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Artificial Insemination in Duck

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Abstract

Duck husbandry plays a crucial role in agricultural economies of numerous Asian nations. Despite the considerable potential for duck farming in egg and meat production, lack of organized duck farms is evident in both public and private sectors. To address the increasing consumer demand, utilization of artificial insemination (AI) techniques in duck breeding can be employed to improve reproductive efficiency and overall production. In AI process, semen is extracted from carefully selected superior drakes under strict hygiene conditions and subsequently introduced into the reproductive tract of duck hens. Quality control of semen involves the assessment of various seminal parameters, such as colour, consistency, appearance, pH, concentration, motility, viability, abnormality and metabolic activity of spermatozoa. Furthermore, extensive research has been undertaken to identify suitable extenders, cryoprotectants, optimal equilibration times and thawing temperatures for the cryopreservation of duck semen. The implementation of advanced reproductive technologies holds the potential to significantly enhance the efficiency and productivity of the duck industry. This review provides a comprehensive overview of the importance of duck reproduction, anatomy of the reproductive tract, and methodologies for semen collection, evaluation, and preservation in duck.

Keywords: Duck, semen collection, semen quality control, cryopreservation, artificial insemination

Introduction

The Asian continent plays a substantial role in the global production of duck meat, contributing 82.6% to the total output. Ducks rank as the second most important species for egg production for human consumption, surpassed only by chickens. With each duck laying approximately 40-50 eggs annually, these eggs are preferred over chicken eggs due to their larger size, weighing around 15 to 20 grams more. Ducks are relatively easy to rear, thriving in scavenging environments and exhibiting resistance to numerous life-threatening diseases.

Popular duck breeds, including Pekin ducks, Muscovy ducks, Khaki Campbell ducks, Indian Runner ducks, and Mule ducks, are commonly raised for both meat and eggs. Duck meat and eggs are valuable sources of protein and iron (Tai and Tai, 2001). Ducks are well-suited for integrated farming systems, such as duck-fish farming and duck farming in conjunction with rice cultivation. Duck farming is particularly prevalent among small-scale and marginal farmers, agricultural labourers, and economically disadvantaged segments of society. Consequently, there is a pressing need for a more efficient breeding system to meet the growing demand for duck products.

To address this demand, the implementation of AI is highly desirable for establishing a systematic duck breeding program. AI involves collecting semen from genetically superior drakes and introducing it into the reproductive tracts of females to facilitate fertilization. AI has gained recognition among village farmers within the poultry industry due to its economic viability. This succinct review emphasizes the potential and practicality of artificial insemination in duck.

Need for artificial insemination

In duck farming, the male counterpart plays a pivotal role in the breeding process and significantly influences fertility. Notably, in commercial breeding operations, some males with questionable fertility may go undetected. This is often attributed to the fact that, despite appearing

outwardly normal, healthy, and displaying sexual aggressiveness, these individuals may, in fact, be sterile.

Advantages of artificial insemination in ducks

Increased Mating Ratio: In the context of random mating practices, the conventional approach involves raising a higher number of drakes for the production of fertile eggs. However, this method is both costly and may not consistently achieve expected fertility levels. AI presents a potential solution to this challenge by overcoming the limitations of the low maximum mating ratio observed in ducks, typically reported as one male for every four to eight females (Ash, 1962; Olver *et al*., 1977).

Genetic improvement: Assisted breeding techniques, including sperm preservation and AI, serve as valuable complements to captive breeding programs. These techniques facilitate the preservation of valuable genetic material from individual animals, allowing its strategic introduction into future generations. This approach mitigates the risks associated with inbreeding, promoting genetic diversity and ensuring the long-term health of the population.

Reduces disease transfer risk: Transporting genetic material rather than live birds between different flocks or populations proves effective in minimizing the risk of sexually transmitted diseases. This strategy reduces the potential for disease transmission by eliminating the need to physically move live animals between locations, thereby enhancing biosecurity and disease control measures.

Use of older males from outstanding performers: In controlled breeding programs, older male birds that have served as "flock improvers" can continue to contribute their genetic influence over several generations. AI and assisted reproductive techniques extend the reproductive lifespan of these older males, enabling the controlled and efficient passing on of valuable traits to subsequent generations.

Use of injured birds: AI and related assisted breeding techniques can address the issue of unsatisfactory fertility resulting from impaired mating behavior in valuable male birds that have sustained injuries. These techniques overcome the limitations caused by injuries, ensuring successful reproduction and preserving the genetic potential of these valuable individuals.

Laying cages can be used: Laying cages are no longer a constraint when there is a need for fertile eggs. By selecting specific ducks and housing them in cages for AI, fertility of the eggs can be ensured. This approach also allows for the precise determination and tracking of the pedigree of the chickens hatched from these fertile eggs.

Successful cross-breeding: Ducks from distinct strains that do not naturally mate can be crossbred through AI. This technique facilitates the controlled introduction of genetic material from one strain to another, enabling the development of crossbred ducks with desired characteristics and traits.

Limitations of artificial insemination in ducks

More labourers: AI demands additional labour, facilities, and management compared to natural breeding. Weekly handling of each male and female duck is necessary for the insemination process, adding to the labour-intensive nature of this technique.

Experience: Implementing AI in duck breeding requires specific training and experience. Individuals involved must be well-versed in the techniques and procedures to ensure successful implementation.

Reproductive biology of ducks

A comprehensive understanding of the reproductive biology of ducks is essential for the organized and scientifically sound implementation of AI in duck industry. Both male and female ducks typically attain sexual maturity at approximately one year of age, despite not reaching their full body mass at that point. The onset of the mating season occurs in early spring, where pairs of various duck species engage in intricate courtship displays. These displays involve a series of movements and counter-movements, including exaggerated preening, head bobbing, feeding behaviors, specific calls, and postures unique to courtship. Occasionally, these displays

may occur in a social context with a large pool of potential mates.

Male gonads and sperm production

Male ducks typically possess paired abdominal testes located cranioventrally to the first kidney lobe. During the breeding season, these testes undergo a significant increase in size, similar to the phenomenon observed in mammals. Sperm production in the avian reproductive system is influenced by temperature, with maturation facilitated by a nocturnal drop in temperature or by the development of scrotal-like external thermoregulatory swellings housing the seminal glomera. Spermatogenesis primarily occurs at slightly cooler temperatures, mainly during the night when the bird's body temperature is slightly lower.

The produced sperm are transported to the epididymis and subsequently carried to the terminal end of the vas deferens, which contains a network of interconnected seminiferous tubules, creating a swelling known as the cloacae protuberance. Near the terminal end of the vas deferens, small, flat structures called seminal vesicles open into the passage.

Additionally, male birds typically maintain relatively low extragonadal sperm reserves, and the ejaculated sperm are expelled soon after production in the testes. The drake, in particular, possesses a single intermittent organ called a phallus, which undergoes a significant increase in size during the mating season and remains reduced in size when not in the mating season.

Fig 1. Housing of ducks in individual cages

Ovary, oviduct, and egg with shell source

In the reproductive anatomy of most bird species, only the left ovary and oviduct remain functional. During the breeding season, the ovary undergoes significant enlargement, presenting clusters of small grapes due to developing follicles. The oviduct, opening medially to the ovary, forms a funnel-shaped ostium. Ovulation, the process where a mature follicle releases an egg, results in the collection of the egg by the ostium, assisted by ciliary currents, and its transportation to the magnum region. Over approximately three hours, the egg acquires a layer of albumen. Subsequently, the egg moves to the isthmus, where shell membranes are deposited in a process taking about one hour. The egg then progresses into the uterus, also known as the shell gland, where the calcareous shell is added. Some bird species apply pigments in distinct patterns at this stage. Finally, the egg moves into the vagina and cloaca before being laid (Sotherland and Rahn, 1987).

Copulation and fertilization

In ducks, there is a notable contrast in the anatomy and physiology of male and female reproductive structures. Male ducks possess corkscrew-shaped phalluses, while female ducks have anti-corkscrew-shaped vaginal tracts. Phallus erection occurs through lymph filling internal chambers, causing the penis to project from the cloaca and bend forward. During copulation, the duck's phallus extends, and sperm travel along the outer layer of the penis in a corkscrew path after initial arousal.

The complexity of the duck's vaginal tract functions to exclude the penis during forced copulations, evolving in response to antagonistic sexual conflict with the waterfowl penis. In natural mating, after semen deposition in the oviduct, the semen enters the sperm storage gland, a specialized structure lined with a simple columnar epithelium situated at the junction of the vagina and shell gland. These structures, referred to as sperm storage tubules, can store sperm for extended periods, ranging from 10 days to 2 weeks. Spermatozoa eventually move up the oviduct to a second storage location at the junction of the magnum and infundibulum. The presence of an ovum in the infundibulum stimulates spermatozoa

activity, leading to fertilization of the ovum by a single sperm cell.

Selection of male and female ducks for breeding

For the successful implementation of AI, critical considerations must be taken into account in the selection of both male and female ducks. Males chosen for insemination should exhibit high productivity, superior genetic quality, sexual maturity, absence of physical defects, and overall good health. Additionally, they should display sexual activity, tameness, and freedom from external parasites. Ideally, the drake should be kept separate from, but within sight of, the females during the insemination process and temperature fluctuations should be minimized to ensure the drake's comfort.

In the case of selecting females for insemination, it is imperative to ensure the absence of hard-shelled eggs in the lower area of their oviduct, as the presence of such eggs could impede the passage of sperm to the ova, hindering the success of the insemination process.

Preparation before semen collection

To prepare drakes for semen collection in an AI program, housing them in individual cages for two weeks prior to the collection process is recommended. This period allows the birds to familiarize themselves with the attendant and the pen, with suggested cage dimensions of 1 meter in length, 1 meter in width, and 0.6 meters in height.

During this preparatory phase, it is crucial to maintain the drakes under optimal management practices, following established criteria for breeding duck maintenance. Inside the cage, a small plastic trough with water can be provided, and feeders and waterers should be fixed to the side of the cage and regularly changed. Birds may be fed *ad-libitum*, with the exception that drakes should have their feed restricted 12 h prior to semen collection. A recommended diet for Domyati drakes includes 2950 Kcal metabolizable energy per kilogram and 15% crude protein, as suggested by Ghonim *et al*. (2010), to enhance reproductive performance and fertility without adverse effects during the laying period.

To ensure a clean semen sample without loss or contamination, it is important to remove all feathers around the cloacal orifice (vent) and wipe the area with a muslin cloth. As semen ejaculation is a reflex action, a period of daily massage practice for one week, without semen collection, can be implemented to acclimatize the drakes to the handling process, reducing fear and stress. A calm and unhurried approach is necessary during actual semen collection, and visitors should remain outside the shed to minimize disturbances.

Semen collection

Fig 2. Semen collection by manual massage method

Figure-3. Artificial insemination with pooled semen

To achieve successful AI in ducks, selecting an effective and reliable method for semen collection is crucial. Two common methods are the manual massage method and the artificial vagina (AV) method. Research by Kasai and Izumo (2001) demonstrated superior results with the AV method, reporting a fourfold increase in spermatozoa per ejaculate compared to the manual massage method. The semen collected using the AV method exhibited superior motility, viability, and fertilizing capacity. Adaptation of these methods is essential for obtaining maximum clean and high-quality semen with minimal bird handling.

Manual Massage Method

The manual massage method, as modified by Kasai and Izumo (1997), involves careful handling of the drake and abdominal massage to collect semen.

The process includes:

- Gently and quickly picking up each drake, avoiding rough handling.
- Holding the drake horizontally, with the neck resting on the attendant's shoulder.
- Massaging the lumbar region on the drake's back towards the tail, inducing the evagination of the phallus and semen expression.
- Collecting the expressed semen into a wide-mouth glass vial, minimizing contamination. By following these steps with precision, semen can be effectively collected using the manual massage method.

Artificial vagina method

The AV method, adapted from Nishiyama *et al*. (1976), involves using a teaser female to stimulate the male duck for semen collection:

- Restraining the teaser female in a holding device before introducing it to the male's cage.
- Allowing the male drake to mount and grasp the teaser during copulation.
- Holding a collection tube close to the male's cloaca to collect ejaculated semen. This modified AV method effectively utilizes a teaser female to stimulate the male for semen collection.

Insemination

Collected semen samples, diluted with NSS in a 1:1 ratio, can be used for insemination. The AI technique involves applying pressure to the hen duck's abdomen and everting the vaginal orifice through the cloaca. Careful palpation ensures the absence of a shell-covered egg in the oviduct. Semen is deposited 2–4 cm into the vaginal orifice using a sterilized tuberculin syringe. Penfold *et al*. (2001) found that AI with 100 µl of extended semen resulted in fertilization and hatch rates equivalent to natural mating. Semen may be diluted with modified Ringer's solution, and Ghonim *et al.* (2009) suggested collecting semen twice weekly with a dilution rate of 1:1 for enhanced fertility in Domyati ducks. From an economic standpoint, a dose of 20 x 10^6 spermatozoa per insemination is considered sufficient to improve fertility percentage, reflecting the efficiency of AI in Domyati ducks.

Determination of semen quality traits

The determination of semen quality traits in male ducks is a crucial step in assessing their suitability for AI. Here are the key points mentioned in your text:

Visual examination: At the time of semen collection, a visual examination of the semen is performed. Semen that is off-colour, watery, or contaminated with blood, fecal matter, or urates debris should not be used for insemination. Ideally, semen should be white, viscous, and clean.

Pre-semen discharge: Before the actual semen discharge, a clear and thin discharge (usually 2-4 ml) may be encountered. This discharge is a result of secretions from the glands in the genital tract and is intended for the lavage of the tract before the actual semen discharge.

Dependence on sexual stimulation: The volume of the pre-semen discharge is dependent on the level of sexual stimulation and excitation of the drake. It can vary based on individual responses.

Timely evaluation: Within 30 min after collection, several key parameters can be determined for each drake. These parameters include ejaculate volume, sperm

motility (both mass and advanced), and spermatozoa concentration (Bakst and Cecil, 1997).

Key sperm parameters: Three critical sperm parameters are often evaluated to determine a male's fertilizing potential. These parameters include:

- Sperm Concentration: Measures the number of spermatozoa in the ejaculate.
- Viability: Viability assesses the percentage of live, healthy sperm within the sample.
- Motility: Motility evaluates the ability of sperm to move, both in mass and progressive

Semen pH

Semen pH serves as a critical parameter in assessing the reproductive health and fertility of avian species, particularly in the context of AI in ducks. The measurement of semen pH is typically conducted using a pH meter or pH paper, with most avian species, such as Pekin ducks and domestic fowl, exhibiting a near-neutral pH in freshly collected semen. However, notable variations exist among species, with the Northern pintail demonstrating the most basic semen pH of 8.5. Interestingly, a decline in pH occurs within 30 to 60 minutes of semen collection at room temperature, transitioning from alkaline to acidic conditions. This shift is thought to be linked to the increased production of lactic acid released by fructolysis. Understanding these dynamics in semen pH is crucial for a comprehensive assessment of semen quality, providing valuable insights into reproductive biology and aiding in the successful implementation of AI programs

Semen colour, consistency and appearance

The assessment of semen colour, consistency, and appearance plays a crucial role in evaluating the quality of ejaculates, especially in avian species like ducks subjected to AI. Research by Penfold *et al*. (2001) focused on the Northern Pintail (*Anas acuta*) duck, indicating that high-quality semen typically appears cream or white. In contrast, clear or opalescent semen, observed more in April and June, contains a significant number of epithelial cells with only a few spermatozoa exhibiting poor motility and high abnormal morphology. Other studies, such as Samour *et al.* (1985), conducted semen collection from Muscovy and Mallard drakes through electrical stimulation, reporting a milky-cream colour. Abnormalities in semen colour and consistency may serve as indicators, prompting the examination of spermatozoa concentration to address potential issues, as reduced concentration is linked to lower fertility levels (Roberts, 1986). Understanding these visual characteristics provides valuable insights into semen quality and aids in optimizing AI outcomes.

Semen volume

Semen volume, a crucial parameter in AI, is a key factor determining the number of females that can be covered by a male bird's ejaculate during the artificial collection process. Accurate measurement of semen volume, often done using a tuberculin syringe with precision up to 0.01ml, provides essential information about the reproductive capacity of each drake. Studies by Kasai and Izumo (1997) reported an average semen volume of 0.29 ml per ejaculate in drakes. Further investigations by Kasai and Izumo (2001) compared the semen volume collected through the AV method and the manual massage method in Osaka drakes. The AV method yielded a greater volume (0.54 ml) compared to the manual massage method (0.26 ml). This discrepancy was attributed to the larger amount of accessory fluid secretion involved in the ejaculated semen, a mixture of semen from vasa deferentia and fluid from the ejaculatory groove region. Sexual stimulation was identified as a factor that can enhance ejaculatory volume (Nishiyama *et al.,* 1976). Understanding semen volume dynamics is crucial for optimizing AI procedures and improving reproductive outcomes.

Sperm concentration

For effective AI in ducks, understanding sperm concentration is paramount. Before semen collection begins, it is advisable to have a known volume of semen diluent, a specially formulated medium to sustain sperm viability, at ambient temperature in the semen receptacle. During routine AI procedures involving 10-12 drakes, semen is pooled in a single receptacle, and after gentle mixing, the semen volume is determined. The AI dose is then calculated based on sperm concentration. The

Haemocytometer (Neubauer) method, as described by Allen and Champion (1955) and Taneja and Gowe (1961), is commonly employed to determine sperm concentration. Research by Kamar (1962) revealed variations in sperm numbers among different duck breeds, with Pekin drakes exhibiting the highest sperm concentration (5.85 million/ mm^3) and Dumyati drakes having the lowest (2.10 million/ mm^3). Sperm concentration dynamics are influenced by factors such as the collection method, age, time, season, frequency of collection, and individual variations among drakes. This knowledge is crucial for optimizing AI protocols and ensuring reproductive success in duck breeding programs.

Sperm viability

Assessing sperm viability is crucial in determining the functionality of spermatozoa in AI protocols for ducks. Viable sperm are those with intact plasmalemma, indicating their potential to contribute to fertilization. Commonly used on commercial breeder farms, the Eosin-Nigrosin technique is employed to evaluate sperm viability. In this method, sperm are stained with Eosin-Nigrosin, and a smear of the stained sperm is examined under a bright-field microscope. Viable sperm, appearing pearly white, can be distinguished from non-viable sperm, which stain pink to magenta with eosin. The nigrosin serves as a background, enhancing the differentiation between viable and non-viable sperm. Alternatively, more advanced laboratories may utilize flow cytometry with stains such as calcein AM or SYBR-14 and propidium iodide for a precise sorting of viable and non-viable sperm. Research by Kamar (1962) reported varying percentages of live spermatozoa among different duck breeds, with 78% for Domyati, 84% for Sudani and Pekin, and 88% for Rouen drake semen, providing valuable insights into sperm viability across different genetic lines.

Sperm motility

The assessment of sperm motility and mobility is a critical aspect of evaluating semen quality in ducks, particularly in the context of AI. Sperm motility refers to the movement of spermatozoa, which can be classified as progressive (in a forward direction) or non-progressive (random movement or oscillations). Progressive motility is often subjectively determined at ambient temperature using a microscope, employing techniques like the hanging-drop method, or objectively with computer-assisted semen analysis systems. In a study by Kasai and Izumo (2001), microscopic observation of individual sperm in highly diluted semen collected by the AV method and manual massage method revealed that sperm motility from the AV method (73.4 ± 2.0) was significantly greater than that from the manual massage method (61.1 ± 3.5). The increased motility observed in the former may be attributed to reduced contamination of collected samples. It's important to note that while microscopy-assessed motility has little correlation with fertility, semen samples with over 70% motility are generally considered indicative of good quality semen in duck reproductive research.

Abnormal spermatozoa

The evaluation of abnormal spermatozoa is a crucial component in assessing semen quality for AI in ducks. Examination of wet and dry smears allows for the identification and characterization of various sperm abnormalities. Penfold *et al.* (2000) observed six types of abnormalities, including microcephalic, bent head, bent midpiece, bent flagellum, giant cell, or head encased in a cytoplasmic droplet. In a study on Northern pintail ducks, Penfold et al. (2001) reported that approximately 15 percent of collected spermatozoa exhibited pleiomorphic abnormalities, with a prevalence of bent mid-piece, head encasement in a cytoplasmic droplet, and microcephaly. The percentage of structurally normal spermatozoa was found to be 85.6 ± 1.7. The frequency of semen collection and dilution rate significantly influenced coiled and clumping sperm percentages. Notably, Ghonim *et al.* (2009) recorded the lowest percentage of abnormal spermatozoa in Domyati drakes with a twice-weekly collection and a 1:1 dilution rate. The percentages of abnormal spermatozoa varied under different feeding conditions, with diets containing varying levels of metabolizable energy and crude protein affecting these percentages in Domyati drakes, as outlined by Ghonim et al. (2010). These findings highlight the impact of collection frequency and nutritional factors on the incidence of abnormal spermatozoa, emphasizing the

importance of these considerations in duck artificial insemination programs.

Estimation of metabolic activity of spermatozoa by MBRT

The Methylene Blue Reduction Test (MBRT) provides a straightforward method for assessing the metabolic activity of spermatozoa in semen. This test relies on the anaerobic production of hydrogen ions during spermatozoa's metabolic activity. These hydrogen ions, in turn, facilitate the reduction of methylene blue to leucomethylene blue, resulting in a colourless solution. The time taken for this reduction is inversely proportional to the number of liberated hydrogen ions, directly correlating with sperm motility and concentration in the semen sample. Following the protocol by Herman and Madden (1953), a solution of methylene blue is prepared in 3.6 percent sodium citrate buffer. The egg-yolk citrate diluter is created by combining equal volumes of egg yolk and sodium citrate buffer. In the test tube, 0.2 ml of semen is mixed with 0.8 ml of the egg-yolk citrate diluter, and then 0.1 ml of methylene blue solution is added and thoroughly mixed. The tube is sealed with a layer of liquid paraffin and placed in a water bath at 45ºC. The time taken for the bluish colour of methylene blue to disappear indicates the methylene blue reduction time. Nahak *et al.* (2014) reported an overall mean time of 10.03 ± 0.24 minutes for the decolourization of a unit amount of methylene blue in white Pekin ducks, showcasing the applicability of MBRT in assessing the metabolic activity of spermatozoa.

Table 2: Chemical composition of extenders used for freezing duck semen

Constituent	1	2	3	4	5	6	7
Magnesium acetate	0.080		0.080			0.080	
Calcium chloride	0.040						
Magnesium chloride		0.034			0.068		
Sodium chloride				0.480			
Sodium bicarbonate				0.280			
Sodium acetate		0.430			0.851		
Potassium citrate	0.200	0.640	0.200		0.128	0.200	0.140
Sodium glutamate	0.200	0.867	0.200	0.820	1.920	0.200	1.400
Di-potassium hydrogen phosphate		2.270					
Potassium dihydrogen phosphate		0.065					
Disodium hydrogen phosphate							0.980
Sodium dihydrogen phosphate							0.210
Glucose							0.900
Fructose		0.500			1.000		
Lactose	3.000		3.000			3.000	
Inositol				0.280			0.900
Glycine	1.400		1.400	0.040		1.400	
Mannite	0.800		0.800				
TES	3.000	0.195					
Tris			3.000				
EDTA				0.001			

(Han *et al*., 2005: Commercial semen cryopreservation techniques)

Cryopreservation of semen

Cryopreservation is a vital technique in duck breeding and genetic resource conservation, providing flexibility and efficiency in special breeding programs. The process involves several key steps and variables, each influencing the success of the cryopreservation procedure. In the recommended method, 0.1 mL of pooled semen is transferred to a 1.5 mL Eppendorf tube, diluted with an equal volume of extender, and held at 5°C for 2 h. Subsequently, 0.1 mL of dimethyl sulfoxide (DMSO) is added to each tube and gently mixed. After equilibration, the samples undergo freezing by immersion in a liquid nitrogen bath at -196°C and are thawed at 40°C. The choice of cryoprotectant is crucial, with studies favouring 10% DMSO. Extenders containing specific components, such as potassium citrate, sodium glutamate, disodium hydrogen phosphate, sodium dihydrogen phosphate, glucose, and inositol, have been identified as effective. The process involves critical considerations, including cooling rate, freezing conditions, and the thawing process. Optimal results are achieved with an equilibration time of 15 min and a thawing temperature of 40°C, as reported by Han *et al.* (2005). This comprehensive approach to cryopreservation contributes significantly to the success of avian spermatozoa storage and assists in the conservation and breeding efforts in duck populations.

Table 1: Freezing procedure

Steps	Treatment	Procedure
1	Diluent	Semen extender
2	Semen: diluent	1:1
3	Hold at 5ºC	2h
4	Cryoprotectant	10% DMSO
5	Equilibrate at 5°C	2h
6	Semen package	Eppendorf tube
7	Freezing	Plunged, LN2
8	Thaw temperature	40º C

(Han *et al*., 2005: Commercial semen cryopreservation techniques)

Evaluation of fertility

The assessment of fertility in AI is conducted by examining the collected eggs through the candling method. This evaluation is typically performed on the tenth day of incubation using a light candling test. By determining the percentage of fertilized eggs and monitoring their subsequent hatching rates, researchers can effectively estimate the success of the AI process. Due to the observed low fertility rates in natural mating, AI has been preferred for specific breeding purposes, as demonstrated by Rouvier *et al.* (1984) in the production of mule ducks in Taiwan. This method provides a reliable means of evaluating the efficacy of AI techniques and ensures the optimization of breeding programs.

Factors affecting semen quality and fertility of eggs produced by AI

Levels of energy and crude protein content in the feed used for the ducks, frequency of semen collection, dilution rate of semen, insemination dose of semen, extenders used, technique of artificial insemination and season and time of artificial insemination.

Conclusion

In conclusion, AI emerges as a pivotal solution to counter the challenges associated with low fertility in ducks, which may stem from factors like injuries, aging, or diminished libido in superior drakes. The hygienic collection of semen, employing methods such as massage or AV, ensures the acquisition of high-quality samples. Typically, the collected semen is pooled and appropriately diluted using extenders before being employed in the breeding process. Moreover, the integration of advanced reproductive technologies, such as the cryopreservation of semen and AI, proves to be instrumental in the duck industry. These techniques not only offer enhanced productivity but also address specific breeding challenges. By providing increased flexibility and efficiency in managing breeding programs, these technologies contribute to genetic resource conservation and improved breeding outcomes. Consequently, the utilization of AI and related advancements holds significant promise for

the duck industry, playing a crucial role in its overall success.

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