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Innovative Strategies for Optimal Reproductive Management in Poultry Through Artificial Insemination

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ABSTRACT

Artificial insemination (AI) has revolutionized poultry breeding, enabling superior genetic control and enhanced breeding program efficiency. This review provides a comprehensive guide for poultry producers on the successful application of AI in chickens. It delves into the avian reproductive systems, emphasizing the importance of understanding both male and female anatomy for optimal insemination practices. Key factors affecting fertility are explored, including semen collection techniques, hygiene considerations, and proper evaluation of semen quality. The importance of semen diluents and storage for maximizing sperm viability is highlighted. Different insemination methods, such as the automatic gun and glass straw methods, are presented along with their advantages and considerations. Proper handling of birds during insemination and the crucial role of timing are emphasized. The abstract concludes by outlining the advantages of AI in poultry breeding, including increased genetic selection, disease prevention, and improved production efficiency.

Keywords: Artificial insemination, poultry, Fertility, Hatchability

Introduction

Artificial insemination (AI), the controlled deposition of semen into the female's reproductive tract, has revolutionized animal breeding. It was pioneered by Spallanzani in 1784 with canines, this technique was first successfully applied in birds by Ivanov in 1907, resulting in fertile chicken eggs. By the 1920s, AI adoption spread across the American poultry industry, and by 1950, its use with laying cages in Australia became widespread. However, natural mating in modern poultry breeding presents challenges [1]. The heavy body weight and broad-breasted conformation favored for meat production often hinder successful copulation, leading to reduced fertility. This has driven the essential role of AI in commercial poultry production, particularly with broiler breeders, where it demonstrably outperforms natural mating, especially as the birds age [2]. To achieve successful artificial insemination (AI) in chickens, poultry producers must possess a comprehensive understanding of chicken reproductive anatomy and skilled techniques for semen collection, storage, and insemination. This includes knowing the optimal frequency of semen collection, evaluating semen quality, using proper dilution methods, and determining the correct sperm dose. Additionally, timing insemination relative to ovulation and choosing the most effective insemination method are crucial for maximizing fertilization rates. Mastering these aspects of AI empowers producers to achieve superior genetic control and enhance breeding program efficiency [3].

Avian Reproductive Systems: Foundation for Successful Artificial Insemination

The success of artificial insemination relies heavily on understanding the reproductive systems of both male and female chickens. In females, the cycle begins with ovulation, where a mature follicle releases an unfertilized egg yolk into the oviduct's infundibulum. Fertilization by sperm stored there ideally occurs within 15-18 minutes. The fertilized egg then travels through the oviduct, where each section contributes to its development. Albumen (egg white) is deposited in the magnum, followed by the shell membrane formation in the isthmus [4]. Finally, the uterus spends the longest time (around 21 hours) creating the hard eggshell. The entire journey from ovulation to laying an egg typically takes 25 hours. Meanwhile, in males, sperm production occurs continuously within the testes. These are transported via the vas deferens to the cloaca, the combined opening for the digestive, urinary, and reproductive tracts. Until around 15 weeks old, testes development focuses on cellular multiplication, particularly Sertoli cells. These cells provide crucial support and nourishment for developing sperm, and their number directly influences sperm production potential [1]. Good management practices are vital for male health and Sertoli cell function. Light stimulation plays a key role in triggering rapid testes growth and sperm production. In the following three weeks, testes size increases significantly, and sperm production begins. Testes weight peaks around 28-30 weeks, but a natural decline in size and fertility sets in beyond 35 weeks [6].

Fertility and Hygiene Considerations

Oral antioxidants like those containing Vitamin E, Selenium, and Vitamin B12 (e.g., Impak) have shown promise in improving fertility in poultry. However, proper hygiene practices remain paramount for successful insemination [3]. Contamination from a dirty hen's cloaca or contaminated semen can significantly reduce sperm survival and fertilization rates. Feed should be withdrawn 3-4 hours before insemination to minimize this risk to prevent fecal and urate contamination during the procedure. Insemination equipment must be meticulously cleaned with hot water after each use and sterilized at the day's end. Disposable equipment should be discarded to avoid cross-contamination [7]. Additionally, personnel hygiene is crucial. Hands must be thoroughly washed before semen collection and insemination; disposable gloves are highly recommended. Daily clothing changes are also advisable to maintain a sanitary environment [8].

Semen Collection, Evaluation, and Insemination Techniques

Semen Collection: The abdominal massage method is the primary technique for semen collection in chickens. It requires two people: one to restrain the rooster in a crouched position, and another to gently massage the abdomen towards the tail three to four times. The expelled semen, ideally white, thick, and creamy, is collected in a funnel. A second massage may yield more sperm, but this fraction is diluted with clear fluid and reduces overall sperm concentration per unit volume, potentially harming fertilization rates [9].

Hygiene and Precautions: For optimal semen quality, the area around the rooster's cloaca should be cleaned before collection. Contaminated semen with feces, urates, or bacteria significantly reduces sperm viability and fertilization success. A forceful ejection of semen is often indicative of cleaner samples. Here are some additional precautions such as Trained personnel should perform semen collection and insemination, Avoid applying excessive pressure to the cloaca during collection, as this can lead to blood contamination, Clip feathers around the cloaca to minimize contamination risks, Protect semen samples from sunlight and dust during transport by storing them in a box, void collecting semen too soon after feeding and watering, as a full digestive tract increases the risk of fecal and urate contamination during massage. Withhold feed for 4-5 hours beforehand, High ambient temperatures negatively impact sperm health. Discard semen collected after long intervals, as it may contain degenerating sperm cells, and Collect semen on alternate days [5].

Frequency of Collection: The number of healthy sperm cells in a semen sample directly affects fertilization rates. Naturally, sperm quality declines with longer intervals between collections. Regularly collecting semen from roosters, typically three times a week maintains optimal sperm production and fertility in hens [2].

Semen Evaluation: Semen quality assessment is crucial for successful insemination. In the past, insemination decisions were based solely on semen volume. Later practices focused on sperm count, and more recently, the emphasis shifted to the number of viable sperm per dose. While field conditions often prioritize motility evaluation through visual examination, good-quality semen appears thick, white, and creamy. Several advanced physical and biochemical tests are available for more comprehensive semen analysis [5].

Semen Diluents: Poultry semen is highly concentrated with a low volume. After ejaculation, sperm viability begins to decline. Diluents are essential for increasing semen volume and maintaining sperm viability. These solutions offer several benefits such as, Increasing the number of inseminated hens per unit volume of semen, ensuring uniform sperm distribution within the diluent, facilitating insemination, extending sperm survival for both short-term and long-term storage using cryoprotectants like glycerol, maximizing the breeding potential of superior males through artificial insemination. The primary goal of semen diluents is to enhance rooster reproductive efficiency and reduce insemination costs [10].

Storage of Semen: Hens possess a natural ability to extend sperm survival within the oviduct after mating or insemination. Specialized regions called sperm storage tubules (SSTs) located at the uterovaginal junction (UVJ) receive, protect, and nourish sperm for extended periods. These tubules gradually release stored sperm over time, ensuring an adequate sperm population at the fertilization site. The efficiency of SSTs declines with hen age [6].

Insemination Technique: Insemination typically involves two people. One person restrains the hen in a crouched position and applies gentle abdominal pressure to evert the oviduct (vagina) through the cloaca. The other person inseminates a well-everted oviduct with a dose of good-quality semen using a tuberculin syringe, reaching a depth of 2-4 cm [11].

Timing of Insemination: Timing significantly impacts fertility rates. Evening insemination generally results in higher fertility compared to mornings, as hard-shelled eggs within the uterus are less common in the evenings. Morning insemination might encounter eggs already present in the uterus, hindering sperm movement toward the ovary [9].

Sperm Dose for Insemination: Maintaining consistently high fertility throughout the breeding season requires inseminating a minimum number of high-quality sperm cells at regular intervals. Moderate doses (240-350 million sperm) are sufficient to achieve high

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fertility in chickens. Exceeding 350 million fresh, high-quality sperm per insemination offers no additional benefit [6].

Dilution Rate: The semen-to-extender ratio varies depending on flock age. Younger flocks typically require a higher semen percentage in the mixture compared to older flocks [8].

Dose Rate Calculation: The dose rate is calculated by multiplying semen volume by motility percentage per milliliter, then dividing this value by the required number of sperm cells and multiplying by 100. For example, assuming a mature rooster produces 5 billion sperm per ml and we need to inseminate 350 million sperm [12].

Insemination Methods in Poultry

There are several methods for inseminating hens, each with its advantages and disadvantages. Here's an overview of two common techniques:

1. Automatic Gun Method: This method is more complex and requires specialized equipment.

Equipment:

Gallus catheter: A tube used to collect semen directly from the rooster's phallus. **Silicon tube:** Transfers semen from the phallus to the collection funnel. **Suction tip:** Opens the tube to initiate semen flow. **Insemination gun:** Delivers a specific semen dose. **Plastic straws:** Hold the semen for insemination, and semen collector funnel [13].

Procedure

Semen collection: A trained handler gently stimulates the rooster's vent to induce phallus protrusion and semen release. The Gallus catheter and suction tip collect the semen into the funnel. **Semen dilution and straw filling:** The collected semen is mixed with an extender solution to increase volume and viability. Plastic straws are then filled with the diluted semen, ensuring no fecal contamination. **Insemination gun preparation:** The semen-filled straw is attached to the insemination gun, which allows for precise dose control. **Insemination:** The hen is restrained, and her oviduct (vagina) is everted through the cloaca. The inseminator carefully inserts the gun and straw into the oviduct, depositing the desired semen dose [14].

2. Glass Straw Method: This method is simpler and less expensive but requires more handling of the semen [15].

Equipment:

Glass funnel: For semen collection, **Glass straws:** Hold the semen for insemination, **Disposable syringe:** Creates suction for semen collection and straw filling, and **Silicon tubing:** Connects the syringe to the straw as shown in Fig 1.

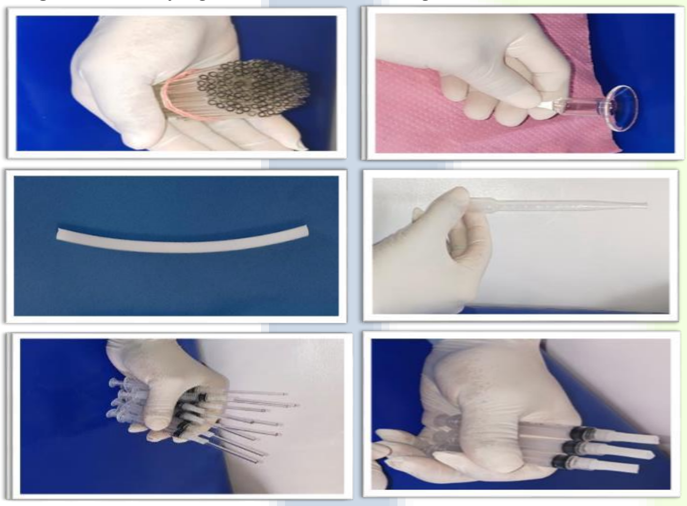

Fig.1 Instrument used for AI in Poultry **(Pictures are Capture by Umar Farooq)**

Procedure

Semen collection: Similar to the gun method, the rooster is stimulated to release semen, which is collected in the glass funnel. **Dilution and straw filling:** The extender is mixed with the semen, and a glass straw is attached to a syringe with a short silicon tube connector. By pulling the syringe plunger, a vacuum is created, drawing the diluted semen into the straw. **Insemination:** The hen is restrained, and her oviduct is everted. The inseminator carefully inserts the straw into the oviduct and releases the semen dose by pushing the syringe plunger [16].

Considerations: Both methods require strict hygiene protocols to prevent contamination. The automatic gun method offers greater precision and efficiency but is more expensive due to the specialized equipment. The glass straw method is simpler and cheaper but requires more handling of the semen, potentially increasing the risk of contamination [11].

Proper Handling During Semen Collection and Insemination

Gentle handling of both roosters and hens is essential throughout the insemination process, from capture before semen collection to release after insemination. Rough treatment can stress the birds, potentially leading to the regurgitation of semen in hens [10]. For optimal fertility, semen needs to be deposited deep within the oviduct, ideally 2-4 cm or as close as possible to the sperm storage tubules (SSTs) located at the utero-vaginal junction (UVJ). This placement ensures the sperm have the best chance of reaching the fertilization site [11]. During insemination, the syringe or insemination gun must remain inside the vagina until all the semen is deposited. Improper placement or premature removal can lead to semen leakage and reduced fertility. Additionally, semen should never be deposited directly into the uterus, as this can disrupt normal egg-laying patterns (oviposition) [6]. To minimize the risk of spreading infections among birds, a single syringe or insemination gun should never be used on multiple hens without proper cleaning and sterilization. This applies to all semen collection equipment as well, including funnels, syringes, and glassware. Maintaining a clean and sterile environment is crucial for successful insemination and bird health [16].

Advantages of Artificial Insemination in Poultry

Selective breeding gets a boost with artificial insemination in poultry. Top roosters sire more chicks, even if injured or old. Valuable genes travel the world, shipped as preserved semen. Hens can't discriminate by color with AI, ensuring successful crossbreeding. This method also prevents diseases like Marek's from spreading and reduces the number of roosters needed, saving on feed and space. Overall, AI leads to healthier flocks and increased production efficiency [17].

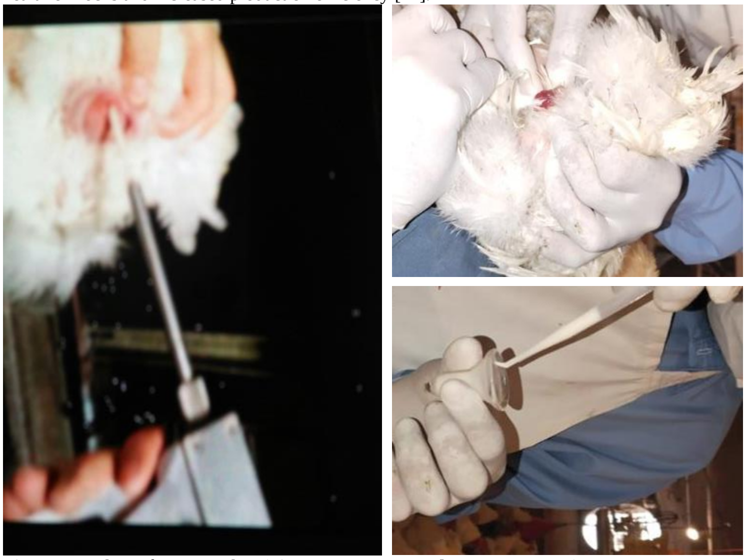

Fig. 2: Procedure of AI in Poultry **(Pictures are Capture by Umar Farooq)**

Conclusion

Artificial insemination (AI) stands as a cornerstone of modern poultry breeding. By empowering producers with knowledge of avian reproductive anatomy, semen handling techniques, and proper insemination methods, AI unlocks superior genetic control and breeding efficiency. From strategically selecting roosters to maximizing sperm viability through dilution and storage, AI ensures valuable genes reach a wider range of hens. This not only eliminates color bias in breeding but also safeguards against diseases like Marek's. Moreover, AI minimizes the number of roosters needed, reducing feed and space requirements. Overall, AI fosters healthier flocks, bolstered fertility rates, and ultimately, increased poultry production efficiency.

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