Genetic improvement through Progeny testing - a case study

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1.Introduction

Breeding programs for genetic improvement can be pure breeding and selection, continuous cross breed production and cross breeding to limited inheritance level with subsequent selection or grading up. Pure breeding and selection can be resorted only when the animals in the population are having superior trait of economic importance; milk yield in case of dairy cattle. When the population has animals with very poor productive traits, improvement through selection within breed will yield very low results. If there are breeds having high productive traits that are adaptable to the local environment, grading up of the local population will provide genetic gain.

Cross breeding with exotic breeds is to be considered when the enhancement in productivity through grading up is not sufficient. The level of exotic inheritance will have to be limited based on susceptibility of crossbred to the environment. Continuous cross breeding with two or more breeds for taping the hybrid vigor is suitable only when the final product leaves the population as in meat purpose animals. Hence this is not a suitable system in dairy cattle improvement programs.

The guidelines for genetic improvement in cattle provided by the Government of India and programme followed by the states are in consideration of the above factors. Pure breeding is advocated in breeding tracts of various known breeds in India while cross breeding with Bos taurus breeds is practiced in non-descript cattle. Since the best buffalo breeds of the world are in the country, grading up is used for improving the non-descript buffaloes.

The enhancement in productivity due to cross breeding will be through additive gene action and heterosis. The heterosis obtained in the first generation will wean out in the subsequent generations. In order to overcome the reduction in performance due to the loss of heterosis and to enhance productivity with generation, selection within cross-bred population is warranted. In any population the gene flow from one generation to another is through four paths viz, sire to son, dam to son, sire to daughter and dam to daughter. When the mating system is artificial insemination using deep frozen semen, about 77 % of the genetic gain in cattle population will flow through the first two paths cited above. Hence the genetic improvement in cross breeding programme of dairy cattle using artificial insemination with frozen semen for mating, emphasis on selection will have to be oriented towards the parents of the bulls used. Selection of dams for daughter production will yield least results. Moreover as the average herd size per farmer is very small, it would be unpractical in our country.

Selection of bull dams can be based on the individual's performance, as it will be more accurate and less expensive. However, sire selection will have to be through performance recording of the relatives as the milk production is a sex-limited trait. Thus the most accurate method of sire selection is that based on progeny testing.

This paper describes the progeny testing programme for dairy cattle improvement in tropical small holdings, taking the Kerala programme as a case study.

2. Breeding programme of the state

Kerala did not possess any breed of cattle with good dairy qualities. Genetic improvement in the state started in low levels from 1960 through Key village schemes and later through Intensive Cattle Development Project (ICDP). Initially dairy breeds of the country were tried for grading up the non-descript with little results. Later Jersey bulls were used for cross breeding using chilled semen. With the formation of the Indo-Swiss Project for Kerala (ISPK) definite cross breeding programme was undertaken. With the joined effort of the Kerala Livestock Development Board (KLDB), the erstwhile ISPK and the Animal Husbandry Department (AHD) of the State, majority of the cattle population was converted to cross breed.

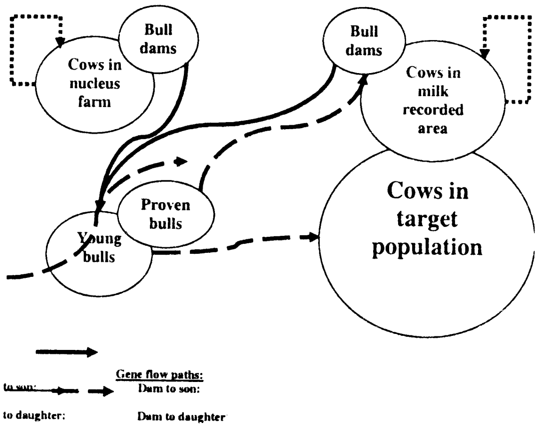

Fig 1 : Breeding scheme of the state showing different populations and gene flow

2.1 Breeding policy

The major objective in the breeding policy of the state is to enhance milk production potential of the cattle population. The means identified for achieving this objective is cross breeding of the non-descript cattle with exotic dairy breeds viz., Jersey, Holstein Friesian and Brown Swiss. The restriction in the system is that the exotic inheritance should be limited to around 50 to 62.5 % so as to retain the adaptability of the local germplasm.

1.1 Breeding scheme

The breeding scheme elaborates the population/ sub-populations and the paths through which the gene flow. The scheme also elaborates the selection criteria in various paths. The breeding scheme of the state is depicted in figure 1. Selection is carried out in the paths sire to son and dam to son. Selection of bull dams is done in the nucleus farms of the KLDB and in the milk recorded area based on the individuals' performance in their first lactation. The bull sires are selected based on performance of their female progenies in the farmers' premises.

1.2 Breeding plan

Breeding plan is the quantified scheme. The sizes of the populations in the figure depicted above are arrived based on the following factors.

- Breedable cattle in the target population
- Semen productivity of the crossbred bulls per annum
- Success rate of artificial insemination
- Migration of animals in different age groups from the milk recorded area
- Minimum number of progenies required for reasonable accuracy in progeny testing
- Selection intensity required for bull dams and bull sires
- Culling rate in males from calf hood to adult stage

1.3 Breeding activities

The activities taken up in the state constitute those for data management and controlling the reproduction. The data generated in the milk recorded area and nucleus farms of the KLDB are collected, corrected and analyzed for breeding value estimation of bulls and selection of proven bulls/elite cows. Programme is successfully carried out in the state by efficient management of the reproduction through systematic semen collection, storage and large-scale artificial insemination network.

2. Progeny testing programme

The tool used for selection of superior sires and estimating their breeding value in Kerala is progeny testing. The progeny testing programme of the state is a young bull programme with field recording system. In this programme the genetic superiority is transferred to the target population through the bulls, which are progenies of the selected parents. Another progeny selection programme is the orthodox programme where the proven bulls are used in the field. Comparative studies have shown that the annual genetic gain in the target population is equal in the young bull programme and the orthodox programme where 50 % of the test bulls are used as proven (Chacko, 1985). In another study involving the use of 40, 80 and

160 test bulls for progeny testing in an year, the discounted value of the genetic gain through the two progeny selection options were seen as same for the first two options with 43 % improvement in orthodox programme when 160 bulls were used (Chacko et.al, 1992). However, the difference in genetic gain from the different options was found to be decreasing with time. While translating the theoretical aspects into operation, the increase in milk recorded area and enhancement in semen storage facilities is very high with four fold increase in test bull size while opting for the 160 bull orthodox programme. The decline in effective control with increase in the milk recorded area can further reduce the estimated increase in genetic gain by switching to the orthodox programme. The functional flow chart of the progeny testing programme of the state is depicted in figure 2.

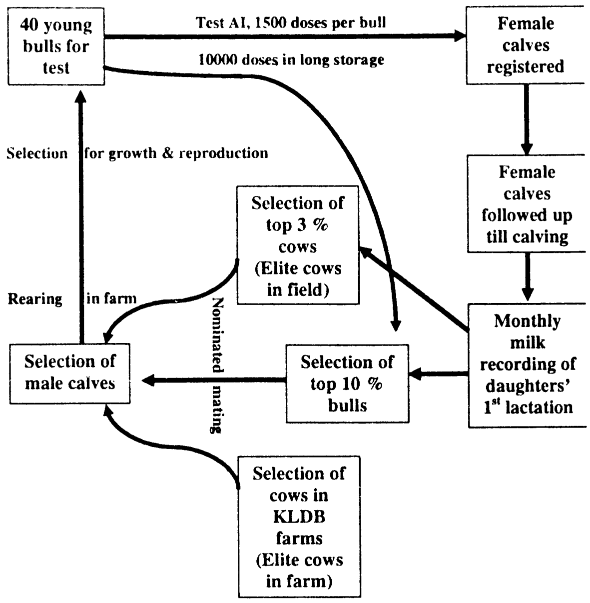

Fig 2 : Operational flow diagram of young bull progeny testing programme in Kerala

1.1 Establishing field progeny testing programme

In a cross breeding programme, establishing a progeny testing programme is essential to obtain constant genetic improvement and to counter the reduction in potential from the weaning out of heterosis effect. The appropriate time for starting the progeny testing programme in a cross breeding system in tropics has been worked out as year seven from the start of cross breeding (Chacko, 1988) with complete establishment by year 10. This is true in conditions where the mating is by artificial insemination using frozen semen and where there is well-established artificial insemination network.

In tropical situation with less contusive dairy environment, with crossbred population of Zebu cattle, the generation interval is expected to be high (Chacko, 1989). The results in Kerala have shown that the age of bulls at completion of test insemination production is seven to eight years and the age at first calving of progenies in farmers' premises is over 10 years. The genetic gain in a population is inversely proportional to the generation interval and hence an improvement in the reproductive performance can enhance the genetic improvement. It is said that too much reliance on second and third lactation of progenies for assessing the bulls will lead to bias by preferential treatment (Van Vleck, 1977). Moreover, waiting for subsequent records will also increase the generation interval. Considering the above factors, the Kerala programme of sire selection is based on the first lactation performance of the daughters.

In an area with low average cattle holding size per farmer, establishment of milk recording system is very difficult. The accuracy of the progeny testing result is seen to increase rapidly with number of progenies till 50 and then the increase rate becomes slow. Further enhancement of the number can also result in a downward trend of accuracy due reduction in effective control over the milk recordings. Hence the progeny testing programme in the state is so designed for obtaining 50 first lactation records of each bulls put to test. The test doses required for artificial insemination is dependent on the conception rate, follow up of female calves registered and migration of animals from the progeny tested area. The Kerala programme involves the use of 1500 doses of test insemination, which is based on the results obtained as mentioned in table 1. Only herd book registry and incentive programs for the farmers can reduce the losses in identified progenies, thereby reducing the number of test inseminations.

	Numbers	Percentage	Cumulative percentage
Test AI	1500		
Female calf birth reported	225	15	
Female calves registered	180	80	12
Heifers in the area	81	45	5.4
First calvers	69	85	4.6
Completed first lactations	51	74	3.4

Source: Chacko 1992

It is established that computation of lactation yield from the monthly recordings is sufficient for progeny testing. In the progeny testing programme of the state in addition to the monthly recording of milk yield, environmental effects are also recorded like the housing type, feeding practices, sex of calf, season of calving etc.

When the bulls used are for a target population, which are in more than one agro-climatic zone, it is essential to distribute the test insemination of all the bulls equally in different zones. In Kerala three agro-climatic zones are identified for splitting the test insemination and they are the high ranges, mid ranges and costal area.

The details of cows enrolled in the milk recording programme of the state for progeny testing over the years is given in table 2.

1.1 Data generation and analysis

The recorded first lactation milk yield of daughters is not the genetic value alone but is also affected by various factors. Hence the data has to be corrected for classifiable effects before using for sire evaluation. Various factors identified for data correction in the Kerala programme include the age at first calving, season of calving, month of calving, sex of calf, agro-climatic zone, progeny testing centre within the zone, lactation length, nutrient availability (DCP and TDN) and shed type. Statistical significance of the effect made by these factors on the milk yield is assessed using computer aided least square analysis programme. The first lactation yield is then corrected using a model as given below.

Yield = Mu + e_1 + e_2 + ... e_n + E

Were **Mu** is the recorded yield; e_1 to e_n are the effect made by the environmental factor that affects the yield in statistically significant manner; **E** is the random unclassifiable error.

The corrected milk yield is used for the breeding value estimation of the bulls, which is done using the following formula.

$$BV = 2 \times {}^{n}/_{(n+k)} [(X_1 - X_3) + 0.2 (X_1 - X_2)]$$

Where: **BV** = Breeding value of the bull

$\mathbf{X_1}$ = Least square corrected first lactation average of daughters

$\mathbf{X_2}$ = Least square corrected first lactation average of cows in best three PT centres

$\mathbf{X_3}$ = Least square corrected first lactation average of population

Table 2. Details of cows enrolled in milk recording and completed lactations over years

Year	Enrolled	Completed
Up to 1989-90	34520	24810
1990-91	2823	2140
1991-92	3600	2464
1992-93	2606	2946
1993-94	3049	1955
1994-95	2713	2428
1995-96	2658	2178
1996-97	2715	2399
1997-98	2508	2380
1998-99	2182	1972
1999-2000	2519	1833s
2000-01	2408	2207
Total	64301	49712

Source: Annual report of KLDB s2000

n = Number of daughters

k = 4 - h^2/ h^2

h^2 = Heritability for milk production

1996	2012	2220
612		
1997	1698	2235
614		
1998	1599	2372
677		
1999	1789	2424
657		

Source: Annual report of KLDB 2000

Table 3. Average standard lactation milk yield (Kg) in cows under field milk recordsing programme

Year	Number	Yield	SD
1990	2039	1796	569
1991	3017	1833	560
1992	1700	1960	621
1993	1823	1985	596
1994	1897	2046	618
1995	1827	2134	604

The estimated annual genetic gain can be calculated by modeling the selection intensity, heritability, genetic variation and generation interval in different gene paths in the programme. The estimated gain in the young bull programme for Kerala per annum has been estimated as 23 kg per animal per lactation (Chacko, 1980). It is also estimated that the excepted gain will be 26 kg per animal when multiple ovulation and embryo transfer is included for the bull production programme in Kerala (Chacko et. al., 1992). The realized genetic gain will be much less and even in closed herd dairy production in UK, 60 to 70% expected gain is reported as the realized gain over (Rendel and Robertson, 1950). The situation will be much lesser in situation like Kerala with cross breeding of non-descript as the breeding programme using more than one exotic breed, due to the following factors.

- Heterogeneity of the genetic groups
- Small herd size per farmer
- Sub-optimal management practices

The performance of the daughters of bulls in the milk recorded area under progeny testing programme in Kerala over years is given in table 3.

1. Summary

Programme for improving the non-descript animals with exotic breeds warrant a sound selection system among the crossbred population. This is essential when the programme is not for continuous crossbred production. In tropical condition with poor dairying environment and small holding size, a sire selection programme through progeny testing was considered as impossible. Even with the all the constraints Kerala has been successful in establishing a field progeny testing programme and could continue the same for over twenty years. This system in the state has helped very much in sustaining the milk production and also in producing an incremental increase. The success in the state has been well appreciated by the Government of India and the plans are to establish similar systems in the other states of the country taking the Kerala as a model. The Kerala case will be a model for any dairy cattle improvement programme in low input and small holding populations.

2.References

Annual report of Kerala Livestock Development Board Ltd 2000., Kerala, India

Chacko, C.T., 1980: The genetic consequences of different selection policies for crossbred bulls for use in AI in Kerala (India), Diss. Institute of Genetics, Univ. of Edinburgh.

Chacko, C.T., Bachmann, F., Schneider, F. and Kropf, W., 1985: Result of dairy cattle improvement programmes under field conditions in India: Kerala as a case study, Lead paper 36th Annual meeting of EAAP, Kallithea, Greece.

Chacko, C.T., Schneider, F. and Unnithan, N.R, 1988: Progeny testing in a large scale crossbreeding programme in Kerala, India - Scope and limitations, Proc. VI World conf. On Anim. Prod., Helsinki, Finland.

Chacko, C.T., 1989: A sire evaluation system for crossbred bulls in India, Proc. Of 23rd Dairy industry congress, Hyderbad, India.

Chacko, C.T., 1992: Progeny testing of crossbred bulls in Tropics - The Kerala programme - A case study, Proc. Of National seminar on progeny testing of bulls in tropics, Thiruvananthapuram, Kerala, India.

Chacko, C.T., Beda Angehrn and Gopakumar, C.P., 1992: Consequences of MOET in crossbreeding programme - modeling with the Kerala programme, Proc. Of National seminar on progeny testing of bulls in tropics, Thiruvananthapuram, Kerala, India.

Rendel, J.M. and Robertson Alan, 1950: Estimation of genetic gain in milk yield by selection in a closed herd of dairy cattle, J. Genetics, 50:1.

Van Vleck, L.D., 1977: Theoretical and actual genetic progress in dairy cattle, Proc. Int. Conf. on quantitative genetics, the Down State Univ., Ames.