospholipids are reduced and this causes separation of the lipid phases, which is related with irreversible alteration to membrane proteins leading compromised cell viability. Because, phospholipid composition contains lower percentage of phosphatidylcholine and the higher percentage of phosphatidylethanolamine and sphingomyelin in boar, making it strenuous to evaluate the stability of boar sperm membranes. So, semen sample should be kept at 15–20°C (Paulenz *et al*., 2000).

Types of extender

According to Gadea (2003), extenders can be divided into two major groups:

- Short-term semen preservation (<1-3 days)- Eg: Beltsville Liquid(BL-1), Beltsville Thawing solution (BTS), Illinois Variablle Temperature(IVT)
- Long term semen preservation (>4 days) – Eg: Zorlesco, Androhep®, Acromax® and X-Cell®.

SIGNS OF OESTRUS

Sow becomes restless and will often seek out boar, before three days oestrus, the vulva becomes progressively swollen and congested. A peculiar repetitive grunt is exhibited. Occasionally a mucus discharge will be observed (Noakes *et al*., 2002). Burger (1952) demonstrated that oestrus could readily be determined by firmly pressing the loin of the sow with palms of both hands, the oestrus sow will stand motionless with cooked ears whereas sows not in heat will object to this approach.

TIME OF INSEMINATION

Soede *et al*. (1995) reported that when sows were first inseminated at 24 to 0h before ovulation, a second insemination on 0 to 5h after ovulation didn't influence the percentage of normally developed embryos. Inseminations occurring too early or too late during oestrus and in relation to ovulation could reduce fertility and an insemination occurring too late in oestrus could even increase embryonic loss and cause endometritis (Kemp and Soede, 1997).

ARTIFICIAL INSEMINATION METHODS

In newly developed AI techniques, the deposition of the semen is accomplished in uterus or in uterine tube. So, there are intra-cervical artificial insemination (ICAI), intra-uterine artificial insemination (IUAI), deep intrauterine artificial insemination (DIUAI) and the intra-tubal artificial insemination (ITAI) through laparoscopy. These new techniques are applied in order to decrease the number of spermatozoa and the volume of the insemination dose. The

spermatic concentration and the semen quantity are highly reduced, without hampering the reproductive efficiency.

Intra-cervical artificial insemination

ICAI is the predominant breeding method on farms of all sizes (Knox *et al*., 2013). This technique involves the deposition of spermatozoa into the posterior part of the cervix using a Melrose (Minitube®) pipette that engages with the folds of the cervix (Roca *et al*., 2006). ICAI involves a large population of spermatozoa, above 2500 million in 80 to 100 ml of insemination dose and is deposited into the posterior folds of the cervix.

In the ICAI technique, the semen is placed in the first few centimetres of the cervix. Cervix acts as a natural barrier that inhibits the arrival of the semen into uterus, consequently facilitating the occurrence of the back flow reflux through vagina. The occurrence of backflow in the swine species is frequent and it was noticed in 100 per cent animals inseminated (Steverink *et al.*,1998). For this reason, gilt insemination is not as widely practiced as the insemination of sows.Uterine contractions happen with insemination and function to hasten sperm transport.

In natural mating, the penis introduced into female trigger the oxytocin release and consequently, contributes to spermatic transport. According to Langendijk *et al*. (2005), the AI pipette should remain in the cervix during enough time for liberation of the oxytocin. The pipette fixed in cervix for approximately 10 minutes.

The use of the frozen semen in ICAI is still associated with the reduction from 10 per cent to 20 per cent in the parturition rate, when compared to the use of chilled semen (Bernardi*et al.*, 2005).Under the field condition, it is an accessible and easily accomplished procedure.

Intra-uterine artificial insemination

The objective of this insemination procedure is the deposition of the semen straight away into body of uterus. Intrauterine insemination could permit a reduction in the quantity of spermatozoa and amount of inseminating dose. Several instruments have been developed to traverse the cervix and place the spermatozoa in the uterine body or posterior horn of multiparous sows. The majority of these devices are aided by a commercial AI spirette used to provide a cervical lock. IUAI was performed using an intrauterine catheter “Verona” (Minitube®). The devices, usually 15–20 cm longer than a conventional catheter, are introduced through the passage of the spirette and subsequently extend via the cervical canal forward to the uterine body. Sumransap *et al.* (2007) observed good fertility with 1000 million spermatozoa directly deposited into the uterine body.

Diehl *et al*. (2006) observed that it is nearly impossible to introduce the catheter into the uterus of primiparous females. In those cases, while the catheter is introduced, constant stimulation of the female by massage on lumbar area allow the success of the technique. The main advantage for this insemination procedure is decreased backflow loss (Mezalira *et al.,* 2005).

Deep intrauterine artificial insemination

Sperms are deposited near one of the uterotubal junctions and therefore this technique prevents most of the uterine backflow and PMN effects. Thus DIUAI greatly reduces the need for high numbers of sperm and volume (Roca *et al*., 2003). The DIUAI technique could be employed in the use of the processed spermatozoids such asfrozen and sex sorted spermatozoa (Vazquez *et al*., 2005).

The recently, designed device has length of 1.80 m, 4 mm and 1.80 mm of outer and inner diameter of the tube respectively. Deep uterine catheterization is achieved after the introduction of a commercial AI spirette, to form a cervical lock. The catheter is then introduced through the spirette, moved through the cervical canal and pushed forward along the body of uterus and uterine horn. This technique provides the deposition of the semen in one of the uterine horns near the fertilization site (Vazquez *et al*., 2008). Wongtawan *et al.,* (2006) reported incidence of bleeding in sows is low (<2 per cent) during and after this insemination procedure. This procedure did not reduce the subsequent fertility of the sows (Bolarin, 2006). Roca *et al*. (2003) observed that good fertility has been achieved using 50 to 200 million unsorted spermatozoa, 70 to 140 million sex-sorted spermatozoa and 1 billion cryopreserved sperm by DIUAI.

Intra-tubal artificial insemination

The aim of this technique is to inseminate with a few numbers of spermatozoa in small volume to increase the insemination efficiency while using sex-sorted spermatozoa or sperm-mediated gene transfer. Insemination into the oviduct is believed to be able to maximally reduce the quantity of spermatozoa required (Rath, 2002).

For execution of this method, general anaesthesia in gilts/sows was induced with ketamine (0.15 ml/kg Body weight) and azaperone (0.03 ml/kg Body weight) (Brüssow *et al*., 2013).The sows are placed in a Trendelemburg position at an angle of approximately 20° above horizontal. A 1.5-cm nick is made close to the umbilicus. The edges of the incision are pulled up with counter traction and a 12-mm Optiview trocar (Ethicon Endo-surgery Cincinnati OH, USA) with an inserted 0° laparoscope advanced into the incised area. After

entering the peritoneal cavity, the hand piece of the Optiview is removed and replaced by the 0° laparoscope. The abdominal cavity is inflated to 14 mmHg with CO_2. Two accessory ports are placed in the right and left side of the abdomen, to facilitate access for laparoscopic duval forceps for manipulating the uterine horn and grasping the oviduct for the insertion of insemination needle, respectively. After deposition of semen in both the oviducts, the trocars are removed and minor suturing is applied. The complete minor surgery requires only 15 min (Vazquez *et al*., 2008). High (92.3 per cent) fertilization rates were achieved with only 10–20 million spermatozoa (Fantinati *et al*., 2005).

The polyspermy block in the porcine oocytes is low compared with other species (Day, 2000). So, a high percentage of polyspermic oocytes could be expected using intra-tubal laparoscopic insemination. Polyspermy was evident only when one million spermatozoa are inseminated. The incidence of polyspermic penetration is very low when 3 or 5 lakhs spermatozoa are inseminated. When spermatozoa were placed in the oviduct before ovulation (pre-ovulatory insemination) and during ovulation (peri-ovulatory insemination) polyspermy was very low and high, respectively (Vazquez *et al*., 2008).

Several factors, such as aged spermatozoa, improper semen handling and intervals between insemination-ovulation can reduce the reproductive performances when few numbers of spermatozoa are used (Rozeboom *et al*., 2004).

CONCLUSION

Using relevant insemination procedures, it is now possible to achieve high fertility rates with cooled, frozen–thawed or sex-sorted boar semen. The IUAI allows for better use of the ejaculates, compared with the ICAI. The IUAI technique can be applied at commercial farms instead of ICAI without threatening the reproductive efficiency. Deep intrauterine insemination and intra tubal insemination was useful tool in the application of biotechnologies such as frozen or sexed sorted semen. However, the high cost of the equipment for this procedure and the difficulties in execution of the technique still remain as impediments for its application in commercial farms.

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