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The Role of Open Nucleus Breeding and Moet in The Genetic Enhancement of Livestock

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Abstract

The primary goal of a breeder is to achieve genetic improvement that enhance productivity in the shortest time possible and at nominal cost. Although various mating systems and conventional breeding programs have led to advancements in livestock, the rate of genetic improvement is low in developing countries like India. This limited progress is due to various factors such as restricted access to artificial insemination, a shortage of high-genetic-merit sires, unorganized herds, and the small herd sizes of farmers etc. Nucleus breeding systems, with their intensive selection processes, help improve the productivity of livestock, because of their higher intensity of selection and facilitate sustainable genetic improvement.
Keywords: Open Nucleus Breeding; MOET; Genetic gain; Artificial insemination

Introduction

In the context of a rapidly growing human population and changing environmental conditions, with limited resources, limited availability of feed, and scarcity of fodder, there is an increasing demand to breed animals capable of adapting to the changing environment and maintaining their productivity. In developed countries, genetic improvement is typically achieved by artificial insemination and progeny testing of bulls based on the performance of their progenies. However, in developing countries, it is difficult to achieve genetic improvement due to a lack of infrastructure, limited awareness among farmers, and the small population size of herds. Multiple Ovulation and Embryo Transfer (MOET), coupled with Open Nucleus Breeding systems, brings about rapid genetic improvement. A nucleus breeding system (NBS) is an organized approach used in animal genetics and breeding to improve livestock through selective breeding. In this system, animals are divided into a nucleus, which consists of a smaller population of elite animals, and a larger main population. The ultimate aim of this system is to increase genetic gain within the nucleus, which is then transferred to the test herd (called the multiplier) and ultimately to the village or commercial herds.

Components of NBS

1. **Nucleus**

It is the top tier and contributes to 10-15% of the animals. The nucleus mainly consists of the best animals of high genetic merit. Selection of these superior animals is done by evaluating the performance of the progeny, pedigree, and also relying on genomic data. Here, the selection is based on the breeding value of the animals. The common methods used for the selection of elite animals include artificial insemination, MOET, and genomic selection. The increase in genetic gain which is obtained is passed on to the multiplier and village herds.

2. **Multiplier/ Tester**

The multiplier produces the breeding stock to meet the demands of the commercial/village herd. It receives genetic material like embryos, sperm, animals, and oocytes and produces the breeding stock, which is then distributed to the lower tier. It contributes to about 30-40% of the system.

3. **Commercial/ Village Herd**

This is the terminal tier of hierarchical breeding and contributes to around 40-60%. The animals are raised here mainly for commercial purposes, such as meat, milk, and eggs. The main aim is to increase productivity by selecting animals with higher genetic merit from the nucleus.

Types of NBS:

Based on the gene flow, NBS is classified as follows,

1. **Closed NBS**

In the closed nucleus population is isolated, and no genetic material (animals, semen, or embryos) is introduced from outside populations. All genetic improvement occurs within the nucleus. Selection pressure is high in the nucleus for key traits, such as milk yield, growth rate, or disease resistance. Genetic flow is one-way, from the nucleus to the base populations. For example, in highly controlled breeding programs, such as for poultry or pigs, where maintaining a strict genetic line is crucial.

Advantages:

- Since the nucleus is closed, breeders have more control over genetic progress
- Selected traits are uniformly distributed across the population.

Disadvantages:

- Risk of Inbreeding

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- Animals selected in the controlled nucleus environment may not perform as well in diverse or low-input commercial environments.

2. Open NBS

An Open Nucleus Breeding System allows for genetic input from external sources, such as the commercial or base herds, into the nucleus population. This system creates a two-way flow of genetic material, which helps to maintain genetic diversity. The key features include that genetic material can flow both ways between the nucleus and the base populations, and superior animals from commercial herds can be selected to enter the nucleus. The genetic flow is two-way.

Advantages:

- Introduction of superior animals from the base population into the nucleus,
- Reduces inbreeding and improves the overall adaptability of the herd.

Disadvantages

- Evaluating and selecting animals from the base population requires more management
- It increases the risk of disease transmission

The cooperative nucleus breeding system consists of multiple breeders or farmers collaborating to maintain and improve a shared nucleus population. Farmers contribute animals to the nucleus and benefit from the improved genetics that result. Here, farms work together to manage the nucleus and improve genetics. Genetic flow is from the cooperative nucleus to the commercial herds

3. Dispersed NBS

A variation where the nucleus population is not housed in a single location but is distributed across multiple farms or units. Each farm or unit contributes to the genetic progress of the whole nucleus system. Key features of dispersed NBS include that the nucleus population is spread across multiple farms, and there is coordination between the farms. Similar to closed or open systems, genetic flow is from the nucleus (or dispersed nucleus units) to the commercial population.

Advantages

- Reduced risk of disease outbreaks wiping out the entire nucleus

Disadvantages

- Management and coordination

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Multiple ovulation embryo transfer (MOET)

Multiple ovulation embryo transfer (MOET) is a technology which includes super ovulation, fertilization and embryo recovery, short-term in vitro culture of embryos, embryo freezing and embryo transfer. It is beneficial as it increases the number of offspring produced by elite females (hence most advantageous in case of large ruminants. Consequently, MOET can be utilized to increase the population of rare or endangered breeds, facilitate ex situ preservation of animal genetic resources, support progeny testing of females, and enhance rates of genetic improvement in breeding programs. Open Nucleus Breeding Systems (ONBS) are also accompanied by MOET, which maximizes annual genetic gain. The development of MOET technology enables an increased reproductive rate in cows. MOET is relevant where progeny test schemes are not feasible, as high selection intensity is applied to females, resulting in a shorter generation interval. Within ONBS, MOET serves as an alternative to conventional progeny testing for the evaluation of bulls and bull mothers.

Types of MOET

1. Juvenile MOET Scheme:

Here, Bulls and cows are selected at an early age, before first breeding. Selection is based on information from dam, full, half siblings, sire's record. The generation interval is short, around 2 years

2. Adult MOET Scheme:

In this scheme, the bulls and cows are selected after their first lactation record. Males are selected based on records of full siblings, half siblings, and dams. Females are selected based on their own lactation record, full, half sibs and dam's. The generation interval is longer, about 3.75 years

3. Hybrid MOET Scheme:

In hybrid MOET, the females are selected based on their first lactation record and males are selected using progeny testing.

How the nucleus breeding system works:

A group of elite animals is selected in the nucleus based on performance records, including disease resistance, productivity, and adaptability. To ensure gene flow, superior animals from the nucleus herd are subsequently utilised for breeding with lower tier herds , commercial or village herds. In order to ensure ongoing genetic development, two-way selection is carried out by reintroducing high-performing animals from the lower herds into the nucleus herd. The nucleus herd's bulls are utilised for natural service or artificial insemination (AI) to transfer enhanced genetics to other herds, while selected females contribute to next-generation breeding in the nucleus. Furthermore, thorough records of pedigree, performance,

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and selection criteria are kept in order to ensure accurate selection and improvement in traits like milk production, disease resistance, and growth rate.

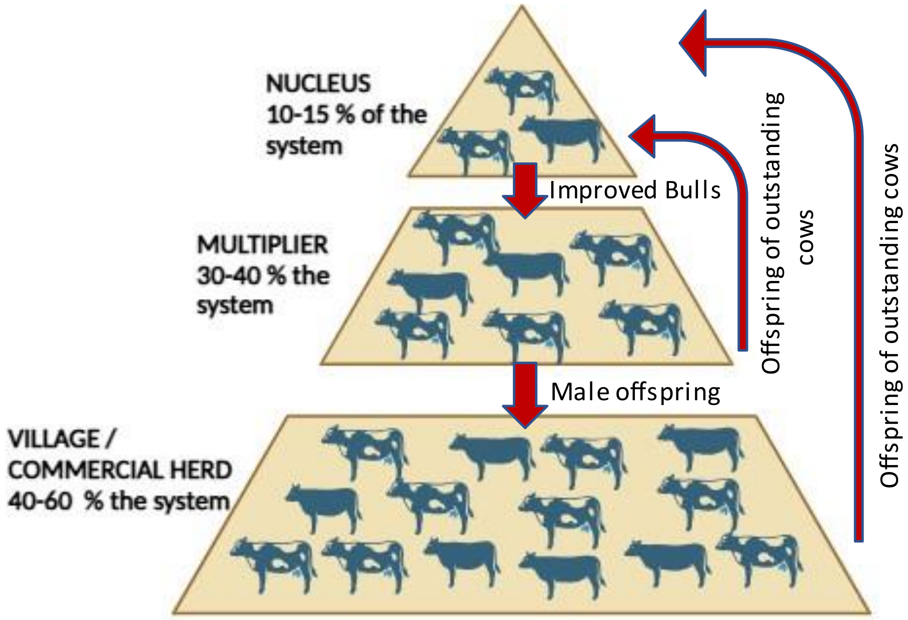

Figure 1: Schematic representation of the Open Nucleus Breeding System, showing the hierarchical structure with gene flow (Dempfle and Jaitner, 2000)

Maximizing genetic improvement through MOET-ONBS

By combining MOET with an Open Nucleus Breeding System (ONBS), breeders can greatly speed up genetic progress. MOET enables the increased reproductive rate of top-performing females, which helps spread superior genetics throughout the herd. Moreover, the two-way gene flow in ONBS promotes genetic diversity and adaptability, which is particularly beneficial in environments where resources are limited, and disease resistance is critical. The combination of these two methods enhances selection accuracy, reduces inbreeding rates, and facilitates shorter generation intervals.

Conclusion:

Multiple Ovulation Embryo Transfer-Open Nucleus Breeding System (MOET-ONBS) is the best system in the developing countries like India for genetic improvement in dairy animals. ONBS would be best medium to introduce newer animal biotechnologies such as embryo sexing, embryo cloning and gene transfer. MOET -ONBS have been shown to yield higher rate of genetic gain as well as accuracy of selection and lower rate of inbreeding and generation interval. It offers two-way gene flow and also suggests conservation of animal genetic resources. Open nucleus systems can operate effectively with multiple ovulation embryo transfer procedures for maximum genetic progress in farm animals.

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