L IMPROVEMENT IN THE TROPICS - THE PROGRAMMES FOR INDIA

P.N. Bhat and V.K. Taneja 1/

1. INTRODUCTION

India is the seventh largest country in the world. It is well-marked off from the rest of Asia by mountains and the sea, which give the country a distinct geographical entity. Bounded by the great Himalayas in the north, it stretches southwards and at the Tropic of Cancer, tapers off into the Indian Ocean between the Bay of Bengal on the east and the Arabian Sea on the west. It covers an area of 3 287 263 sq. km. The mainland lying entirely in the northern hemisphere extends, between latitudes 8°4' and 37° 6' north and longitudes 68°7' and 97°25' east, and can be categorized under four well-defined regions as, the great mountain zone, plains of Ganga and the Indus, the desert region and the Southern Peninsula. The climate broadly is tropical monsoon type with four distinct seasons which are winter, summer, rainy and post-monsoon. The rainfall is ill distributed and varies from place to place and year to year. The total cropped area is 175 million hectares while only 38 million hectares are under irrigation.

India is predominantly an agricultural country with about 70 percent of its population dependent on income from agriculture. Most of the land is used for cereal production and a negligible portion (around 4 percent) is under permanent pastures and grazing land. Indian agriculture depends mostly on cattle to meet its draught requirements. Bullocks supply the motile power for ploughing, lifting water from wells and transport needs in the rural areas for crushing sugarcane and oil-seeds and for a variety of other purposes. Cattle also provide milk and milk products for human consumption thus meeting part of the need for animal proteins of high biological value for the human diet.

2. CATTLE NUMBERS AND THEIR TRENDS

According to the 1982 livestock census, there are 182 million cattle and 79 million buffalo which produce around 31.8 million tonnes of milk annually against the requirement of 54 million tonnes to feed the human population of 712 million at the recommended level. The deficiency in milk production is not caused by lack of cattle numbers, but more so by their low level of production. Low productivity is mainly due to large incidence of disease, inadequate nutrition, hostile climate, unorganized breeding, social unawareness of economic benefits and non-commitment to social change in the society.

The livestock trends indicate that the cattle population has increased by 15 percent over the 1959 base. The corresponding increase in the human population during the same period was 79 percent. The population of working bullocks has also increased over the years in spite of the use of fossil energy for agricultural operations sugggesting increased usage of bullock power in agriculture. The total area under permanent pastures and grazing land as percent of the reporting area has, however, slightly gone down from 4.2 percent in 1970-71 to 4.0 percent in 1978-79. These trends suggest that more and more land is being used for cereal production for human use and that the feed resources for livestock are likely to be further reduced. There is thus an urgent need to reduce cattle numbers to match existing feed resources and improve the quality of our cattle both in respect of their milk production and draught capacity.

3. CATTLE RESOURCES

There are 26 well-defined breeds of cattle which constitute around 18 percent of the total cattle population in the country. The remaining cattle populations have not yet been defined into breeds and are generally named after the area and habitat they occupy. The performance potential of these cattle is related to the economic needs of the area. These local cattle have a poor growth rate (100 to 150 g per day), later maturity (age at first calving, 60 months) and low milk production (500 kg in a lactation). In any programme of improvement they form the core for action. The defined breeds can mainly be classified as milch, dual purpose and draught type. Some of the important ones are Sahiwal, Red Sindhi and Gir - milch type; Tharparkar, Hariana, Deoni, Ongole, Rathi, Kankrej and Goalao - dual purpose; Kangayam, Hallikar and Khillari - draught type. The age at first calving in these breeds ranged from 40 to 50 months except in Hariana where it was slightly higher. The calving interval was between 15 and 20 months. The milk yield, barring a few breeds like Sahiwal, Red Sindhi, Tharparkar and Gir, where was more than 1500 litres, in all others was below 1000 litres in a lactation. The milk yield per day of calving interval ranged between 1 and 4 kg. There are no breed societies which register animals, maintain herdbooks and ensure purity of breed and its improvement.

Most of the cattle breeds that exist today have been evolved over centuries due to large variation in soil, climate, agricultural practices and through natural selection mostly for adaptation to agro-climatic conditions, survivability and to a very limited extent these have been selected for milk for draught quality. These breeds have considerable adaptability to harsh climate, poor nutrition and possess good resistance against certain animal diseases and are economically well suited to the areas where they exist. Experimental evidence shows that zebu cattle have lower metabolic heat production which suits them well in hot climates and makes them a comparatively better utilizer of low quality roughages. It is for these qualities that some Indian breeds have been used in crossbreeding in Latin Americn countries, Australia and southern parts of United States to evolve breeds for beef and dairy production. Improved zebu breeds, viz. Gir, Kankrej and Sahiwal, have been bred and raised in Brazil, West Indies, Australia and Kenya as purebreds for milk and meat.

4. HUSBANDRY AND MANAGEMENT PRACTICES AND EXISTING INFRASTRUCTURE

Animal husbandry is a normal adjunct to crop agriculture and cattle are kept for milk production and for motile power for various farm operations, village transport, irrigation and production of manure. The animals are generally maintained on agricultural byproducts and crop residues. Animal rearing is done mostly by small and marginal farmers and landless labourers with a holding size of 2-3 animals per farm household. Average land holding with these owners is very meagre, being 1/2 to 2 acres. This is the kind of input available in most of the areas.

Animal husbandry is a state subject; health and breeding aspects of cattle are looked after through a network of veterinary hospitals and artificial breeding centres. A veterinary surgeon is the focal point around whom most animal improvement programmes are centred. In most of the planned improvement programmes, this focal point has been given the main responsibility of artificial insemination and field recording of data. Supplementary staff in the form of animal husbandry specialists, livestock assistants and field supervisors are provided to implement the development programmes. An artificial insemination network is used for dissemination of superior sires of temperate dairy cattle through crossbreeding to increase milk production. In order to meet the semen requirement, sires of temperate dairy breeds are maintained at the main germplasm units which also have the facilities of deep freezing of semen. Improvement in cattle production is also directed at improvement through feeding, generation of marketing facilities, advisory services and veterinary aid including artificial insemination.

Institutional structures funded by the government also exist. These maintain herds of cattle which act as nucleus or multiplier herds for purposes of training and research in various colleges and universities. Some farms have been established with the purpose of producing quality bulls and undertaking progeny testing programmes for some important indigenous breeds. Large government herds like military dairy farms also exist for commercial milk production. These herds are used for spreading superior germplasm to rural populations for improvement of their native cattle. This is the kind of structure that exists today on which any breeding plan has to become operational.

5. PROGRAMMES OF IMPROVEMENT

The breeding policy to begin with was to improve the defined indigenous (both dairy and draught) breeds through selection and local cattle through grading up with superior indigenous breeds. This was done through a number of cattle development programmes such as the key village scheme, hill cattle development programme, Goshala development and Gosadan schemes etc. In 1961, the animal husbandry wing considered the need for an effective and rapid increase in milk production in cattle and set up a working group to review the cattle breeding policy in the country. The working group examined the cattle breeding policy followed in each state and recommended broadly a revised policy for achieving increased milk production. The policy envisaged a) crossbreeding of cattle with exotic breeds in areas having local cattle, b) selective breeding among improved indigenous purebreds and c) grading up of local with improved indigenous breeds. It was suggested that the bulk of exotic inheritance should come from Jersey; Brown Swiss and Holstein might be tried to a limited extent. Simultaneously, attempts were to be made to provide suitable inputs.

According to the revised breeding policy, extensive areas were to be covered by such recognized dual purpose and dairy breeds as Hariana, Tharparkar, Gir, Sindhi, Sahiwal etc. To achieve the ultimate objective of raising the quality of cattle, both in regard to milk production and draught, it was thought necessary to undertake production of a large number of superior bulls, preferably progeny tested or pedigreed, of these breeds of cattle for extensive use through natural and artificial breeding and for future replacement.

Scientific programmes, to improve the productivity of the native breeds, were initiated and a number of farms of these breeds were established for production of superior quality bulls. The bulls produced were far below the numbers required for the development programmes. Bulls at these farms were selected on the basis of breed characteristics, body conformation and milk yield of their dams wherever available. Examination of records of these farms, in general, does not show any significant improvement in production over the years. It was, therefore, decided that infrastructure should be developed to test the bulls on the basis of their daughters' performance before they are used in developmental programmes. Accordingly, progeny testing programmes for some of the improved indigenous breeds, like Tharparkar and Red Sindhi under centrally sponsored schemes and Sahiwal, Hariana and Gir, under the state sponsored schemes were initiated. Results of these schemes were not encouraging mainly because of the small herd size used. Non-existence of deep freezing facilities at these farms also contributed to the failure of these schemes because by the time bulls became available after test, they were too old to donate any semen.

A fundamental change has taken place in the cattle development programmes since the formulation of breeding policy. Crossbreeding, which was to be taken up in a restricted manner, and in areas of low producing cattle, has now spread indiscriminately all over the country including the tracts of well established improved indigenous breeds. The country since then has advanced in the area of deep freezing of semen and use of liquid semen is being replaced by frozen semen. Large-scale crossbreeding programmes are being undertaken through programmes such as intensive cattle development projects, Operation Flood and other bilateral projects. Due to the energy crisis, there is a belief that animal power should be developed on scientific lines. In view of these changes, it is essential that a fresh look at the cattle breeding policy of the country be made.

The major strategy for development of indigenous cattle for milk has been to crossbreed with improved European dairy breeds. Initial crossbreeding attempts were not encouraging because of diseases such as rinderpest and other such killer diseases. With the control of these diseases with prophylactic vaccines, planned crossbreeding experiments with various Euro-American breeds (Holstein, Ayrshire, Jersey, Guernsey, Red Dane, Brown Swiss) were taken up in different parts of the country. Crossbred grades with different levels of exotic inheritance from one or two exotic breeds have been produced and their performance tested under different agro-climatic conditions. The following conclusions emerge from these experiments:

i. Exotic inheritance of around 50 percent is the most ideal for growth, reproduction and milk production, and the yield in higher crosses falls short of theroretical expectations. The grading up, therefore, to a total replacement of genes will not lead to higher production in cattle (Taneja and Bhat, 1972; Bhat et al., 1978a, b; Taneja et al., 1979; Rao and Taneja, 1982).

ii. The crosses of temperate with improved indigenous breeds (Sahiwal, Red Sindhi, Gir, Tharparkar) attained the same level of performance under uniform feeding and are superior to crosses from other native cattle.

iii. Holstein crosses were superior to other temperate breed crosses for growth and production while Jersey crosses have better reproductive efficiency (Bhat, 1974, 1983).

iv. Decline in milk yield from F1 to F2 generations on account of inter se mating among F1 crossbreds is small (Taneja and Bhat, 1978). The Targe decline in some experiments is due to poor quality of crossbred bulls used.

These results indicate that in areas with good feed resources, specially irrigated cultivated fodder, crossbreeding of indigenous low producing cattle with Holstein and stabilization of exotic inheritance at 50 percent through inter-breeding and further improvement through selection may be adopted. Such crossbreds would produce around 3000 litres of milk per lactation and would have improved reproductive performance.

A number of breeds like Taylor, Jersind, Karan Swiss, Karan Fries and Sunandni have been evolved using crossbred populations as the base foundation. In addition, five crossbred genotypes (two and three breed crosses) with Hariana, Gir and Ongole as the indigenous breeds are under performance testing at five locations in the country under the All India Coordinated Research Project on Cattle. The three breed crosses with 75 percent exotic inheritance from two breeds have shown high potential for growth, reproduction and production under optimum input conditions and are under further testing. The work on their nutritional requirement and adaptation is in progress. These genotypes are also proposed to be used as a base for developing new strains of crossbred dairy cattle.

Most of these breeds have existed at the Institutional farms except Karan Swiss and Sunandni which have been developed using crossbreds available in the field. Field recording is not in practice in most parts of the country and, therefore, progeny testing is restricted only to Governmental/Institutional farms. This is a serious limitation in accurately assessing the sire values, and achieving the desired selection intensity because of the use of few sires. There is, thus, a need to produce crossbreds in larger numbers under field conditions. These animals should be identified, registered and breed societies formed which should take up performance recording and develop programmes for synthesis of the breed and its improvement.

6. CURRENT ACTION PROGRAMMES

India is a vast country with a large variation in climate, agriculture and economic conditions. A large part of the area in the country is with low inputs and would, therefore, need well adapted indigenous breeds both for milk and draught animal power. Crossbreds have shown high performance where plenty of green fodder and other essential inputs like health care are available. The breeding programmes, therefore, for improvement of both indigenous breeds and crossbreds need to be drawn up. A system needs to be set up which would allow selection within the population to be effective. While developing strategies for genetic improvement, location specific parameters especially inputs have to be given first preference.

The indigenous breeds to be improved through selective breeding need to be identified. The magnitude to which these are to be used in grading up of local cattle and their numbers required should be worked out in detail so that appropriate programmes for their multiplication, improvement and production of quality bulls are drawn up. The existing set up of small independent farms of these indigenous breeds has not given desired results.

In order to overcome the problem of small herd size and make the within population selection more effective, the programme of associated herd testing has been introduced. This has so far been attempted for Sahiwal which is one of the high yielding dairy breeds of the Indian sub-continent. The breeding tract of this breed has now been left in Pakistan and only a few herds are available in India. The herd strength on most of these farms varies between 50 and 300. These farms were established with the purpose of producing quality bulls for use in the developmental programmes. Most of these herds did not register any improvement in milk over their period of existence. This was because of small herd size; use of sires selected on the basis of their dam's record and conformation resulted invariably in a negative genetic trend. It was observed, that only in a few herds was there an improvement in the milk yield over the years, which was due to use of sons of outstanding sires.

Initially nine farms covering a total population of around 900 Sahiwal animals were included in the associated herd testing programme. Most of these herds had varying levels of inbreeding ranging from 0 to 12 percent. The average milk yield in 305 days was around 1600 kg, body weight at first calving around 320 kg, mature weight of 360 kg, and the calving interval 450 days with herd life being around nine years. Semen of the first set of Sahiwal bulls was used in these farms during 1980-81. In the second cycle of mating, 8 Sahiwal bulls were used. A number of daughters of these bulls have now become available at these farms. The programme is in its third cycle of mating. The progeny test information on the first set of bulls is likely to become available this year. It is hoped that 1 to 2 bulls from each set with 10-20 percent superiority over the herd average would become available. These bulls then could be used on existing farms and also in the Sahiwal herds in the country or outside for herd improvement and in designed matings for production of young bulls for use in progeny testing.

Recognizing the importance of indigenous breeds for draught power and the need for developing animal power on scientific lines, the Indian Council of Agricultural Research has initiated a much larger programme for Hariana and Ongole breeds. The major objective is to conserve and improve these breeds for milk and draught qualities. Hariana is a dual purpose breed and is widely used in the Indus-Ganges plains. Initially six breeding farms with a total population of more than 1200 Hariana breedable females were included in the programme. The semen freezing facilities are being developed at the Germplasm Unit at Hariana Agricultural University, Hissar. A total of 20 bulls coming from high yielding dams and selected on the basis of body conformation will be used in each cycle. The bulls will be brought to the Germplasm Unit and semen frozen for use in six herds. Each bull will be allotted 60 cows for breeding. The female progeny born will be raised at the respective farms for performance recording while 5 male calves each for breeding and draught (work) per bull will be brought to the Germplasm Unit. Draught studies on these selected bull calves will be made. Bulls will be finally ranked on the basis of their daughter's milk production and draught qualities of their sons and the top 2 to 3 bulls identified for use in production of future bull calves and improvement in the herds. Correlation between milk yield and draught power will also be studied. As soon as the programme commences, around 10 000 females registered with the Central Herd Registation scheme, operational in Rohtak, Ajmer, Mahendragarh and Bhiwani districts, will be involved in the programme. In addition, around 15-20 percent of total animals available with small and landless farmers could also be associated in the programme by developing the field recording system for progeny testing. The bulls, thus selected after the progeny test, will be used in the Hariana breeding tract and other adjoining areas where the Hariana breed has been used for upgrading the local cows.

A similar programme for Ongole has been proposed during the 7th plan. Ongole is a dual-purpose breed. Its breeding tract extends over parts of Krishna, Kistna, Guntur, Nellore and Vizagapatam in Andhra Pradesh. The centre of the Ongole area is embedded with rivers. The banks of these rivers form excellent grazing land, as due to the fear of floods they are less cultivated. Very few farms of this breed are available. However, a large number of animals of this breed are registered with the Ongole Breeders Association. The existing Ongole farms are being strengthened by adding more animals so as to have at least 800 breedable cows at the farms. The Ongole animals on the farms, and those registered with the breeder's association, are proposed to be involved in an improvement programme on the pattern suggested for the Hariana breed.

Some of the other well-defined breeds like Gir, Kankrej, Nagore and Rathi are being improved through the use of semen of selected bulls under various state developmental programmes. No crossbreeding is permitted in breeding tracts of these herds.

A number of breeds/genotypes, on account of crossbreeding, have been produced in the country. These have shown high performance under optimum inputs and are well adapted to local conditions. For the survival of these breeds, it is essential that these are multiplied and produced in large numbers under field conditions so that an effective progeny testing programme for continuous improvement could be undertaken. For this, the development of a field recording system is very important. In order to explore the factors affecting field recording, the Indian Council of Agricultural Research has initiated a project on "Standardization of field recording of performance data and its use in progeny testing". This project is operating at four locations in the country where they have a well-developed field recording system. A large number of crossbred genotypes with

50 percent exotic inheritance around these four locations are available. Emphasis is to stablize around this level through inter se mating among crossbreds, followed by intensive selection.

Military dairy farms are a government organization having a very large population of Holstein x Local (Sahiwal, Red Sindhi, Gir, Tharparkar) crosses with 3/8 to 5/8 Holstein inheritance. These crosses have been produced as a result of continuous forward crossing to Holstein and backcrossing to indigenous breed bulls. These farms maintain more than 10 000 breedable crossbred females of the Holstein spread over different regions in the country. These facilities of men and material available at the military dairy farms are being used for developing a new dairy breed, 'Frieswal', by using Holstein x Sahiwal crossbreds as the base. Initially, 4000 Holstein x Sahiwal crossbred females at four large farms in northern India have been included in the programme. The objective is to stabilize the breed at 50 percent Holstein level. For this the elite Sahiwal cows available at the military dairy farm, Meerut, with a herd average of more than 3000 litres of milk are being used for production of crossbred bulls using semen of top progeny tested Holstein bulls. A total of 40 halfbred bulls (50 percent Holstein inheritance) are proposed to be used each cycle for progeny testing. Bull rearing and semen freezing facilities are being developed at the military dairy farm, Meerut. These facilities of military dairy farms will permit progeny test evaluation of large numbers of crossbred bulls. The semen of the tested bulls will also be made available to the developmental agencies. A series of crossbred strains/genotypes with high performance through these crossbreeding programmes will become available in the next few years.

The future emphasis on crossbreeding research in cattle would be to study the genetic aspects of production of crossbreds, effects of inter-breeding among crossbreds and to develop a suitable criterion for selection of these cattle for making further improvements in production and reproduction traits. This would require production of pedigreed progenies of large numbers of crossbred bulls, their performance recording and analysis of such records to obtain estimates of genetic and phenotypic parameters and their utilization for development of a selection criterion. This will also provide data for determining genetic merit of crossbred sires based on their progeny performance.

The programmes suggested for improvement of these indigenous breeds and synthesis of crossbred strains, if implemented with suitable financial inputs and technical manpower, are expected to improve substantially both the quality of draught animal power and milk yield.

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1/ Indian Veterinary Research Institute, Izatnagar - 243 122, India.

SAHIWAL IN KENYA AND PAKISTAN

J. Hodges1/

1. The Sahiwal cattle are an international animal genetic resource able to contribute to many developing countries.
2. Their ability to survive, produce and reproduce at medium levels of milk per lactation in tropical conditions makes them a valuable option to consider for crossing with lower producing indigenous breeds in the developing countries or for breed substitution.
3. The countries with the largest populations are Pakistan (about 10 000 purebred animals), Kenya (about 2500 purebred animals) and India (about 2000 purebred animals).
4. Many other countries have crossbred Sahiwal cattle, either produced from indigenous breeds or from black and white temperate cattle. The demand for these types of animals is increasing, shown by the growing demand for semen under the FAO semen donation scheme.
5. The population of Kenya has recently been studied by a graduate student of the Kenya Government who has analysed the records from the Sahiwal stud at Naivasha from a genetic angle.
6. FAO is currently supporting a similar genetic analysis of the Pakistan Sahiwal kept for many decades on the government livestock stations. This is being undertaken under contract for FAO by the Pakistan Agricultural Research Council in cooperation with the Swedish Agricultural University.
7. It is hoped that the analyses of the Kenya and Pakistan populations may be combined at a later stage, in order to identify the genetic differences, if any.
8. It is also hoped that a rational basis for using the limited numbers of this breed for the benefits of both the home countries and the importing countries may then be developed and be the means of accelerated genetic improvement.

1/ Animal Production Officer, (Animal Breeding and Genetic Resources), Animal Production and Health Division, FAO, Rome.

IMPROVEMENT AND CONSERVATION OF BUFFALO GENETIC RESOURCES IN ASIA

S. Sivarajasingam 1/

1. INTRODUCTION

The contribution of buffalo to the Asian agrarian economy is considerable by way of milk, meat and draught power production and as a source of security that requires minimum inputs. The domesticated buffaloes in Asia, representing 98 percent of the world buffalo population, are broadly grouped as the river and swamp types. The former which constitute approximately 69 percent are found predominantly in the Indian subcontinent. In India they supply 59.3 percent of the total milk produced.

The multipurpose swamp buffalo (30 percent) predominates in other parts of Asia especially China, Indonesia, Philippines, Thailand and Vietnam providing draught power and meat in rice growing areas and milk in other regions. The Mediterranean type predominant in west Asia, represent about 1 percent. The buffalo distribution in Asia is given in Table 1 by country. It is sufficient to mention here that the wild buffalo such as Anoa of Celebes, Tamarao of Mindoro and the Ami or Indian wild buffalo do exist and could provide potential genetic resources for further investigation.

Table 1 BUFFALO POPULATION IN ASIA BY COUNTRY, 1984

Country		Population (x 1000)
West	Asia	
	Iran	230
	Iraq	140
	Syria	3
	Turkey	758
South	Asia	
	Bangladesh	1 750
	Bhutan	28
	India	64 000
	Nepal	4 400
	Pakistan	12 777
	Sri Lanka	951

East	Asia	
	China	19 196
South	least Asia	
	Brunei	15
	Burma	2 100
	Indonesia	2 391
	Kampuchea DM	600
	Laos	915
	Malaysia	255
	Philippines	2 900
	Singapore	2
	Thailand	6 150
	Vietnam	2 664
	Total	122 225

Source: FAO

The trends in the growth of human and buffalo populations in Asia are given in Figure 1. There is a steady increase in the human population while that of the buffalo is not sustained at a similar pace. Buffaloes produce 45 percent and 31 percent of all milk and meat produced in 1984 by large ruminants in Asia, respectively (FAO statistics).

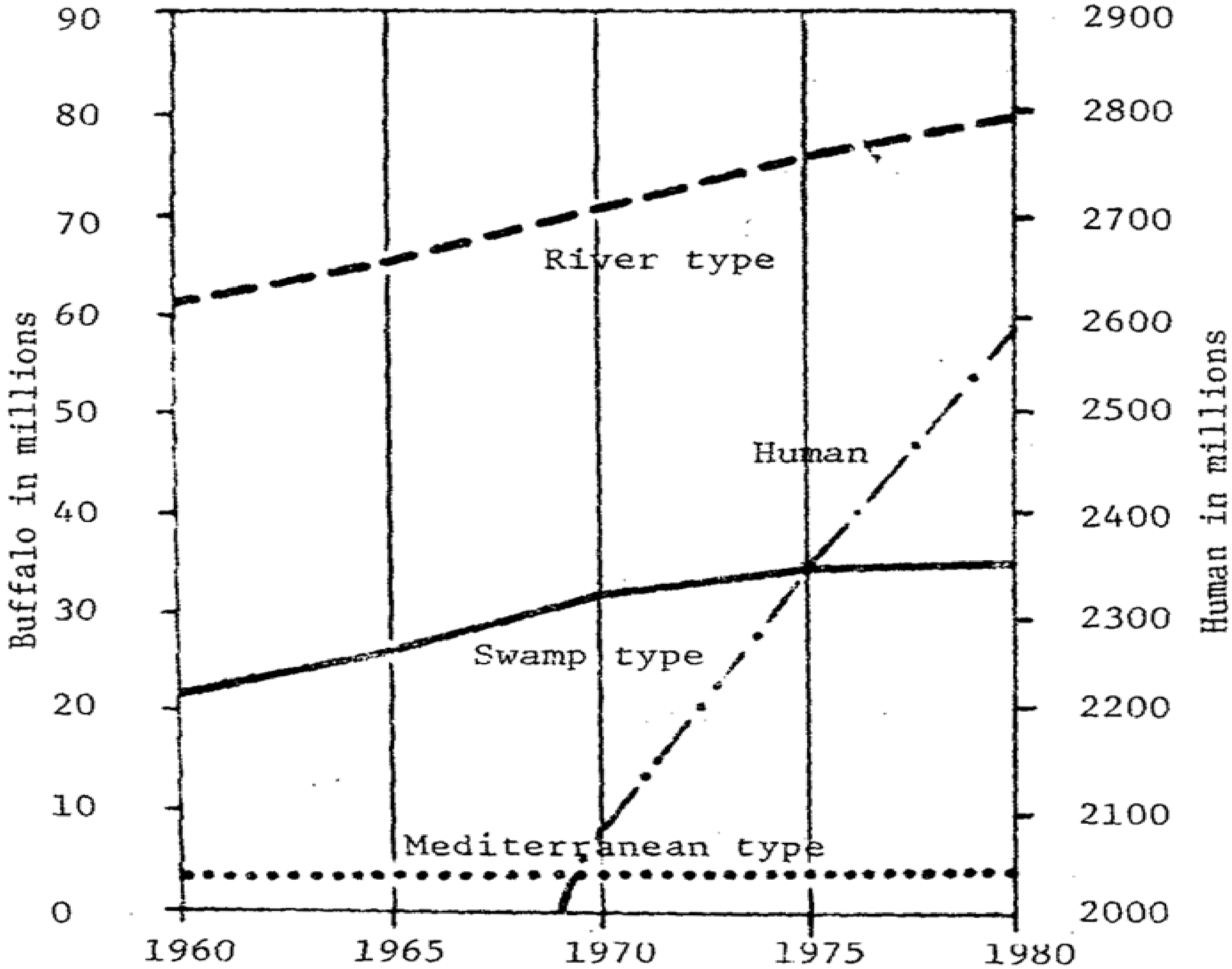

Figure 1. Trends in buffalo and human populations in Asia (Adapted from Mahadevan, 1983, Proc. Preconf. Syrap. of the 5th World Conf. on Anim. Prod., Tsukuba, Japan and FAO, Production Yearbook 1970-1983).

Buffaloes have been domesticated over several centuries. However, they have been subjected to genetic manipulation such as selection and crossbreeding only during recent decades. By virtue of the fact that it is Often conSidered a neglected species, much of its genetic variation may not have been lost except through natural selection in the domestic environment. However, two areas of concern need to be mentioned. Firstly, a complete documentation and evaluation of the variability and characterization of the various breeds and strains are lacking. Secondly, the animals, the swamp type in particular, are being displaced from their traditional ecosystems due to changing farming practices, agricultural intensification and inadequate allocation of multiplication facilities. These problems are worsened by their low reproductive rates.

This paper is mainly concerned with the potential of the buffalo germplasm which is the basis for improvement, effective methods of conservation and utilization and constraints of buffalo rearing in Asia. This will be discussed under the following headings:

2. Buffalo Performance Characteristics

2. BUFFALO PERFORMANCE CHARACTERISTICS

The potentials for improving the river and swamp buffaloes depend on the existing genetic variability within and between breeds, standards of health, feeding and management and infrastructure for recording of production data. A considerable amount of evaluation or documentation studies or both have been reported on buffaloes under varying environments. A brief review of the various production traits is given below only to show overall characteristics of the buffalo breeds.

2.1 Milk Yield and Length of Lactation

Milk is an important source of animal protein (including essential amino acids), vitamins and minerals. Efforts to improve buffaloes and cattle have been undertaken in many developing countries where the rural poor are largely dependent on livestock. A summary of yields of buffalo breeds is presented in Table 2.

The river buffalo, extensively used in the Indian subcontinent for milk production, has a production average between 1181 kg to 1934 kg with lactation lengths ranging between 283 and 313 days. The most widespread breed is of the Murrah type which has also been exported to several southeast and east Asian countries for crossbreeding with swamp buffalo. The latter breed, rarely used for milk production, produces less than 800 kg per lactation of about 250 to 330 days. Work on persistency and milk let-down in milch buffaloes is limited. It is a usual practise to allow calf suckling for about 30 to 40 seconds before milking to initiate milk let-down. Whether this is really necessary needs further investigation. Table 3 shows overall averages for buffalo milk constituents. Fat percent ranged between 7 to 10 with a mean of 7.5 amongst dairy breeds. Values for swamp buffalo were within a similar range but only a few samples were available. These values for buffalo are more than double that of cattle for which the mean is 3.7 percent. Protein percent is also higher than for cattle where mean is 3.5. The calorie value of buffalo milk is 31.5 percent higher than that of *Bos taurus* cows such as Friesian and Guernsey (FAO, 1959).

Table 2 LACTATION MILK YIELD AND LENGTH

Country	Breed	Mean lactation		Source
		Milk (kg)	Length (days)	
India	Murrah	1 813	283	Bhat et al. 1980; Gill 1985; Mostager et al. 1981; Rao and Nagarcenkar 1977
	Nili-Ravi	1 765	309	Bhat et al. 1980; Rao and Nagarcenlcar 1977
	Bhadawari	1 181	276	Bhat et al. 1980; Rao and Nagarcenkar 1977
	Surti	1 934	313	Bhat et al. 1980; Rao and Nagarcenkar 1977
China	Swamp	778	293	Liu 1978; Cheng 1984
Malaysia	Swamp	245	240	Camoens 1976; Braend 1981
Thailand	Swamp	333	250	Chantalakhana 1975
Philippines	Swamp	490	245	Eusebio 1975; Rigor 1958
Sri Lanka	Swamp	355	248	Jalatge 1980; Wijeratne 1962
Nepal	Nepali	255	121	Keshary and Shrestha 1980
	Murrah	1 272	255	Keshary and Shrestha 1980

Table 3 MILK CONSTITUENTS OF BUFFALOES

Country	Breed	Fat %	Protein %	Total Solids %	Source
India	All	7.5	4.3	16.8	FAO 1959
China	Swamp	9.8	-	-	Cheng 1984
Thailand	Swamp	9.3	-	18.1	Chantalakhana 197E
Philippines	Swamp	9.4	5.2	20.4	Eusebio 1975

2.2 Weight Characteristics

Body weights at various ages of adult buffaloes are given in Table 4. Birth weight and subsequent weights are higher than indigenous cattle in these areas of Asia. Mature buffaloes over three years of age weigh between 450 and 800 kg. A number of comparisons have been made on weight gains between buffaloes and cattle, from which no definite conclusions could be made bearing in mind the low quality of inputs we need to consider reflecting the actual conditions of the smallholder farms. It is interesting to note here the trials of Shute (1966) in Trinidad where the daily gain of buffaloes was 0.21 kg compared to zero values for Jamaica Red cattle and Brahman cattle under poor pastures. The gains increased to *0.62* kg for buffaloes and 0.50 and 0.30 kg for the other cattle breeds respectively on moderate pastures.

Table 4 BODY WEIGHTS AT VARIOUS AGES (KG)

Country	Breed	Birth	6 mths	12 mths	18 mths	Mature	Source
India	Murrah	29	119	212	264	500	Bhat 1977; Randhava 1962
	Nili-Ravi	31	134	219	289	510	Bhat 1977; Randhava 1962
China	Swamp	34	167	250	-	577	Liu 1978
Malaysia	Swamp	32	138	204	281	-	Aman and Othman 1983; Camoens 1976 Liang et al. 1982
Thailand	Swamp	29	98	144	-	473	Chantalakhana 1975, 1981, 1984
Philippines	Swamp	28	88	121	141	463	Campos 1985
Sri Lanka	Surti	21	-	-	-	-	Thamothanam 1980
Taiwan	Swamp	-	-	-	-	425	Ma 1980

2.3 Size Characteristics

The milk buffaloes of India are strikingly larger than their swamp counterparts in east and southeast Asia where they are used for draught purposes as shown by the three body measurements in Table 5.

Table 5 BODY MEASURMENTS

Country	Breed	Weight (kg)	Body length (cm)	Wither height (cm)	Heart girth (cm)	Source
India	Murrah	Adult	150	138	222	ICAR 1939, 1941, 1950, 1960
	Nili-Ravi	Adult	153	133	222	ICAR 1939, 1941, 1950, 1960
	Surti	Adult	141	128	188	ICAR 1939, 1941, 1950, 1960
China	Swamp	495	147	128	193	Liu et al. 1985
Thailand	Swamp	500	140	126	190	Chantalakhana 1975, 1981
Taiwan	Swamp	425	138	127	193	Ma 1980
Philippines	Swamp	Adult	-	128	197	Bacaiso 1951

2.4 Carcass Characteristics

In Table 6 some characteristics of buffalo carcass are given. Most of the work has been concentrated on the swamp type. Dressing percentage in most reports is below 50 percent whereas in cattle it is usually a little above 50 percent. However, the Murrah buffalo proved to be superior in many carcass traits (Ognjaovic, 1974) including a dressing percentage of 54.7 percent. There are considerable differences between the swamp buffalo reports due to the wide differences between reports, in the methods of characterization of the various cuts, variation in feeding, age and sex of the animals and regional genetic differences within the swamp buffalo.

Table 6 CARCASS CHARACTERISTICS

Country	Breed	Trait	Sexes	Mean	Source
China	Swamp	Dressing percent	M,F,C	43	Cheng 1984
Thailand	Swamp	Dressing percent	M,F	46	Chantalakhana 1984, 1975
Philippines	Swamp	Dressing percent	M,F,C	45	Castillo 1975
Malaysia	Swamp	Dressing percent	M	47	Liang et al. 1982
Sri Lanka	Swamp	Dressing percent	M,F	51	Tilakaratne 1980
Taiwan	Swamp	Dressing percent	M,F	44	Ma 1980
China	Swamp	Bone percent	M,F,C	34	Cheng 1984
Thailand	Swamp	Bone percent	M,F	22	Chantalakhana 1984
Philippines	Swamp	Bone percent	M,F	25	Castillo 1975
Thailand	Swamp	Slaughter wt, kg	M,F	500	Chantalakhana 1975
Philippines	Swamp	Slaughter wt, kg	M,F	364	Castillo 1975
Malaysia	Swamp	Slaughter wt, kg	M	306	Liang et al. 1982
Philippines	Swamp	Carcass length, cm	M,F	115	Castillo 1975; Eusebio 1975
Malaysia	Swamp	Carcass length, cm	M	131	Liang et al. 1982
Thailand	Swamp	Hide percent	M,F	13	Chantalakhana 1975
Philippines	Swamp	Hide percent	M,F	12	Castillo 1975
Thailand	Swamp	2 Rib eye area, cm^2	M,F	42	Chantalakhana 1984
Philippines	Swamp	Rib eye area, cm^2	M,F	37	Castillo 1975

Thailand	Swamp	Loin eye area, cm^2	M,F	42	Chantalakhana 1984

M = male, F = female, C = castrates

Ages range between 2-5 years.

A number of studies have compared carcass characteristics between buffaloes and cattle (Kissir et al.', 1969; Ognjanovic, 1974 and Charles and Johnson, 1972 and Charles, l982) and showed only marginal differences in quantity and quality indicating that the buffalo has a potential role to play in the beef industry of Asia.

2.5 Breeding Efficiency

A major concern in buffalo production is its low reproductive efficiency. The oestrous cycle in buffalo is similar to that of cattle although their external manifestation is not as strongly expressed as in cattle. Peak luteal levels of plasma progesterone are lower (1 to 2.5 ng/ml) and occur later in the cycle (Kamonpatana et al., 1979 and Jainudeen et al., 1982).

Overall reproductive performance compiled by a review of references is given in Table 7. Age at puberty amongst swamp buffaloes was reported to be at 2.8 years and first mating usually after the third year. However, these values largely depend on management factors. Among Murrah buffaloes, first signs of heat were also observed at the age of 2.8 years (Bhattacharya, 1954). Late first calving age and long calving intervals are common. Longer calving intervals are frequent especially among the swamp types used for draught purposes because they are rarely exposed to bulls and pregnancy when having a suckling calf running along is considered a nuisance in the field. Oestrous cycle varies between 20 and 28 days with some variation in the oestrous duration. Postpartum oestrus and bull fertility are also largely affected by seasonal variations.

2.6 Draught Characteristics

The draught power of the swamp buffalo has been reported in various countries in southeast Asia and China Table 8). They are often used in rice cultivation for ploughing. On the average they plough between 0.025 to 0.032 hectares of padi land per hour. Number of working days vary between two months and five months depending on the type of agricultural activity. Buffalo have been reported to be far superior to contemporary indigenous cattle in Taiwan (Ma, 1980). Buffalo can plough an area almost three times that covered by Yellow cattle per day. They also outlive their cattle counterparts by having a working life of 10 to 15 years compared to 6 to 12 years for cattle.

The primary function of the swamp buffalo as a beast of burden has been greatly reduced due to mechanization and the introduction of double cropping in Malaysia, China, Taiwan and Thailand. However, they are salvaged in areas where fragmentation of farms has led to small units as in Thailand and the buffalo remains a significant component. More recently, swamp buffalo are being used to haul bunches of fruit in oil palm plantations in Malaysia. They are superior to mini-tractors in that they could reach all points of collection even on difficult terrain.

3. GENETIC IMPROVEMENT OF BUFFALOES

More than 70 percent of buffaloes are nondescript and are in the hands of villagers. Genetic improvement could only be realized if there is a simultaneous alleviation of feeding and management standards including proper recording and Al or a superior bull distribution network on the ground. Objectives, in line with the envisaged production system, should also be well defined. The buffalo indigenous to China and southeast Asia, covering a wide range of ecosystems, is generally grouped together as the swamp type although distinct types are recognized. The swamp buffalo has a multipurpose role and is usually confined to traditional farming systems. The relative priority of each role varies from region to region. It is important to identify those types of buffaloes that are more efficient in draught, beef production or adaptability so that breeding goals can be more precisely defined.

Recently in 1984 ACIAR organized a workshop on the evaluation of large ruminants for the tropics in Rockhampton (ACIAR, 1984). It was obvious, also in the case of the present review, that the information available was scanty and 'disconnected' in the sense that no breed could be meaningfully characterized and its potential compared with other breeds of buffaloes. It is useful to mention here that some of the workshop's

Table 7 REPRODUCTIVE CHARACTERISTICS

Trait	India	China	Malaysia	Thailand	Philippines	Taiwan	Sri Lanka	Source
Age at puberty (yrs)	2.8	2.8	2.8	3.0	-	-	-	Camoens 1976; Chantalakhana 1975; Cheng 1984; Liu 1978
1st mating age (yrs)	-	3.3	-	-	-	3.0	-	Cheng 1984; Liu 1975, 1978
1st calving age (yrs)	3.5	4.7	-	-	3.6	-	3.6	Bhat 1980; Eusebio 1975, 1984; Jalatge 1980; Liu 1985; Rao 1977
Gestation (days)	308	315	332	-	320	-	309	Liu 1978; Eusebio 1984; Wijeratne 1962; Camoens 1976; Cheng 1984; Jalatge 1980; Mostager et al. 1981; Rao 1977
Calving interval (days)	480	-	651	395	415	-	-	Bhat 1980; Camoens 1976; Chantalakhana 1981; Eusebio 1984; Gill 1985; Liang et al. 1982; Mostager et al. 1981; Rao 1977
Post partus oestrus (days)	-	296	-	-	-	-	-	Liu et al. 1985
Oestrus cycle (days)	-	23	28	20	22	-	-	Camoens 1976; Campos 1985; Chantakakhana 1981; Cheng 1984; Ensebio 1984; Liu 1984
Oestrus duration (hr)	-	43	4	32	22	-	-	Camoens 1976; Campos 1985; Chantakakhana 1981; Cheng 1984; Ensebio 1984; Liu 1984;

								Liu et al. 1985
Calving rate	-	-	-	56	-	-	-	Chantalakhana 1981; NaPhuket 1975

recommendations included identification of genetically different populations of the swamp buffalo, an increase in their draught efficiency, and numbers especially in Thailand and China and milk capacity in Philippines. A similar approach could also be extended to the buffalo of the Indian subcontinent with emphasis on milk and draught efficiency.

Table 8 DRAUGHT POWER PERFORMANCE

Country	Breed	Trait	Sexes	Mean	Source
China	Swamp	Plough, ha/h	M,F,C	0.028	Cheng 1984; Liu 1978
Thailand	Swamp	Plough, ha/h	F	0.025	Songprasert and Niempus 1978
Taiwan	Swamp	Plough, ha/h	F	0.032	Ma 1980
Taiwan	Swamp	Burden capacity, kg	F	869	Ma 1980; Liu 1975
Taiwan	Swamp	Draught power, kg	F	287	Ma 1980; Liu 1975
China	Swamp	Cart load/an., kg	F	1 000	Cheng 1984; Liu 1978
Thailand	Swamp	Cart load/an., kg	F	155	Ma 1980
Taiwan	Swamp	Cart speed, m/min	F	51	Liu 1975; Ma 1980
Thailand		Work days/year	F	122	Buranamanas 1963
Taiwan		Work days/year	F	53	Liu 1975; Ma 1980

M = males, F = females, C = castrate

3.1 Selection for Size

Size is an important characteristic to be considered only in relation to efficiency of milk, meat or draught production and adaptation. The buffalo is at the larger end of the size scale among all domestic indigenous ruminant livestock and its surface area to body weight is therefore smaller compared to other species in the same environment, especially cattle. It has also been reported that buffaloes have a larger gastrointestinal volume than cattle (Moran and Wood, 1982) in relation to total body size. This has a bearing on feed intake which is in turn positively associated with rate of passage of feed and negatively related to digestibility. The complex relationship between size and other factors such as intake, digestibility, heat load and its dissipation within the river and swamp types needs to be further studied before breeding goals can be formulated. A curvilinear relationship was observed between body size and milk yield among Holsteins where sires that were just above average for size proofs produced daughters that yielded more milk than smaller or larger contemporaries (Sivarajasingam et al., 1984). A similar trend may be expected in the tropical environment.

3.2 Breeding and Selection for Milk

A considerable amount of work has been done in India including progeny testing for milk (Nagarcenkar, 1979; Gill, 1985 and Tiwana and Dhillon, 1985). The milk yield in 305-days and total yield increased from 1062 kg and 1120 kg in 1971 to 2346 and 2450 respectively after 12 years of selection through a progeny testing programme. Heritability for milk yield among river buffalo shows a medium to high value (Table 9). However, reproductive traits in Table 10 show lower estimates but higher than in most cattle breeds. These figures indicate much genetic progress could be achieved through selection of superior bulls for milk production. The current genetic limit for milk yield which is as high as 4000-4200 kg (5 animals) per lactation of 305 days is encouraging (Gill, 1985). It will be of interest to study the efficiency at these high levels compared to cattle of similar production.

Table 9 HERITABILITY (h^2) AND REPEATABILITY (r) OF LACTATION YIELD AND LENGTH

Country	Breed	Lactation			Source
		Yield h^2	r	Length h^2	
India	Murrah	0.24	0.50	0.11	Agarwala 1955; Bawa and Dhillon 1980; Bhat et al. 1981; Dhinsa 1963; Mangurka and Desai 1981; Rao and Nagarcenkar 1977; Singh and Desai 1962; Sreedharan and Nagarcenkar 1978
Pakistan	Nili-Ravi	0.20	-	-	Ashfaq and Mason 1984
Sri Lanka	Murrah	-	0.49	0.06	Mahadevan 1960

Table 10 HERITABILITY OF SOME REPRODUCTIVE TRAITS

Trait	Country	Breed	Mean	Source
1st calving age	India	Murrah	0.25	Agarwala 1955; Bhat et al. 1981; Gokhale and Nagarcenkar 1974; Goswami and Nair ?; Gurung and Johar 1983; Mangurka and Desai 1981; Rao and Nagarcenkar 1977
Calving interval	India	Murrah	0.17	Bhat et al. 1981; Rao and Nagarcenkar 1977
Gestation period	India	Murrah	0.11	Arunachalam et al. 1981; Bhat et al. 1981; Ghanem 1955;Rao and Nagarcenkar 1977

3.3 Breeding and Selection for Beef

An improvement programme for beef production has been limited to the last few years mainly in China and Thailand. Main characteristics were weights at weaning and later ages. Heritability for body weights are given in Table 11 and are generally medium to high as in the case of beef cattle.

information regarding river buffalo is limited but genetic variation is expected to be high. Response based on performance testing for growth and family selection for carcass characteristics will prove effective. As for dairy buffalo, implementation of improvement programmes with farmers will involve high costs and management difficulties. A possible solution is to establish test stations around the country to evaluate selected bulls for growth, carcass (using relatives), reproductive and draught characters. Top bulls are selected and used to improve the national herd. Embryo transfer technology could be a useful tool here to multiply bulls for natural mating in the absence of proper facilities for AI.

Table 11 HERITABILITY OF BODY WEIGHTS

Age	Country	Breed	Mean	Source
Birth	India	Murrah	0.45	Bhat et al. 1981; Rao and Nagarcenkar
			1977;	Tomar and Desai 1965, 1967
	India	Surti	0.16	Rao and Nagarcenkar 1977
	Thailand	Swamp	0.63	Chantalakhana 1981; Chantalakhana 1984
6 months	India	River	0.37	Bhat et al. 1981; Mangurka and Desai 1981; Tomar and Desai 1965
12 months	India	River	0.57	Bhat et al. 1981; Rao and Nagarcenkar 1977; Tomar and Desai 1965
24 months	India	River	0.57	Bhat et al. 1981; Mangurka and Desai 1981; Rao and Nagarcenkar 1977

3.4 Breeding and Selection for Draught

Breeding for genetic improvement involves retention of superior males for semen collection, and females for regular calf production. However, most of the buffaloes identified for draught are deprived of their normal reproductive activity. Males if not sold for beef, are often castrated. For the females, having to nurse a calf is considered a nuisance by the owner during ploughing. Even if the animals are fertile and given the opportunity to mate, the rate of success is expected to be low due to the low levels of feed quality and stress due to work in the field.

In many countries, the farm sizes are declining due to fragmentation resulting in an accompanied increasing scarcity of feed resources. Under such circumstances the decline in body size as a result of castration of larger animals for draught purposes may prove to be a compromise or even an advantage (Mahadevan, 1985). He cites the work of Vercoe et al. (1985) who favour more efficient utilization of small animals for draught purposes under situations of limited feed resources and selecting for superior heat tolerance individuals within the population. However, the choice of identification of existing strains that are heat tolerant, low in maintenance requirement and resistant to parasites and other diseases amongst the swamp buffalo population and using them in crossbreeding programmes may be more applicable in developing countries (Mahadevan, 1985).

3.5 Multipurpose Breeding Strategies

Although selection for site, milk, beef and draught has been discussed separately, they are not mutually exclusive and they are also not the only traits of concern. Buffaloes in smallholder and institutional farms are known to have slow reproductive rates and high mortality rates. These are largely due to environmental and partly genetic factors. As was mentioned earlier, more than 70 percent of the buffaloes in all countries of Asia can be considered nondescript. Well defined breeds and breeding programmes are only confined to institutional farms. This needs to be extended to improve the national herds hand-in-hand with development of a recording system and related infrastructure. However, costs of operating such a system based on conventional progeny testing will be enormous. An alternative system like the Irish progeny testing and selection programme (Cunningham, 1979) will be more effective. This system will also allow selection for total economic merit to include traits like reproductive efficiency and feed efficiency which are vital in buffalo production.

Breeding strategies tend to vary from country to country. In the Indian subcontinent, breeding for milk first and draught second will continue. In southeast Asian countries, except Malaysia, draught power is of prime importance followed by beef in most areas or milk in the Philippines. In Malaysia and to some extent in the Philippines and Sri Lanka, swamp buffaloes are significant contributors to the beef industry. However, declining buffalo numbers due to the advent of farm mechanization, their slow reproductive rates and few numbers compared to the indigenous Kedah-Kelantan cattle in Malaysia, the future of the swamp buffalo in this country is uncertain. A solution to this problem is to upgrade them using Murrah or Nili-Ravi or both breeds into a dual purpose dairy beef buffalo. This will further enhance the existing village ghee industry and other milk products for which there exists a substantial market. Attempts to conserve the buffalo as a beef animal especially in the Philippines, Thailand, Indonesia, Taiwan and China need to be studied. Besides the fact that their population is decreasing due to earlier mentioned mechanization, low reproductive rates and high mortality rates, the buffalo are also decreasing in size due to reasons discussed earlier in this paper.

Another area that has been extensively discussed, but little work has been done, is efficiency of feed utilization by buffaloes. Buffaloes are considered more efficient utilizers of coarse feeds than cattle but this has not been well documented.

4. CROSSBREEDING RIVER AND SWAMP BUFFALOES

Crossbreeding has been practised in almost all countries where swamp buffalo predominates i.e. China, Burma, Thailand, Philippines, Malaysia and Sri Lanka with the desire of improving milk yield capacity and size for work in the field. China started crossbreeding work as early as 1960 and produced some 45 000 crossbreds by 1977 (Wang, 1979) through AI. The crosses have been further upgraded with Nili-Ravi resulting in grades with 50, 25, and 25 percent of Nili-Ravi, Murrah and swamp buffalo levels of inheritance. They have been evaluated (Liu et al., 1985) and summarized in Table 12.

The crossbreds in the above report had good conformation, a massive body structure with well develped hindquarters, with an average daily gain of 0.8 kg on grass. Average fat content of crossbred milk was 7.5 percent. The temperament of triple crosses as superior but the same could not be said for the halfbred, Murrah x swamp crosses. Reports on crossbred performance, although on a smaller scale, have also been reported in the Philippines (Eusebio, 1975), Taiwan (Liu, 1975), Sri Lanka (Jalatge, 1980) and Nepal (Keshary and Shrestha, 1980). These reports had lower milk yields ranging from 492 to 956 kg than the work in China shown in the Table 12. However, the results do indicate genetic potentials of crossbreeding to improve the swamp buffalo for milk and meat. In this context, it is also relevant to note that an FAO/UNDP project in collaboration with the Philippine Council of Agricultural Resources, Research and Development (PCARRD) has an ongoing evaluation of the progeny resulting from mating of different breeds/strains of river buffaloes with the Philippines carabao for use as draught, milk and meat animals (Mahadevan, 1985). Preliminary results showed an increase of 32 percent in birth weight, an increase by 100 percent in weight at 18 months (average 300 kg) and a 3 to 4-fold increase in milk yield (1200 1 in 300 days) than the native carabao (Ranjhan, 1985).

Table 12 CHARACTERISTICS OF CROSSBRED BUFFALOES
(adapted from Liu, 1985)

Character	Swamp (S)	Murrah (M)	Nili-Ravi (N)	M x S	N x (MS)
Colour	light grey	black	black	grey	black
White chevron	present	absent	absent	present	rare
Switch	black	white	white/ black	white	white (longer)
Horns	long, lateral curve backwards	short, spiral curl	short, curled back	curve semicircle	-
Draught power (kg)	65	-	-	F_1 80.8 F_2 88.6	- -
Plough mu/h	0.48	-	-	F_1 0.73 F_2 0.55	53.0 -
Dressing percent	48.5	-	-	F_1 56.2	-
Muscle percent	36.9	-	-	F_1 42.6	-
Meat:Bone	1:3.8	-	-	F_1 1:4.8	1:4.5
Puberty age (days)	-	667.0	915.5	669.0	605.3
Age first service (days)	-	1 201.4	1 048.0	974.3	831.3
Oestrous cycle (days)	-	23.2	23.7	21.5	21.6
Gestation period (days)	-	305.5	303.9	309.9	306.3
First postpartum oestrus (days)	-	94.7	127.9	170.6	71.0

Calving interval (days)	-	455.4	465.8	539.5	381.6
Milk yield (kg)	-	1 975.5	2 076.0	2 662.0	1 153.7

Crossbreeding between swamp and river buffaloes raises an area of concern. The differences in the chromosome numbers between swamp (2n = 48) and river (2n = 50) (Fischer and Ulbrich, 1968) buffaloes may have an effect on the fertility of the offspring considering synaptic possibilities in the F_1s resulting in some genetically, unbalanced meiotic products that degenerated. This was revealed by Bongso et al. (1983) where a large proportion of degenerating spermatocytes and abnormal spermatids were found in testicular biopsies of F_1 hybrids. The F_1 produced by river and swamp matings had a chromosome number 2n = 49 (Fischer and Ulbrich, 1968 and Bongso and Jainudeen, 1979). Reports by Bongso et al. (1984) showed further segregation resulting in three F_2 populations (2n = 48, 49 and 50), two populations (2n = 49 and 50) when backcrossed to river buffalo and two populations (2n = 48 and 49) when backcrossed to the swamp buffalo. These interesting findings were however limited to small sample sizes. It is now necessary to relate these genotypes (different chromosome numbers within different levels of exotic inheritance) to fertility and extent of heterosis for production traits in smallholder farms and large commercial ones.

5. CONSERVATION, IMPROVEMENT AND UTILIZATION

The buffaloes of Asia have evolved within their ecosystem over several centuries and have thus acquired adaptive characteristics and still remain useful in food production. The review of literature above though not exhaustive, and previous meetings on Animal Genetic Resources Conservation (FAO, 1981, FAO, 1983 and SABRAO, 1981) have revealed that although a wealth of information has accumulated, large gaps exist in the total characterization of buffaloes and other species. For instance, efficiency of the buffalo for milk, meat, draught or multipurpose on high and poor quality roughages and byproducts is limited or absent. Such information is vital in agricultural planning strategies and allocation of animals and breeding programmes to various farmers and farming systems. The buffalo of Asia are generally lumped together as the swamp type although wide variation is recognized. Blood markers are useful in the characterization of breed structure and the relationship between the varieties of the buffalo population. Blood markers, especially those related to membrane antigen, may be of value for understanding, control and eradication of diseases (Braend, 1981).

5.1 Genetic Conservation - Why?

Conservation of live specimens of buffaloes or other livestock consumes sizable manpower, valuable space and costs besides demanding proper planning skills. However, the buffalo needs to be conserved for the following reasons in brief:

a. They possess adaptive characteristics to thrive in the stressful environment which could be lost through dilution and intensive selection for production traits.
b. They also possess the ability of converting poor quality feed resources into meat, milk and working capacity in the field.
c. The genetic variability should be maintained which is the basis for genetic improvement for the future. Fortunately, buffaloes, unlike cattle, have not undergone massive selection and crossbreeding until only very recently. There is still genetic variability to be salvaged.
d. The opportunity could be lost to exploit heterosis through cross breeding.
e. The future expectations of our buffaloes are unknown or unknowable. Selection goals in cattle breeding in the past have changed. From single trait selection we have turned to selection on total merit, when we

may have lost some of the negatively correlated valuable genes. Selection for conformation traits are beginning to show their importance in relation to lifetime stayability and production. With raising production costs, we are now looking at yield per unit dry matter or energy input. In this respect the buffalo has an important role. The future spectrum of diseases and feed availability is unknown. Therefore we need to maintain the present variability or even increase it.

f. Finally, we ask ourselves, do we have the right to destroy, or even neglect our indigenous germplasm collection which rightfully belongs to our children and grandchildren who may find greater uses for them.

5.2 Genetic Conservation - How?

Without going into details, the following points need to be highlighted.

a. Live animals. An actively breeding population should be maintained, perhaps, each line or variety in a different farm to reduce costs. Two major advantages of live animal conservation are a) they are always available for immediate utilization in the event of any setbacks in the upgraded population; b) they are constantly exposed to new strains of diseases and their resistance evaluated. Such live animals would also contribute to education and to community awareness of the indigenous fauna. Cost of maintenance is often argued to be high. This may be an exaggeration overlooking their cheap maintenance costs, better longevity, lower veterinary costs besides revenue from milk and meat. A major problem that needs to be defined is the type of selection to be practised without altering the genetic variability. It is suggested here that both random selection as well as overall merit (with equal weighting for each trait) should be practised with minimum intensity.
b. Cryogenic storage. This is convenient and cheap and further work needs to be done. Another advantage is that the genotype will not be subjected to genetic drift. A disadvantage is that the animals, especially in the case of females, have a time lag when live adults are urgently required.
c. DNA genetic material storage. This is a useful tool but certainly not an immediate task.

Conservation by the last two methods has been discussed at length and mode of action outlined (FAO, 1983).

5.3 Improvement within Conservation

It is evident that the buffalo plays an integral part of our farming system and its numbers have been maintained or increased. Various river breeds have been documented and evaluated. Strains of swamp buffalo have been observed but attempts to characterize them genetically have yet to be made. Conservation should begin with a proper sampling technique to represent the existing variability and in sufficient numbers. In these populations for conservation, selection should be minimal and to maintain population size constant, either random culling or culling based on total merit should be practised. However, for the national herds genetic improvement could be achieved through selection and crossbreeding. For both, germplasm collection and national herd data banks are essential to monitor their genetic progress.

6. CONCLUSIONS

The total buffalo population now stands at 122 million in Asia. The swamp buffalo population is decreasing in some countries, especially Malaysia, Thailand, Philippines and Taiwan. Growth and carcass characteristics of buffalo and cattle are comparable. Draught capacity and the working lifespan of buffalo is superior to that of cattle. There is a management tendency in smallholders to deprive larger swamp buffaloes from producing offspring leading to a high likelihood that the buffalo body size may be affected. The river buffalo is larger than the swamp. Interrelationship between size, growth, milk yield and draught power needs to be further studied also with respect to feed efficiency and adaptation. The former produce about 1800 kg milk per lactation of 305 days. First calving age, intercalving periods and postpartum oestrus are longer than in cattle and perhaps this is a physiological phenomenon associated with a longer (310 days) buffalo gestation period. Feed efficiency with complete characterization of the buffalo breeds is timely with data banks having interregional links for exchange of information and material. The various strains of swamp buffalo need to be identified. Their special capabilities and adaptation to the particular niche has to be defined. Conservation of valuable breeds and strains of buffaloes is reemphasized before genetic variation is"diluted. Finally, crossbreeding and its advantages are being pursued in various countries and show preliminary prospects of genetic improvement of swamp buffaloes in spite of initial setbacks of differences in chromosome numbers between the river and swamp buffaloes and the genetic imbalance in germ cells resulting from meiosis.

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[1/] Livestock Research Division, MARDI, P.O. Box 12301, General Post Office, 50774 Kuala Lumpur, Malaysia.