NUCLEUS BREEDING SCHEMES

The genetic improvement in productivity per animal in the shortest possible time with nominal cost is the main aim of the animal breeder. The conventional breeding programmes *viz.,* selection and mating systems have made significant contribution in the genetic improvement of livestock but the rate of genetic improvement had been low in developing countries like India. The main reasons have been the non availability of sires of high genetic merit in required numbers, poor spread of A.I. due to lack of infrastructure, small size of farmer's herd, high cost of data recording and the selling of animals before time in field whereas in organized herds the main reasons had been the less intense selection particularly for female side, small population size and putting emphasis on non productive traits etc.

A new concept, considering the above situations for changing the breed structure so as to increase the overall genetic merit of the breed is discussed here. This has been named as **Nucleus Breeding Scheme** which may be closed or open depending on the direction of gene flow. A nucleus herd is created which is used entirely for production of males for breeding in the population. It is known through the effect of selection that mating of best with the best (selective breeding) is effective in bringing genetic improvement. Under Nucleus Breeding Scheme, a breed is structured in such a way that all the animals are not allowed to make contribution for genetic improvement but very few are given this opportunity. In India, a breed of livestock is kept at organized/institute farms known as organized herd(s) and kept by farmers known as commercial herds/flocks or village herd/flocks which are very small to the extend of 1-2 animals per farmer but collectively the village herds constitute more population of animals of a breed. However, the genetic improvement can be made in organized herd stocks for obvious reasons. An organized herd under conventional P.T. programme is treated as single herd but under Nucleus Breeding Scheme the herd is divided in two groups' *viz.,* **Nucleus herd and test herd** (multiplier). The nucleus herd is constituted of elite females of high genetic merit and is of a size of about 10-15% top ranking females of the total herd. The aim is to maximize the genetic gain in nucleus herd to pass on to the test herd and village herds. The nucleus herd breeds its own male and female replacements and occasionally introduces a sire or dam from another nucleus herd. The test herd or multiplier takes the males and sometimes the females from the nucleus herd to produce sufficient breeding stock to tweet the demand of commercial herds. Thus the genetic gain achieved in nucleus herd is passed on from nucleus herd to multiplier and then to

village herds. The NBS are of the following two types depending upon the direction of gene flow.

(i) **Closed Nucleus Breeding Scheme (CNBS)** There is one way gene flow only with the direction from top to down herds i.e. Nucleus → Multiplier → Commercial/village herds. The improvement is made in nucleus herd and passed on to multiplier and then to the commercial herds. Thus the only source of cumulative genetic progress in village/commercial herds is that occurred in the nucleus herd. This improvement in nucleus is thus must (essential) otherwise there will be no improvement in other two herds (multiplier and the commercial) because the improvement in nucleus herd is transmitted to other herds.

The time taken in transfer of genetic progress from one herd (nucleus) to the next, known is improvement lag, can be reduced by adopting any of two practices *viz.*, transferring of males and females of nucleus herd directly to the commercial herds and keeping the males and females in the lower herd for short time before replacing them with younger stock.

As there is no gene flow to the nucleus, it is so called as the closed Nucleus Breeding Scheme which is mainly used in pigs and poultry to avoid the risk of introducing diseases in the nucleus flock.

(ii) Open Nucleus breeding scheme (ONBS)

In this scheme, the gene flow is both ways *viz.*, downward from nucleus to other lower herd (multiplier and commercial) and upward from lower herd to upper herd (nucleus) by introduction of superior animals from other herds. Therefore, the superior animals from commercial herd are introduced into nucleus herd. This reduces the rate of inbreeding in the nucleus herd and increases the genetic progress because the superior animals are also available with farmers. This scheme is mostly used in cattle, buffalo, and sheep.

The ONBS can run in an organized (pedigreed) herd at institutional (Govt.) farm or by farming breed societies. The scheme is run by a group of breeders or breed societies and hence require a close cooperation between breeders. They cooperate in forming and running of ONBS for getting breeding bulls in mm from nucleus herd. This is called as **cooperative breeding scheme**.

The progeny generation of nucleus herd is reared, recorded and the males are evaluated on the basis of the performance of their sibs, paternal half sibs and their own performance. The males with high genetic merit for trait under selection can be used in the base population (multiplier)

for genetic improvement through natural service or A.I. The ONBS can be operated without E T.T. as well as by using E.T.T.

NBS using MOET or MOET Nucleus scheme

The NBS can run with or without using the MOET (Multiple Ovulation and Embryo Transfer). When MOET is used in NBS, it is called the MOET Nucleus Scheme.

In developed countries like USA, UK, France, the MOET has given a new era to the cattle improvement programmes. The MOET is a composite technology which involves a number of processes viz. super ovulation, estrus synchronization among recipients, Al. of donor, embryo recovery from donor, and finally embryo transfer in the recipient females. Generally fresh embryos are transferred but these can also be cryo-preserved for future use in case the recipients are not available on the day of embryo flushing or for the purpose of preservation of gene pool.

The MOET augment the reproductive potential of donor females. which are of high genetic merit and are given hormonal treatment. This results in shedding of more number of ova (eggs) which are fertilized by A.I. The embryos so formed are recovered from uterus of donor by flushing and transferred to the recipient cows of low genetic merit. In this way, more than one progeny (about 8) from donor cows per year can be obtained. In one flush about 4 good quality transferable embryos can be obtained and 4 flush can be taken in one year from one donor cow. The conception rate of transferred embryos in recipient (the successful rate of implantation) is about 50%.

Common features of MOLT-Nucleus scheme

An elite herd (or a few elite herds) of males and females is set up and the selection is made at an early age based on family information (sibling test from the information of full and half sisters).

The generation interval is considerably reduced for the reason of sibling zest for selection and not using the performance of the daughters. Thus the accuracy of selection is less under sibling test but this loss in accuracy is outweighted by the reduced generation interval.

The selection and testing is done within elite or nucleus herd(s) under controlled environment. By controlling environment, h= should increase and so improves the accuracy of B.V. estimation. This makes possible the greater degree of control on intensity of selection, generation interval and rate of inbreeding. This is the major advantage of MOET nucleus breeding scheme.

The rate of twinning can be increased by transferring two embryos. There are than increased chances of freemartin which can be reduced by embryo sexing. Thus more number of progeny per donor can be obtained without increasing the herd size of recipients. The problem of getting offspring from high yielding cows that are infertile due to disease or injury may be overcome using E.T. For example: it may allow brucella positive donors to have brucella negative offspring. The females carrying harmful recessive genes causing diseases can be detected by progeny testing of females with E.T.

Variants (Types) of MOET nucleus scheme

The MOET nucleus schemes are of 3 types based on the criteria and age of selection. These are as under:

(i) **Juvenile MOET:** In this scheme the selection of bulls and cows is done at an early age before first breeding. The selection criteria are the ancestor's performance only *i.e.,* dams, dam's ancestors and sibs of dams and sires. The generation interval in this scheme is less.

(ii) **Adult MOET Scheme:** in this scheme the selection of males and females is done on different criteria viz. males are selected on the basis of ancestor's performance (dam, sibs of sire and dam) plus their full and half sisters records whereas the females are selected on the basis of ancestors performance plus their own sibs and their own performance. The generation interval in this scheme is longer than juvenile MOET scheme. The bulls have to be kept for longer time in this scheme till the records of their sibs is collected and the cost of keeping bull is high.

(iii) **Mixed or Hybrid MOET:** In this scheme the progeny testing of males required for nucleus replacement is carried out in nucleus herd. The mixed MOET can be juvenile mixed MOET or adult mixed MOET.

Such species crossing in animals are generally not feasible due to differences in chromosome number. In case where it is feasible it generally results into infertility which is the effect of chromosomal aberrations occurring due to differences in number, size and shape of chromosomes.

1. **Artificial Insemination (AI)**. The semen of the desirable male is injected into the female reproductive tract Although artificial insemination as a technique has been in use for some time, it still qualifies as a form of biotechnology because it changes the reproductive rate attainable with male parents. Being able to collect semen from males and extend one collection into samples needed to inseminate several females has increased the possible intensity of male

selection. Because bulls can produce several thousand progeny per year using artificial insemination techniques, extremely high intensities can be achieved in cattle selection. In addition, evaluating breeding value of animals across herds has been enhanced greatly in accuracy with the use of sires across several herds, made more possible with artificial insemination and frozen storage of semen.

2. Multiple Ovulation and Embryo Transfer (MOET). Capabilities with this technology are still developing. Improvement in multiple ovulation techniques as well as embryo collection, handling and transfer can add greatly to usefulness of this technology. The big gain in selection programs comes through the increase in intensity of selecting females. In cattle where one offspring per female per year is, at best, natural, attainment of perhaps eight per year would make a tremendous boost in possible intensity. In addition, different selection programs are being investigated such as retrospective selection of females already super ovulated at a young age. Generation intervals may be shortened. With improvement in techniques, costs should be reduced. Improved techniques for handling embryos and storing them for extended periods have opened new avenues for breed evaluations and transfer of animals between countries.

The cow is administered with FSH to produce 6 to 8 ovules (multiple ovulation) this female is crossed with desirable male and the zygote of 8 to 32 cell stages are placed in surrogate mothers

3. Clones–Identical copies of the same genotype. Splitting embryos to get two, splitting again to get four, etc. identicals is a reality. Originally this technique was limited to production of only four embryos from the one original. The limitation was the necessary amount of cytoplasm. Use of enucleated cells to receive split embryos to supply cytoplasmic mass for further splits has been the step opening the way for creating possibly an endless number of identical copies. One of the possible uses in dairy cattle breeding, where value of commercial animals is large, would be to produce female embryos through special matings (from the very best sires and dams), make several copies, keep some stored and produce calves from some. After genetically identical heifers have matured and produced a lactation records. The average of the clone would be used to predict the breeding value of all, including the embryo “sisters” that are still being stored. The best clones would be copied again and again and sold based of their breeding value. If the only correlation between phenotypes of clone “sisters” is that due to their common gene effects

(heritability), then accuracy of estimated breeding value would approach unity as the number of "sisters" gets larger.

Cloning:

Cloning refers to the production of genes or cells or organisms with identical genetic constitution. Clone is a population of cells or individuals which are genetically identical. Cloning may be of different types:

i. **Gene cloning**: Multiplication of specific gene into several copies by recombinant DNA technology or polymerase chain reaction (PCR).

ii. **Cell cloning:** Production of specific cell types, e.g. production of hybridoma cells that produce monoclonal antibodies.

iii. **Organism cloning:** Production of individual plant or animals with identical genetic constitution.

1. In higher organisms cloning depends on totipotency i.e. ability of single cell to divide and regenerate into complete individual.
2. Plant cells usually possess totipotent ability. But in animals only zygotes possess this ability.
3. Ian Wilmut (1997) from U.K. produced a clone of adult lamb and named it as Dolly. The procedure involved the following.
4. Isolation of udder cell (vegetative or somatic 2n cells) from a sheep (template of Dolly) and the subsequent culture to form several cells.
5. Isolation of egg cell from a female sheep. The nucleus is removed from the egg (denucleation).
6. Denucleated egg cell is fused with udder cell by electrical stimulus to get a fusion product. It is similar to a fertilized zygote.
7. The fused cell, with the impulse of an electric current is forced to divide under invitro conditions. After a few divisions, the blastocyst is formed. This blastocyst is implanted in the uterus of a foster or surrogate mother.
8. The lamb produced by surrogate mother is genetically and phenotypically identical to sheep from which the udder cells were used for cloning.

4. Controlling Sex. At present, the technology is not available to sex semen, however this does seem plausible. Possible uses would be in crossbreeding programs of cattle where we wish to get female offspring from matings to get replacement heifers and male offspring from matings to get

terminal cross calves. With dairy production, we could mate the top half of the cows to get replacement heifers and the bottom half to get male calves from beef bulls. Uses in other species does not seem to be as economical due the expense on a per animal produced basis would probably be fairly constant; lower value per animal, especially in poultry, limits the use of this possible technology.

TRANSGENIC ANIMALS:

(i) Both animals and plants can take up DNA from their surrounding diverse environments and become transgenic organisms.

(ii) R.D. Palmiter and R.L. Brinter,1982 isolated the gene for the growth hormone in rabbit and in humanbeing.

(iii) These genes were tagged to the promoter region of a mouse gene. The promoter with the gene for growth hormone of rabbit or humanbeing was ligased to the vector pBR 322 to produce recombinant DNA.

(iv) This rDNA was transferred to the zygote of a mouse in vitro. The embryo was implanted in the uterus of mice.

(v) The new born was found to be transgenic. Transgenic animal is the organism in which its own genome contains a part of the genome of other animal.

(vi) Transgenic animals with desired traits are produced by transferring the respective gene from the other animal.

(vii) DNA can be taken into mammalian cells by several methods, like microinjection of eggs, by virus vectors (transduction) or by direct uptake of DNA stimulated by calcium or an electric current (transfection).

(viii) Transgenic animals are used to produce expensive and rare proteins for use in medicine ("pharming" of drugs).

Progeny test:

(i) Certain characters like milk-yield in cattle are sex-limited characters. The genes for these characters are located on autosomes of both sexes, but their expression is limited to one sex only.

(ii) Most of these genes are polygenic with cumulative expression. So these characters are quantitative (expression depends on number of genes) and they follow the quantitative inheritance.

(iii) The genes for these characters are inherited from both males and females. The male animal cannot be ignored at the time of animal breeding, as the genes for the high-yield of milk are also inherited form the male.

(iv) To assess these genes in the male animal, in which they do not express, the progeny test is conducted.

(v) Progeny test is the assessment of characters of the parent/s by studying the characters of its progeny.

(vi) A cow is crossed to a bull. The female progeny is found to be high yielding. It is inferred that the genes for milk are more in progeny than those in the mother.

(vii) The genes for milk are inherited from the mother along with the father. The male animal is with more number of these genes. If the female progeny is low yielding it is inferred that these genes are less in the progeny than those in the mother.

(viii) The male animal is with less number of these genes. Thus, the progeny test is a tool for the animal breeders to assess the male animals for the characters, generally not expressed in them.