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BREEDING VALUE ESTIMATION OF DAIRY BULLS: A REVIEW

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INTRODUCTION

Bull selection in cattle and buffalo in Pakistan has traditionally been done on their appearance and sometimes on the performance or extraordinary records of their dams. The weak relationship between the dam's extraordinary record and the performance of bull's daughters has resulted in little or no improvement in the past (Talbott, 1994; Khan, 1997). The use of any extraordinary record such as show ring winning has further deteriorated the situation, because such selection is mostly for a better environment which is not transmitted to the next generation. The genes and the qualities (traits) controlled by them are transmittable only.

The process of ranking of bulls on the performance of their progeny is called progeny testing and such bulls are called progeny tested or proven bulls. Use of such bulls is the major cause of improvement of cattle in developed countries. Development in bull selection and evaluation procedures have been enormous in the past 30 years. Techniques of selecting the top quality bulls have gone from personal choices to a highly sophisticated job. This paper reviews the progress of bull selection and breeding value estimation and pinpoints areas requiring immediate attention for research and development.

Breeding value estimation in the past

Identification of genetically superior males has been underway long before the identification of genes and principles governing them. Importance of bulls and their selection for traits like milk yield started in the early part of this century. It is relayed that before the discovery of Mendel's principles, farmers like Bakewell had progeny tested rams by leasing them after first use and returning the superior males to the flocks. An index to estimate bulls transmitting ability for milk and fat percentage was proposed as early as 1913 (Pirchner, 1984). A more popular one is Yapp's Index (Yapp, 1924) which calculated the transmitting ability of sires by deviating the dam's record from twice the daughters' records. The basic equation to determine daughter's performance was as follows:

Daughter = (Sire + Dam)/2 or Sire = 2 x Daughter - Dam.

Many modifications and improvements in this equation followed. The summary of the work on progeny testing up to the early thirties is given by Edwards (1932). The Daughter-Dam Comparison (DDC) method of proving sires started in the USA in 1935, replacing sire comparisons on the Daughter Average. Sires were tested by comparing the production of at least five daughters with the production of their dams. Many indices including the Equal Parent Index and the Regression Index were proposed.

Before the advent of artificial insemination (A.I.), progeny testing of dairy bulls appeared questionable in regard to feasibility. It was recognized that after initial use to breed 12-15 cows, a young bull should be retired until 5-6 daughters had records. Loaning and leasing was a much recommended practice (O' Connor, 1962). The advent of A.I. was also accompanied by an increase in participation in milk recording. Consequently, many daughters lacked recorded dams. The advantage over daughter's records (taking into account the sampling nature of inheritance and accounting for environment responsible for determining the yield of the daughter) was overcome by the time lag between the time daughters and dams gave their first records. In many cases comparisons were severely biased due to the environmental changes especially when daughters and dams made their records in different herds (Bath *et al.*, 1985).

The next important method of sire evaluation was the Herdmate Comparison (HMC) method, also known as stablemate Comparison, developed by Henderson *et al.* (1954) and Robertson and Rendel (1954). This method is considered as the first genetic evaluation procedure developed especially for evaluating bulls. The record of each cow was compared with the records of other cows milking in the same herd at the same time. The assumptions that the animals used were random samples of one genetic population in each breed, absence of genetic trend in each breed, same severity of culling for herdmates of all cows, and same level of treatment with no preferential treatment to any cow and her herdmates, were very hard to meet.

The HMC was replaced by the Modified Contemporary Comparison (MCC) in 1974 (Bath *et al.*, 1985). Only first lactation records were used for comparison. Contemporaries were defined as the cows approximately calving at the same time Thus, possibilities of inaccuracies from age-corrections were minimized. Also, inclusion of first records avoided the bias that might arise from including the later records, made only by cows that escaped culling and therefore were subjected to preferential treatment. Number of records, however, were substantially reduced.

Mixed model methods were later employed having Best Linear Unbiased Prediction (BLUP) properties. The predicted Difference (PD), a measure of transmitting ability of the sires, became a more common term for dairy farmers in the form of PD_{74} and PD_{82}, the digits 74 and 82 representing the genetic base i.e. cows calving in 1974 and 1982 as the reference points for comparison (Norman, 1986). Increase in the accuracy of sire evaluation by the MCC necessitated additional complexity in calculations. Henderson (1973) described the developments and computations of BLUP procedure to cope with structured populations and differential culling. The availability of powerful computers helped for the worldwide acceptance and is now considered as the standard procedure for evaluation of progeny tested sires. Two models in this regard are worth mentioning. One is called the sire model, where relationships among sire are also accounted for, and second (an improvement of the first), sire-maternal grandsire model, where contribution of the grandsire is also given due weightage.

Animal model evaluation

The term Animal Model describes the genetic model used for the evaluation of animals. This is an improvement over one of the mixed model methods, the sire-maternal grandsire model. This method combined the desirable properties of the selection index and the capacity of linear model methods to deal with large sets of data with unequal subclass numbers. The information from animal itself, its ancestors and its progeny is incorporated with all known relationships among the animals considered. A lactation record (standardized to 305-2x-ME basis) is considered to be explained by herd management (herd-year-season), herd-sire interaction, and permanent environmental effects.

The herd management effects are defined as the management conditions specific to a season in a given herd and year of calving. The registry status (registered or the grade) and lactation number are also considered with a moving season (2 months) in evaluating dairy animals. Two fixed seasons can also be used (Powell *et al.*, 1991). Thus cows calving in the same herd-year-season, registry status and lactation number are considered to have produced under similar management conditions. However, if less than five lactation records are in the management groups, the latter are combined to obtain sufficient number of contemporaries for valid comparison.

Herd size under field situations is usually so small that either animals are grouped according to some administrative units (Chacko *et al.*, 1984) or no grouping is made i.e., all the daughters of the other bulls serve as contemporaries (Chaudhary *et al.*, 1988). Contemporaries were defined those animals calving over a period of 30 years in the study of Jain and Malhotra (1971). This assumes that any factor like season, year and herd or any interaction among them is unimportant. The issue for small herd size has been discussed by Chauhan (1991) for Indian condition for cattle and buffaloes. Khan *et al.* (1997) reported that the four or five season scenarios were better than the two season scenarios for animal model evaluation of buffaloes. The average number of lactations represented in a HYS combination varied widely from 6 to 28. A very low number of subclasses for a given HYS combination necessitated the use of fewer seasons.

The herd-sire effect limits the influence daughters in a single herd may have on estimate of sire's transmitting ability especially when daughters are few and their distribution in herds is not uniform. Permanent environmental effects are considered because all lactation records are affected by the permanent environment, yet the effect is not transmitted to the next generation. Example of such effects is a quarter lost to mastitis early in a cow's productive life. The genetic merit of a cow also affects her production records. The breeding value of any trait is divided by 2 to determine the genetic superiority (or inferiority) transmitted to the offspring. The temporary environmental effects represent the other random factors that affect a cow's production. These effects may be across lactations. Health disorders or unusual managemental conditions in any part of the year are examples.

Buffalo bull evaluation

Lack of recording systems under field conditions in buffaloes limited the bull evaluation programs mostly to institutional herds. In the recent past however, attempts have been made in many countries including Pakistan to extend such programs to village level for testing bulls under varying levels of management. Estimation of breeding values of buffalo bulls in the past was also limited to some form of contemporary comparison. Most of the indices are modifications of indices developed for cattle in the early days of cattle improvement in Europe and North America.

Earlier attempts on bull evaluation in Pakistan include Nili-Ravi bulls evaluation by Ashfaq (1961). Type and pedigree were poor indicators of milk yield. Therefore, it was suggested that selection in the basis of type and pedigree should only be done when other information such as daughter's performance was not available. Evaluation of buffalo bulls, used up to 1978, was reported by Shah and McDowell (1981) using contemporary comparison. At least five daughters were required with records of 250 days or longer for any sire to be included in the analysis. For the two herds, PD for milk yield ranged from -125 to 132 Kg for Rakh Gulaman herd and between -172 and 260 kg for Qadirabad herd. Cady *et al.* (1983) analyzed data from two farms of Nili-Ravi buffalo in Pakistan and predicted breeding values of sires used. Within herd ranking of sires was done on the basis of best linear unbiased predictors of one-half additive genetic merit for progeny production in 250 to 305-day lactations. Small average difference among sires and fewer number of daughters were predicted to entail high risk and slow improvement in the breed. In another report, Chaudhary *et al.* (1988) ranked four bulls on the basis of performance of their daughters using index given by Jain and Malhotra (1971). Index values range from 2345 to 2422 kg for the four bulls based on 41 daughters.

With the advancement in computing and refinements in statistical techniques, dairy cattle improvement methodologies with some modifications can be adopted to the buffalo evaluation and improvement. Khan *et al.* (1993) developed an animal model to get solutions for age at calving and lactation length adjustment of Nili-Ravi buffaloes. Khan (1997) evaluated milk yield records on 5341 lactations of 2507 buffaloes from four institutional herds and four field recording centers, involved in progeny testing program to evaluate buffaloes and bulls under an animal model. Milk yield for the eight locations ranged from 1835 to 2543 kg. Breeding values for milk yield averaged 9.3 and 32.2 kg in buffaloes and bulls, respectively with low variation in the breeding values of tested bulls. Genetic trend in buffaloes was reported negative but sires used in the recent years were better than the past. However, bulls with more daughters had below average breeding values for milk yield. This perhaps was due to more emphasis on the physical type of the animal than on any other information on pedigree or progeny.

Availability of computing software

Many computer programs are now available that can help calculate the breeding values of bulls and cows with the help of personnel computers (PC's). Programs are available for single and multiple trait evaluation of animals. such computer softwares include DFREML (Meyer, 1988), LSMLMW (Harvey, 1990), PEST (Groenveld *et al.*, 1990), JAA (Misztal, 1992), JSPFS (Miszal, 1992a), MTDFREML (Boldman *et al.*, 1993), DMU (Jensen and Madsen, 1993), and MTC (Misztal, 1994). With such software, solutions to mixed model equations and estimation of variance components are by Restricted Maximum Likelihood (REML) (Patterson and Thompson, 1971). All of them support animal models with fixed and random cross-classified effects as well as covariables. With exception of LSMLMW, programs are basically written for main frame computers or at least for work-stations and are not user-friendly for PC environment. The JAA, DFREML and PEST have been modified for use on PC's. The same os true for MTDFREML and MTC that can be run under DOS (Disk Operating System) or OS/2 (Operating System 2) environments. With the exception of JAA and PEST, these computer programs are used primarily for variance component estimation. Breeding value estimation is a by-product of such estimation. Some of these programs (for example MTC and JAA) also calculate the reliabilities of the animals' breeding values.

Future outlook

Dairy bull and cow evaluations are likely to be more frequent and more precise in the future. Models of animal evaluation are also continuously improving and new traits are being recorded and added. Multiple trait evaluation, for example, is likely to replace the single trait evaluation of production traits. Improvement in data collection techniques would also help in greater genetic response. New technologies like Marker-assisted selection also hold the promise of evaluating quantitative trait value of segments of the chromosome (Soller, 1990). On the contrary, projects of scientific animal evaluation in Pakistan have not yet been initiated. The few in their inception are far behind both at quantitative and qualitative levels. As the genetic improvement in buffaloes and cows for traits like milk and fat yield is possible only through the selection of bulls, proper performance and pedigree records are needed on all daughters of bulls. Preferential treatment of daughters of a bull can hamper the genetic improvement by biased ranking of bulls and should thus be avoided. Recording procedures need simplicity and accuracy for field application. In future, efforts of milk recording and genetic evaluation of bulls in the country need technical and financial assistance. Definition of traits (including type definition) in objective terms and development of models would also be a prerequisite for such programs to be effective. Development of new infrastructure and modification of the current with a self evaluating long term sustainable support programs can help select suitable animals for improving the per unit productivity of dairy cows and buffaloes.

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