IAEA-TECDOC-1620

Selection and Breeding of Cattle in Asia: Strategies and Criteria for Improved Breeding

Prepared under the Framework of an RCA Project with the Technical Support of the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture

IAEA

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

SELECTION CRITERIA AND BREEDING OBJECTIVES IN IMPROVEMENT OF PRODUCTIVITY OF CATTLE AND BUFFALOES

A.K. JAIN
Department of Animal Breeding and Genetics
Punjab Agricultural University
Ludhiana, India

M. MULADNO
Institute Pertanian Bogor
Fakultas Peternakan
Raya Pajajaran No. 1
Bogor, Indonesia

1. INTRODUCTION

Breeding objectives for improving the productivity of or conserving particular breeds or genetic groups of livestock depend upon many factors. Among these factors are the agro-climatic conditions of the area of inhabitation (including endemic diseases), agricultural and livestock systems in vogue, availability of feedstuffs — including crop by-products, herd size, marketing structure and locally available animal genetic resources, socio-cultural and economic level of the livestock owners, available infrastructure and facilities, desire and capabilities of farmers and the political and administrative will of the state to bring about change in animal productivity to improve the living standard of livestock farmers. The religious sentiments of some populations attached with animals, especially cows, shall also not be ignored in defining breeding objectives. In addition, breeding objectives must not only consider the present status of these factors, but also take into consideration the future needs for quantity and quality of animal products. As the generation intervals of livestock, particularly of cattle and buffaloes is quite long, the impact of breeding plans are not expected to be realized for several years, by which time the requirements may be different.

2. TRAITS OF IMPORTANCE

One of the first steps in developing a breeding programme is to consider which phenotypic traits are of importance. From a practical standpoint, traits with a measurable or at least readily recognizable economic value are generally to be given the most emphasis, although traits that provide a less tangible utility for cultural or other reasons may also be considered important. The economic traits are typically those that affect either the income obtained or the costs of production. In the South Asia Pacific region (SAP), the sale or home consumption of milk, meat, dung, and skin of the animals and the sale of surplus animals for breeding and meat are the main sources of economic returns of cattle and buffalo farmers. In addition, many farmers use themselves or rent out their animals for draft purposes, either providing an additional source of income or saving the costs of contracting out for these services. Some of the important traits that need to be included currently for both dairy and beef cattle and buffaloes are listed in Table 1. Traits associated with income are typically called *production* traits. For dairy cattle and buffaloes, these traits are those that are associated with milk production. In most of the countries in the SAP, farmers are paid according to the kilograms of milk sold, so milk yield is obviously a trait of high economic importance. When milk is sold in a formal market, the price paid per kilogram may be adjusted based on concentrations of milk solids. Fat content is almost always considered under such a system, but payment for protein or solids-not-fat is becoming increasingly common. The milk of buffaloes is priced 1.5 to 2 times than cow milk due to its greater concentration of milk solids

(17 to 19% versus around 13%) and in certain areas it may be mixed with cow milk to increase the thickness of cow milk and, in turn, improve its market acceptability.

TABLE 1. TRAITS OF ECONOMIC IMPORTANCE IN DAIRY AND BEEF BREEDS OF CATTLE AND BUFFALOES

Important traits	Dairy cattle/Buffalo	Beef cattle/Buffalo
Production	Milk yield Concentration of milk solids	Body size or weight Growth rate Carcass quality Age and weight at slaughter Leanness, carcass percentage
Reproduction	Age at first calving Calving interval Age at first collection of semen	Age at first calving Calving interval Mothering ability Scrotal circumference
Health	Disease resistance	Disease resistance
Management	Longevity Milk let-down	Calving ease Temperament
Physical appearance	Body colour, shape, and dimensions, udder characteristics, structural traits and body condition	Body colour, shape, dimensions, structural traits and body condition

For beef cattle, economic value of a cow or buffalo is logically based on the amount of meat expected to be obtained from the animal. In contrast to industrialized countries, the sale price is not always based on formally weighing the animal and paying a certain price per kilogram. Rather, the animal is often priced as a whole. Nevertheless, larger animals fetch a higher price, so some measure of body weight is of particular importance. Reaching a mature weight as quickly as possible is advantageous, so weights at different ages, such as weaning, one year-of-age, and slaughter, can be taken to evaluate growth rate. Age at slaughter can also be used to account for growth rate; younger animals would be favoured. Birth weight is also often considered important for beef cattle, but largely for calving difficulty rather than production, so smaller birth weight may be preferred. Carcass quality traits can be important for some of the countries in the SAP, but in most cases this variable is not considered in the sale price, so a farmer can not economically justify considering it in a selection goal.

Traction is also an important output of cattle and buffalo in the SAP. Animals with long legs, straight barrels and tight skin are generally assumed to be stronger and thus favoured for draft purposes. The *Bos indicus* males with large humps and well-developed dewlaps are preferred because of more dissipation of heat due to a larger surface area and more body reserves for drought periods.

Reproduction traits are also important more so in dairy animals. For beef cattle, the number of offspring produced determines the number of animals available for sale. Consistent reproduction is also important for dairy cattle and buffaloes because daily yield is highest in the months immediately following parturition and because longer dry periods (resulting from failure to conceive quickly) result in greater costs for maintenance without any income. Both late age at first calving (AFC) and long intervals between calving, especially in *Bos indicus* cows and riverine buffaloes, have been often cited as constraints to profitability in cattle farming in the SAP [1, 2].

Animal health is important for a number of reasons. First, sick animals require costs for treatment. Healthy animals also tend to produce more meat and milk and reproduce more regularly. The climatic conditions of many of the SAP countries can be demanding, with high temperatures, both extremes in precipitation and high risk for disease, so animals that are naturally resistant to problems associated with these adverse conditions are of high value.

Traits associated with management may also be worth considering. Increased longevity is important for a number of reasons. If their animals live longer, farmers can have the opportunity to sell excess animals or expand their herds, both of which would increase the potential for income. Increased longevity also allows for more opportunities for genetic selection. Because disease often leads to death or culling, the animals that live the longest are often those most resistant to health problems. For many indigenous cattle breeds, the presence of or suckling by a calf is necessary to ensure milk let-down. The milk consumed by the calf can obviously not be sold. In truth, this may not result in much waste, inasmuch as the milk consumed can improve both the health and growth rate of the calf, but selecting for milk let-down without this source of stimulation would at least allow farmers to choose between selling the milk and feeding it to the calf. Calving difficulty can cause losses to both the calf and the cow, so this trait may be important, especially when crossing with exotic breeds with larger body sizes than indigenous breeds or with known dystocia problems. Temperament is important in any situation where interaction with humans is critical, especially when animals are used for draft purposes or when animals must be milked regularly.

Finally, different aspects of physical appearance may be important. As already mentioned, body size is important for both beef and draft purposes. Coat colour or traits of the horns may be of importance for traditional or cultural reasons and thus may affect the market value of an animal. Udder traits may be associated with milk production, resistance to mastitis or ease of milking [3].

Although Table 1 divides traits into dairy and beef or draft, some overlap may occur. This is already obvious in the fact that some traits, such as those related to reproduction are listed in both columns. In addition, sale of male dairy animals can be a significant source of income and some animals may be used for draft purposes. The relative importance of these traits will be different in different areas and is important in determining the final breeding objectives.

3. BREEDING OBJECTIVES

In the strictest theoretical sense, breeding goals and objectives should be established based on formal studies that consider the value (expressed in economic terms) of different traits and their genetic parameters [4]. In many cases, using such an approach for formal derivation of a precise selection goal will not be feasible in developing countries. For this reason, waiting to adopt a breeding programme until such a formal approach can be applied is not recommended. Existing indigenous and other knowledge can likely be amassed and sufficiently organized to develop a reasonable selection objective by using an ad hoc and participatory approach. In fact, many industrialized countries develop breeding strategies based, at least in part, on the wishes of farmers. A safe conclusion is that production traits merit significant emphasis. Although quantifying the amount of emphasis is not easy if some sort of numeric index selection is not applied, which will often be the case, approximately 50% emphasis on production traits seems reasonable and would be consistent with many of the breeding goals used in industrialized countries [5]. The remaining selection could be placed on traits associated with reproduction, health and longevity, body characteristics and cultural preferences. However, assigning a precise relative value to the latter types of traits may be difficult, however.

The beef and dairy cattle production industries in the SAP are of interest to a wide variety of stakeholders. These stakeholders include the livestock farmers themselves, cooperatives, non-governmental organizations (NGOs), various private agencies, the government and consumers. Ideally, all of these stakeholders would have the same objective, but they often differ for breeding programmes in the developing countries. For example, the farmers have the objective to get maximum returns from their livestock rearing, while governments may be more interested in food security and conservation of some of the particularly important indigenous breeds. The private companies will be primarily interested in more profits and consumers will like to have low prices and good quality and while ensuring safety of the products.

Although differences in opinions among stakeholders may exist, participation of the farmers in the establishment of a breeding objective is critical. However, because they will play a primary role in applying the breeding objective, farmers are reluctant at applying an approach to selection for which they see no returns. They may also consider as important traits that have no obvious economic value from one who is uninformed, but may be important for management or cultural reasons. If farmers are not participating in selection programmes, then the programme will have a difficult time achieving success. The government needs to watch and check the distortion of the market by interested parties. The government may intervene to stabilize the market when necessary. Economic studies related to a specific breeding programme can be undertaken by governments, institutions, researchers or scholars to justify the potential benefit of investment in the breeding programme. Such studies can make useful thesis topics for students pursuing advanced university degrees. Frequent interactions among the different stakeholders are necessary for redefining the goals of breeding programmes.

4. BREEDING AND SELECTION CRITERIA

Because of wide variability in the amount of information available for selection of cattle and buffaloes in different countries in the SAP, a number of different methods of selection of females and males may need to be used by the various stakeholders. The primary stakeholders performing selection will be farmers and artificial insemination (AI) service providers, which include government agencies, NGOs, cooperatives and private organizations, and the approaches available will likely differ among these groups, even within the same country.

4.1. Selection criteria by farmer

4.1.1. Female selection

Even under the best management, the low reproductive rate of cattle (relative to other livestock species) limits opportunities for genetic selection of females by the herd owner. The opportunities for selection are further decreased by high AFC and long calving interval found in the SAP. In addition, an absence of performance records makes accurate selection difficult. Most selection that will be done, especially within a farmer's own herd, will be effectively culling of unwanted animals, rather than selection of the best animals. When the opportunity for selection among females is available, such as when females are purchased, farmers should select females on the basis of expected milk or meat producing ability or (considering the conditions under which the animal will be raised), reproduction, health and structural traits. Meat producing ability will primarily be based on body size and appearance of muscularity.

In most countries in the SAP, no formal records will be available upon which to base selection. However, exceptions to this general rule can be found, records exist in some parts of some countries, and efforts are underway to increase record-keeping. Thus, it pays to set down selection guidelines for situations both with and without records.

When no records are present, selection for producing ability must be based on the physical characteristics of the animal. Certain physical attributes can give a clue to milk producing ability. In countries where crossbreeding is practiced, breed characteristics will be a strong indicator of producing ability. Animals with a greater proportion of exotic inheritance will generally have greater producing ability. Such animals will have characteristics such as larger size, a more angular form, and distinct colour markings (e.g. Holstein-Friesian crosses will tend to be nearly solid black, or black and white, depending on the other breed in the cross). Depending on the environment and resources available, one may want to avoid selecting animals with characteristics of exotic breeds that are too distinct, however, as this may indicate that the proportion of exotic inheritance is too high and it may be difficult to feed such animals adequately and they might be prone to health problems. Within breeds, udder capacity of adult cows is likely the most accurate physical indicator of genetic ability for production [6]. Large udders are desirable only up to a certain point, however, and increased capacity resulting from greater width and length of the udder is clearly preferred over increased udder depth and cattle with large, pendulous udders should be avoided. Such udders can be a forewarning of related health problems or indicate advanced age.

If a farmer decides to begin a record-keeping programme, a minimum amount of data must be kept to be of value for future selection decisions. The International Committee on Animal Recording offers guidelines on animal recording in developing countries [7]. Once an animal is born, it should be assigned some form of identity (either a name or number) and the date of birth should be recorded. In addition, the identity of the mother and father should be noted, along with an indication of breed or genetic type of the offspring and its parents. For cattle raised for beef production, body weight should be periodically recorded as the calf grows. Few, if any farmers will have a scale for weighing cattle, so a weight-tape can be used. Other body measurements, such as height at the shoulders or hips could be taken as well. This recording can be done at specific age milestones, such as weaning or one year of age, or at times that have no particular meaning. The important factor, especially in the latter case, is to also record the date when the measurement was taken. For dairy cattle, essentially no data needs to be recorded (in a minimal recording system), until puberty is reached. At puberty, farmers should record when a heifer is bred and to which bull the she is mated. The primary benefit of this is to help in accurately recording the sire of the resulting calf, but can also be used for reproductive management. Once the offspring is born, the date of calving should be recorded for the cow, and a record set of data should be created for the offspring, with the same information described earlier. For beef cows, from this point the primary data needed will be records of breeding and calving. Information on the growth of offspring will also be useful, but this data will be contained in the calf's own record sheet. For dairy cows, records of production should be taken. If one is to follow the practice of record-keeping services in industrialized countries, milk production will be recorded monthly. However, this level of frequency is not absolutely necessary for accurate selection. Even as few as two records per lactation can provide 60% of the information of monthly records. When few records are taken, they should be recorded at the same stages of lactation for all cows that will be compared together, such as at the time of maximum production (30 to 60 d), and mid-lactation

(100 to 200 d). Otherwise, the date of recording must be recorded and the days since calving must be accounted for in a statistical procedure. Recording of breeding and production information should continue for the life of the cow.

When records are available, selection can be made on the animal's own performance if the animal is an adult, or records of relatives if the animal has not yet calved. Let us consider two levels of record availability: (1) where some individual information is available, but no formal comparison of animals has been made, and (2) where some sort of statistical analysis for genetic evaluation is possible.

When only individual phenotypic records are available, past and current production should be examined. If possible, records should be compared to that of animals in the same herd and calving in same season, inasmuch as this factor could affect the availability and quality of feed. When animals from two herds are compared, the difference in production could be due in part to differences in management between the herds, rather than real producing ability of the cows. The effect of the age of the animal should also be considered, as cows tend to produce more milk in each successive lactation, until they reach maturity. In addition to producing ability, the AFC, lactation number and current age should be reviewed to evaluate reproduction and the remaining lifespan. For heifers, records on relatives may be limited to that of the dam, if they are available at all, and then one should evaluate records as if he or she was purchasing the mother. If sire records are available, then these should usually be emphasized over those of the mothers, because they would be based on the average of multiple daughters (i.e. half-sibs of the animal considered for selection) and thus be more precise estimates of the sires' genetic value than single production records of cows.

Selection decisions are made simpler when formal genetic evaluations are considered. With a genetic evaluation, records are collected at a single location and evaluated statistically to estimate genetic values for each animal. Proper genetic evaluations will account for factors such as age and season of calving and compare animals within the same herd. Depending on the complexity of the system employed, the genetic potential of all of the relatives will also be considered. Thus, a farmer can simply rank the animals based on the index available and select the highest ranking animal among the selection candidates.

Regardless of the level of record-keeping done and the information available for selection on producing ability, the cow or heifer should be free from any obvious health problems, including having reasonable body condition considering the feed availability. These aspects are of importance primarily for phenotypic reasons, as they will impact cost of production and longevity of the cow herself, but such traits are, nevertheless, under some genetic influence and thus could have some association with the future performance of the cow's offspring.

4.1.2. Male selection

The male pathway of selection theoretically offers more opportunity for increasing intensity of selection but, unfortunately, the livestock farmers in the SAP often have little or no choice when selecting males for breeding. In some cases, only a single bull is available for a community or village. With AI, the selection of semen from the AI centres, which are usually run by government or one of its agencies, is often very limited and inseminators may either not offer much choice or will make the selection decision on their own. In situations of low sire variety, factors other than the genetic potential of the bull must take precedence. One factor is genetic relationship of the bull to the cow and the desire to avoid inbreeding.

Inbreeding can be a particular problem in areas where bull availability is limited. Also among the factors that farmers may need to consider are the breed and age of the bulls. In countries where crossbreeding is practiced, a farmer may simply want to ensure that a bull of an exotic breed is used, to 'upgrade' their stock consisting of unimproved local animals. In contrast, he or she may want to specifically avoid using an exotic sire, to prevent reaching a level of foreign genetics that has been found to be incompatible with environmental (climate and endemic diseases) conditions. Alternatively, the breeder may be attempting rotational crossing, and may have a specific breed in mind. With regard to age, choice of the youngest available bull may be optimal in many situations. As mentioned, many AI centres in the SAP have only a limited number of bulls that service a community of farmers for many years. Thus, using the youngest bulls tends to decrease the chance that the bull had already been used within the same herd (perhaps even to produce the animal to be inseminated) and thus decrease the likelihood of inbreeding. Also, if the AI centre imports its bulls, younger sires are likely to be genetically superior, due to continual genetic improvement in the originating country.

When farmers have a group of sires from which to make a choice, the goal of selection should be similar to that for selection of females. That is, producing ability of the daughters should be emphasized, while avoiding problems that increase production costs. For beef traits, which are not sex-limited, the bull's phenotype can be considered and growth rate, size and muscularity are traits of importance. For dairy traits, some sort of progeny test should be applied if possible, even if it is ad hoc. If information is available, a sire index, such as the average production of daughters (preferably based on more than 10 offspring) should be considered. If a formal progeny test is not available, and if a farmer is a member of an AI cooperative with a large number of members concentrated in a small area, the farmer may be able to conveniently visit a few neighbouring farms and see several daughters of bulls considered for selection as sort of an informal progeny test. Of course, such opportunities will be limited in areas where little record-keeping is done and may only be feasible in communities served by small cooperatives with few bulls. Again, one must continue to consider that the repeated use of a common bull should be avoided to prevent inbreeding.

When natural service is inevitable, due to non-availability of AI services in the area or poor conception rate by AI, such as with buffaloes, the service bull needs to be selected on the basis of its pedigree performance, its breed characteristics and structural and health condition.

4.2. Selection by local AI service providers

4.2.1. Female selection

Mothers of bulls will likely be chosen from two sources, depending on the resources available. Cows will either be obtained from farmers or selected from within a single nucleus herd operated by the AI service provider (which could be government-owned) or a cooperating organization. Selection from farmers will usually increase the pool of animals from which to select from, whereas a nucleus herd can allow for more control and increased accuracy of data. A nucleus herd may also allow for recording of special data. As mentioned previously, excessive AFC is a factor restricting profitability of dairy production in SAP countries. Although management and nutrition affect AFC, rate of maturity also contributes. The heritability of AFC has been found to be in the range of 0.10 to 0.25 [8, 9]. Heifers that begin to show ovarian activity sooner are more likely to have their first calf at a younger age. Testing of progesterone by using radioimmunoassay (RIA) or enzyme-linked immunosorbent assay (ELISA) can be used to monitor heifers to determine when they initiate reproductive cycling. Application of such a procedure would be difficult for heifers spread out on many different farms, but comparatively straightforward with a central nucleus.

When animals are selected from farmers' herds, ideally farmers involved in the selection programme will have several cows, so that animals can be compared both within and across herds. When purchasing bull calves or females for future bulls, AI service providers have to consider the production and reproduction records, general appearance, breed makeup and pedigree performance of the cow. The most accurate way to select the best cows will be to perform a statistical analysis to obtain a genetic evaluation. Many factors other than genetics will affect an animal's production. Among these factors are herd management, age, and time when the record is taken. These factors should be recorded for each phenotypic record and included as 'fixed' effects in a statistical analysis.

If a formal statistical analysis cannot be done, then data 'adjustment' must be done. Consider the case for records of daily milk yield. Assume that available are four daily milk yields per cow from cows of different ages (in terms of different parities) in different herds. For simplicity, assume that the four records were taken at similar stages of lactation for all cows. Obtaining data allowing for direct comparison of cows across herds and parity numbers would require three steps. First, for each cow, the average production over the four records is obtained. Then, each record should be multiplied times a 'conversion factor' or 'adjustment factor' to account for the fact that milk production increases in each successive lactation. We will use a mature cow as our basis for comparison. Based on information from developed countries, 1.20 is a reasonable adjustment for cows in first lactation. This factor assumes that mature cows give 20% more than cows in their first lactation. Thus, records from cows in their first lactation would be multiplied by 1.20. For cows in their second lactation, 1.10 (10%) is a reasonable adjustment factor. (Ideally, these factors would eventually be estimated using data within the country.) The final step is to account for differences among herds. To make this adjustment, average production should be calculated for each herd. Then, this value should be subtracted from the record of each cow in that corresponding herd.

This process can be summarized in the following equation for a cow j in first lactation in herd i:

$$am_{ij} = \{ [(m_{ij1} + m_{ij2} + m_{ij3} + m_{ij4})/4] \times af_1 \} - ham_i$$

where, am_{ij} is the adjusted milk record for a first parity cow j in herd i, m_{ij1} to m_{ij4} are the four unadjusted milk records from a first-parity cow in herd i, af_1 is the adjustment factor applied to first-parity records (e.g. 1.20), and ham_i is the herd average milk yield in herd i.

A similar process can be done with records for beef production. For example if the m_{ij1} to m_{ij4} are records of body weight taken at different ages. In such a case, if the four data points were taken at similar ages for all animals, the af in the equation above could either be set to 1.00 for all animals, or be used to adjust for another factor, such as differences in the age of the mother. (A specific set of adjustment factors would be needed.)

As indicated previously, in most situations, animals should be selected for more than one trait, i.e. not only milk yield for dairy cattle and buffaloes and body weight for beef. Using minimum culling levels on phenotypic characteristics other than production may be the only feasible way that one can consider a number of different traits simultaneously, especially when formal genetic evaluations are not available. With minimum culling levels, the AI service provider would first rank potential bull mothers based on production traits and then eliminate from consideration the cows with problems in reproduction, health, breed characteristics and general appearance and selecting the highest ranked cows that remain. For example, poor body condition can be an indicator of both health and reproductive problems and one should avoid the use of cows that are too thin as mothers of bulls.

4.2.2. Male selection

Currently, many of the local AI service providers in the SAP rely on the purchase of exotic bulls and semen. Selection of animals for these purchases should be based on the multiple-trait indexes from the genetic evaluation system of the exporting countries. Such indexes will generally consider both production and functional traits [5]. For young bulls, the indexes will be based on the pedigree, whereas older bulls (likely for purchase of semen only), progeny test data will be available. When purchasing semen from progeny tested bulls, paying a premium to obtain semen from the absolute highest ranking sires in the exporting country may not be financially justifiable. Interactions between genotype and environment will likely be present, so the highest ranking bull in the exporting country will likely not maintain the same advantage in the importing country. Genetic correlations of the same trait in different countries have been shown to be less than 1.00 (an indication of interaction) between industrialized countries with relatively similar management [10]. Considering the wide difference in climatic and management conditions between the SAP countries and industrialized countries, bulls are almost certain to differ in genetic value when their genetic material is imported into SAP countries. In addition, most exotic bulls will be used in crossbreeding programmes in SAP countries, but for purebreeding programmes in developed countries. The complementarity and performance of bulls in crosses with different breeds may differ from that when bred to animals of the same breed. Therefore, selecting semen from a team of 5 to 10 above-average (say, >75th percentile) proven bulls or of young bulls with high pedigree indexes will be a more robust (and economical) strategy than buying many doses from the highest ranked bull.

To ensure long term sustainability, AI service providers that currently use only imported bulls and semen should plan to start a progeny-testing programme of local bulls and buffaloes for a genetic improvement programme based on the animals in the local population. Crossbreeding will lead to an initial jump in genetic merit for productivity, but the trend will likely not continue with additional use. A number of reasons can explain this lack of sustained genetic gain. First, the initial cross yielding animals of 50% exotic and indigenous genetics have the maximum heterosis. As proportions of exotic genetics increase, heterosis will decrease and adaptability to local conditions may decrease as well. Also, although genetic progress is continual in purebreeding programmes in developed countries, the same trend is not likely to be obtained through continual use of exotic bulls in the SAP, due to the aforementioned possibility of genotype by environmental interaction.

A programme based on local livestock will allow for selection of animals in the environment to which their offspring will be exposed. Such a programme would likely have to start small and simple and then be expanded as feasible. The programme could either use a nucleus breeding approach [11] or be based on the farmers that have the best management and willingness to do record-keeping. The farmers could be encouraged to be involved in the progeny testing programme by giving them some motivating incentives like some quantity of supplementary feed, mineral mixture, veterinary health care, and semen of available progeny tested bulls for part of their herds. This strategy carries some risks, however. Offered incentives and compensation to farmers to test the semen from progeny test bulls, may make them suspicious of the quality of the semen and, therefore, reluctant to use it. A proper balance has to be reached in this regard.

Ideally, multiple traits would be considered for selection, such as milk yield, AFC and longevity, to consider both production and functionality. Such a plan might be difficult to implement quickly, so, for more simplicity, evaluation could initially be based on 'likeability' scores assigned by the farmer. To evaluate likeability, farmers would be asked to assign an animal a score of from 1 to 5, where 1 and 5 indicate an extremely poor or good cow, respectively. Such a trait would comprise a mixture of productivity, reproduction and health. Studies have shown that such a trait has a heritability near that of directly measured milk yield (around 0.20), and is highly genetically correlated with production and longevity [12]. If individual milk weights were recorded, a single objective measure such as the total milk produced by a given age (e.g. 42 months) could be used to accomplish a similar objective. Using this measure, the highest ranking cows would be those that calved at a young age and produced multiple lactations separated by a very short dry period.

4.3. Crossbreeding

Crossbreeding has been taken as a major tool for improving the animal productivity in different Asian countries. *Bos taurus* cattle have been used as exotic breeds and mated with local *Bos indicus* cows to introduce genes for higher productivity, resulting in much faster advances in productivity than could be obtained through selective pure breeding of local animals. The crossbreeding also brings in added advantages of heterosis. In dairy cattle, Holstein-Friesian is most commonly used and seems to nick well with most of the *Bos indicus* breeds. In beef cattle, there are several *Bos taurus* breeds such as Simmental, Limousine, and Shorthorn which have been used to mate with local breeds in different countries. Crossbreeding between different breeds of buffaloes with sizable genetic variance needs to be studied.

Choice of the exotic breeds to be used in breeding programme usually depends upon the purpose of crossbreeding. In case of dairy cattle, selection of exotic breeds depends upon its milk production, early maturity, and compatibility with local breeds. Because crossbreeding dilutes the gene pool of the indigenous breed, the exotic breed should provide clear advantages over the performance of the native dam breed. In beef cattle, even though body weight is mostly considered to be a trait of economic importance for breeding objective, size of the exotic breed to be used in crossbreeding programme should not be too large to avoid dystocia.

The choice of local breed depends upon availability in a particular region. Preferably, only the non-descript local animals and very lowly productive animals of recognized breeds should be used for crossbreeding. The destruction of valuable indigenous breeds with unique adaptability characters for those particular agro-climatic conditions should be avoided. Indigenous animals should be properly characterized prior to initiating crossbreeding to identify breeds with particularly valuable characteristics.

The exotic animals used in crossbreeding are not naturally adapted to the SAP conditions, so large scale crossbreeding in these countries should be carried out with caution. The need for proper feeding and management of these high yielding animals, biosecurity of sensitive animals, special requirements for health, and proper policies for disposal of surplus males and unproductive animals must be considered. In the remote areas, the government must insure proper health coverage for the livestock by providing mobile veterinary health care. In many instances, the proportion of exotic germplasm in the crossbred animals should be maintained at around 50% for better adaptability. To sustain the genetic improvement in the crossbred animals, the progeny testing of the crossbred bulls should be initiated at the earliest in all the countries, either independently or jointly under some international collaboration.

The livestock farmers that rear crossbred animals should be given adequate training in feeding and management of high yielding animals, biosecurity of their farms, AI, pregnancy diagnosis, clean milk production, and health coverage of livestock. Government institutions and AI service providers should provide this training if they are directly promoting crossbreeding by importing and distributing exotic germplasm.

4.4. Special considerations for breed conservation

With the introduction of crossbreeding on large scale in different Asian countries, the population of the recognized zebu breeds has decreased alarmingly. Thus an urgent need exists to conserve the uniquely adaptable, heat tolerant, disease resistant, draught compatible animals of local breeds of zebu cattle. As there are a large number of zebu breeds, the choice for conservation of some of the breeds will depend upon various factors such as their capacity for economic sustainability and true desire of the people to conserve the breed for social and religious purposes. Table 2 lists some of the cattle and buffalo breeds in the SAP area that warrant specific programmes for selection and conservation.

Conservation of a particular breed requires proper justification. Breeds with reasonable productivity, special characteristics and a core of interested and motivated breeders should be maintained in situ as a breeding population of commercial animals. The characterization and identification of the zebu breeds is essential for making an effort in their conservation. Formal selection programmes should be implemented to maintain genetic diversity within the breed and improve its economic competitiveness with exotic breeds. Breeding objectives should be based on improvement of productivity while maintaining distinct breed characteristics.

Conservation of particularly threatened breeds of cattle and buffaloes needs also to be taken into account in order to maintain diversity in the species. Although management and genetic improvement of a breed in situ is generally regarded as the best way to ensure its survival, some buffalo breeds such as the Toda and South Canara are already in small number and thus needs to be conserved simply to save them from extinction. Ex situ conservation programmes, such as the construction of cryogenic banks of semen, embryos, or a combination of the two [13] can also be used to complement in situ approaches for the preservation of these breeds. Conservation of somatic cells has been proposed as a low cost alternative, if funds are not sufficient to collect and store semen or embryos [14]. A general guideline is to preserve genetic material to obtain at least 25 unrelated animals of each sex [15].

TABLE 2. ZEBU BREEDS TO BE CONSERVED THROUGH EITHER IN SITU OR EX SITU MEANS

Dairy cattle	Dairy buffalo	Draught cattle	Beef cattle	Dual purpose (milk+draught)	Dual purpose (beef+draught)
Gir	Murrah	Nagori	Pesisir cattle	Hariana	Bali cattle
Deoni	Nili-ravi	Krishna Valley	Kedah Kelantan (KK)	Ongole	
Sahiwal	Toda	Amrit mahal		Kankrej	
Red Sindhi	South Canara	Malvi		Mewati	
Red Chittagong					

REFERENCES

[1] CHADHA, K.K., Analysis of Breeding Records of a Buffalo Herd, PhD Dissertation, Punjab Agricultural University, Ludhiana, India (1998).

[2] NANDA, A.S., BRAR, P.S., JAIN, A.K., "Management of buffalo reproduction in India", Proc. 1st Buffalo Symposium of the Americas (VILE, J.B., LOURANCE J.R., OHASKA O.M., Eds), Bedam, Brazil (2002) 144–155.

[3] BOETTCHER, P.J., DEKKERS, J.C.M., KOLSTAD, B.W., Development of an udder health index for sire selection based on somatic cell score, udder conformation, and milking speed, J. Dairy Sci. **81** (1998) 1157–1168.

[4] WELLER, J.I., Economic Aspects of Animal Breeding, Chapman and Hall, London and New York (1994).

[5] MIGLIOR, F., MUIR, B.L., VAN DOORMAAL, B.J., Selection indices in Holstein cattle of various countries, J. Dairy Sci. **88** (2005) 1255–1263.

[6] SHORT, T.H., LAWLOR, T.J., Genetic parameters of conformation traits, milk yield, and herd life in Holsteins, J. Dairy Sci. **75** (1992) 1987–1998.

[7] ICAR, Development of animal identification and recording systems for developing countries, http://www.icar.org/Documents/technical_series/tec_series_09_sousse.pdf, Sousse, Tunisia (2004).

[8] AHMAD, M., SIVARAJASINGAM, S., Analysis on the productive and reproductive traits in sahiwal cows, 6th World Congr. Genet. Appl. Livest. Prod. **23** (1998) 399–402.

[9] CERÓN-MUÑOZ, M.F., TONHATI, H., COSTA, C.N., MALDONADO-ESTRADA J, ROJAS-SARMIENTO D., Genotype x environment interaction for age at first calving in Brazilian and Colombian Holsteins, J Dairy Sci. **87** (2004) 2455–2458.

[10] ZWALD, N.R., WEIGEL, K.A., FIKSE, W.F., REKAYA, R., Identification of factors that cause genotype by environment interaction between herds of holstein cattle in seventeen countries, J. Dairy Sci. **86** (2003) 1009–1018.

[11] GEARHEART, W.W., KELLER, D.S., SMITH, C., The use of elite nucleus units in beef cattle breeding, J. Anim Sci. **68** (1990) 1229–1236.

[12] VISSCHER, P. M., GODDARD, M. E., Genetic parameters for milk yield, survival, workability, and type traits for Australian dairy cattle, J. Dairy Sci. **78** (1995) 205–220.

[13] BOETTCHER, P.J., STELLA, A., PIZZI, F. GANDINI, G., The combined use of embryos and semen for cryogenic conservation of mammalian livestock genetic resources, Genet. Sel. Evol. **37** (2005) 657–675.

[14] GROENEVELD, E., A world wide emergency programme for the creation of national genebanks of endangered breeds in animal agriculture, Anim. Genet. Resources Inform. **36** (2005) 1–6.

[15] MEUWISSEN, T.H.E., WOOLLIAMS, J.A., Effective sizes of livestock populations to prevent a decline in fitness, Theor. Appl. Genet. **89** (1994) 1019–1026.