ASSISTED REPRODUCTIVE TECHNOLOGY AND ITS APPLICATION IN LIVESTOCK

Abstract

The production of animals has benefited significantly from the implementation of assisted reproductive technology. In breeding, marker systems are generally used for marker-aided selection (MAS). Marker-assisted selection is a procedure through which beneficial genes can be detected by the presence of marker genes. Marker assisted selection (MAS) is a type of indirect selection method in which a trait of interest is selected based on a marker related to the trait instead of the trait itself. To improve genetic evaluation and selection, all information gathered at markers and QTL will be blended with phenotypic data.

The potential advantages of nuclear transfer cloning employing mammalian somatic cells are immense. However, in every species where actual clones have been developed, somatic cloning has been shown to be unsuccessful. High rates of foetal mortality and abortion can frequently be observed. The incomplete reprogramming of the somatic nuclei during the cloning process has been linked to these developmental abnormalities. Although a number of techniques have been employed, major advancements in nuclear transfer efficiency have not yet been made. Molecular biology is advancing at a pace never seen before these days. The ability to create transgenic animals is one of them. The first successful transgenic animal was a mouse. A few years afterwards saw the arrival of pigs, sheep, cattle, and rabbits. The effects of aberrant reprograming during pregnancy, the neo-natal stage, and development in the cloned generation are all part of the continuum known as the cloning syndrome. However, it does not seem to be passed on to successive generations after sexual reproduction.

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The majority of in vivo studies regarding somatic cell cloning in cows has concentrated on developing while pregnant and the neonatal phase.

Broadly speaking, the primary initial three phases of artificial reproductive technologies (ARTs) - 1) artificial insemination (AI) and gamete and embryo sexing, 2) multiple ovulation and embryo transfer (MOET), and 3) in vitro fertilisation, or IVF, procedures - have developed into effective commercial uses that enable genetically-based growth in production, shortened generation intervals, disease control, and cost savings. The procedures included in the 4th phase of ART are considerably more experimental and include transgenesis, stem cell biology, and nuclear transfer (NT) cloning of embryonic or somatic cells. These technologies are totally reliant on earlier technological generations and are entwined with each other and the molecular tools that are currently accessible. However, a number of reproductive issues continue to prevent livestock from reproducing to their full potential, which has an impact on profitability and productivity. It is obvious that the use of these technologies as profitable endeavours will remain dubious if they are not combined with other aspects of animal production, like proper animal husbandry techniques, animal nutrition, and animal health.

Keywords: Assisted reproductive technologies (ART), marker-assisted selection (MAS), nuclear transfer cloning (NT), transgenesis, pluripotent Stem Cells (PSCs).

I. INTRODUCTION

The technical description of assisted reproduction technology (ART) is reproductive technology used to improve the genetic material of livestock.

For animals, it generally includes four successive generations of assisted reproductive technologies (ART). The commercial application of the first three generations of ARTs, which involves artificial insemination (AI), multiple ovulation and embryo transfer (MOET), in vitro fertilization (IVF) procedures, and gamete and embryo sexing, is successful. On the other hand, the fourth generation of ARTs, which includes nuclear transfer (NT) of somatic or embryonic cells, genetic marker-assisted selection (MAS), stem cell biology, and transgenic animals, tends to be less successful. Even though their commercial uses have been relatively small, the third and fourth generations of assisted reproductive technologies (ART) provide the potential for improving the breeding rate of superior animals.

The fourth generation of assisted reproductive technologies is increasingly being implemented. The categories that follow are the fourth-generation ARTs: -

1. **Genetic Marker-Assisted Selection:** Genetic marker-assisted selection has been implemented in association with phenotype in recent years. Previously, selection for breeding in livestock was carried out on the basis of superior phenotypes.

   The widespread availability of information on the animal genomes can be used to improve breeding programs through the improvement of desired features. Quantitative trait loci (QTL) are chromosomal regions or loci that are responsible for many traits, each of which might impact the trait's variability [1].

   Genetic marker-assisted selection (MAS) is the method by which genetic markers have been used to identify the target loci that specifically affect the single desired trait gene and also quantitative trait loci (QTL) [10]. The size of the QTL determines the genetic gain in MAS [2]. By way of example, there are commercial markers that have been linked to cow tenderness [1].

2. **Nuclear Transfer Cloning (NT):** Nuclear transfer cloning is a form of cloning in which the nucleus of a somatic cell has been introduced into an enucleated metaphase-II oocyte, which leads to the generation of an animal new who is genetically identical to the somatic cell donor.

   While working at the Roslin Institute in Roslin, Scotland, in the 1990s, Ian Wilmut, Jim McWhir, and Keith Campbell conducted studies. Many sheep were primarily utilized in the experiment, including those born in July 1996. One of these sheep, Dolly, was born on July 5 of that year's experiment. The first sheep to be commercially cloned, Dolly, was developed from the nuclei of fully differentiated adult cells as opposed to those of early embryonic cells [4].

Low efficiency and a high chances of developing defects are complications with somatic cell cloning [12–18].Currently, 0–10% [3] of nuclear transfer is efficacious. Between weaning age and the age of four, cloned calves developed from somatic cells have an annual mortality rate of at least 8% [11].

3. **Transgenesis:** Transgenesis is the process by which one introduces a desired DNA segment or gene (transgene) to an animal so that it is capable of transmitting the transgene to all of its progeny.

   An animal has been determined to be transgenic if a foreign gene has been introduced into its genome for the purpose of altering its DNA. Somatic cell nuclear transfer (SCNT), gene transfer into gametes, and the DNA microinjection technique are the three types of techniques utilized to transfer foreign DNA [5].

   Nowadays, transgenesis has been employed in the majority of food animals, which comprises fish, cattle, sheep, goats, pigs, rabbits, and sheep. The first transgenic animal is a mouse. The first transgenic livestock, i.e., sheep, were developed in 1985 by microinjection of foreign DNA into one pronucleus of a zygotic (Hammer et al., 1985) [6]. For many years, microinjection was the technique of choice, even though more efficient methods based on somatic cell nuclear transfer (SCNT) are now available. At present, transgenic animals are not employed in breeding schemes, even though they are used to improve milk's protein content and develop proteins for therapeutic purposes.

4. **Biology of Pluripotent Stem Cells (PSCs):** Pluripotent stem cells have the ability to self-renew and mature into the three primary germ cell layers, which eventually result in the development of all of the adult body's cells and tissues.

   PSCs can be generated from two different sources: induced pluripotent stem cells (iPS cells), which can be generated by reprogramming somatic cells, and embryonic stem cells (ES cells), which are obtained from an embryo [7].

   Induced pluripotent stem cells (iPSCs) are produced from two endangered species: Mandrillus leucophaeus and northern white rhinoceros [20].

II. APPLICATION OF ASSISTED REPRODUCTIVE TECHNOLOGIES

- Assisted reproductive technology is utilized to expand the lineages that are less common.
- It is done in order to produce a large number of young, quality females.
- By allowing female progeny testing, it is used for improving genetic research.
- It shortens the generation gap.
- It might assist in reintroducing genetic material to breeding populations.
- The use of sires with superior genetic material is expanding due to technology similar to artificial insemination.
- It might be useful for directly recovering gametes, such as oocytes and sperm, from an animal's gonads following death or gonadectomy.

- The relative contributions of the aging oocyte and the aging reproductive tract to decreased reproduction in elderly animals are assessed using embryo transfer technology.
- It is possible to transport frozen embryos across great distances, such as from one nation to another, utilizing cryopreservation embryo technology, which makes exporting cattle more affordable.
- It is used to create twins in cattle by either implanting a single embryo into each uterine horn of an infertile cow or transferring a second embryo to the recipient cow that had given birth a few days previously using the embryo transfer procedure.
- Any gene that is responsible for causing any abnormal conditions can be identified through marker-assisted selection [9].

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