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# Crossbreeding of Cattle in Africa

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**Abstract**

Africa is endowed with a very wide range of mostly Bos indicus indigenous cattle breeds. A general statement with regard to their performance for meat or milk is that they are of inferior genetic value. Attempts to improve their performance have rarely relied on within-breed improvement but have concentrated on crossing to supposedly superior exotic Bos taurus types. Exotic types have not always – indeed have rarely -- been chosen on objective criteria and the imported breeds generally indicate the colonial past of individual African countries rather than on use of "the right animal in the right place". Most attempts at increasing output have been undertaken under research station conditions. Results on station have been very variable but the limited success achieved has rarely been carried over in to the general African cattle population. This paper documents a number of attempts to alter the genetic make-up of African cattle in several countries and discusses the reasons for the failure of most of these.

**Keywords:** Bos indicus, Bos taurus, livestock experiments, milk production, meat production

## 1. Introduction

African countries differ greatly in climatic, ecological and agricultural conditions and in socioeconomic factors. In many countries, nonetheless, cattle are the most important livestock species. The rapid and continuing increase in demand for livestock products offers immense market opportunities for producers. If the productivity of small holder farmers were to be improved to commercial levels it would have the potential to improve human nutrition and alleviate poverty and on the continent. Climate change is predicted (rightly or wrongly) to be highly dynamic and could have adverse effects on crop and livestock productivity. The type of cattle to be used and the production strategy to be followed should depend primarily on the environment and the level of management. The availability of a very wide range of indigenous cattle resources with adaptive and productive differences coupled to judicious introduction of exotic genetics should allow the animal to be matched to the total environment, management capabilities and markets.

In short the animal should be fit for purpose and be the right animal in the right place (Wilson, 2009a). In the harsh and often remote areas where extensive pastoral systems prevail the indigenous pure Zebu or Sanga or naturalized types are likely to be the best production strategy. In the more favourable areas crossbreeding with small indigenous cows may succeed in improving the output of cattle farming. Crossbreeding, often unstructured and with no precise objectives, has been undertaken many times in the past and will certainly continue to be practised in the future. Genetic "improvement" has been successful in some places but spectacularly unsuccessful in (probably) many more. This chapter looks at some of the winners and losers in crossbreeding cattle in Africa and attempts to extract lessons to be used in future development.

## 2. Principles of crossbreeding and African practices

Genetic diversity controls many useful traits that have an influence on productivity, adaptability to harsh environments and disease resistance. Indigenous animals are often used (but perhaps more often underused especially in Africa) in conventional breeding programmes due to inadequate characterization and failures in identifying genotypes that possess the most useful traits.

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For many policy makers and research scientists the result has been to consider indigenous animals of low inherent genetic merit and to look to cross breeding with "improved" or "highly productive" types to enhance the performance of the livestock sector on the continent.

On a global basis the three main crossbreeding strategies can be typified as:

- breed replacement;
- establishment of stable crossbreeding systems; and
- creation of synthetic populations.

All three of these strategies have been used in Africa in addition to many "endogenous" ones. A major concern in Africa is that a perceived solution does not answer a problem because the perception (usually that of a scientist or policy maker) does not conform to the known reality (from the point of view of the small holder farmer who is in the overwhelming majority of African livestock producers). Most formal crossbreeding – there have been thousands of uncounted and unrecorded informal experiments among the mass of producers – has been designed to produce a single purpose animal, usually dairy but also beef. This approach has failed to take into account the multipurpose nature of African cattle production which requires not only economic output (milk, meat and traction combined) but also social output (investment, savings, peer acceptance).

Where crossbreeding has been practised considerations other than "the right animal in the right place" have often been paramount. There have, of course, been several introductions of "international" breeds such as the Jersey and the Holstein-Friesian (the latter in many situations definitely not being "fit for purpose"). Jerseys, for example, have been used in situations as diverse as Cameroon (Mbah et al., 1986), Egypt (Khishin and El-Issawi, 1954), Ghana (Sada and Vohradsky,1968), Rwanda where they were crossed with Sahiwal rather than with local cattle (Figure 1) (Compère, 1963) and Uganda (Kiwuwa and Redfern, 1969). Holsteins and Friesians similarly have been introduced to many countries including Cameroon (Mbah et al., 1986), Ethiopia (Alberro, 1983; Haile et al., 2009), Nigeria (Knudsen and Sohael, 1970; Johnson and Oni, 1986), Uganda (Trail et al., 1971) and Zambia (Mubita, 1992). Brown Swiss have been used in Rwanda (Compère, 1963) and Mozambique (personal observation).

**Figure 1. Jersey-Sahiwal crosses at the Songa research station of the Institut des Sciences Agricoles du Rwanda (Photograph: Trevor Wilson, June 1983)**

Away from the international breeds the colonial powers in the pre-independence period often promoted their own genetics in the countries of their tutelage with little apparent regard for their suitability for the local environment. In Tanganyika Territory in the 1920s the British imported North Devon, Aberdeen Angus and Ayrshire from the UK with a leavening of Indian Zebu and South African Sanga blood (Figure 2) (DVSAH, 1926). In Kenya the North Devon was again imported (Wilson 2009b) among many other British breeds.

North Devons were also imported to Southern Rhodesia/Zimbabwe but were eventually surpassed by their close relative the Sussex (Tawonezvi and Ward, 1989).

In another leap of faith Tarentaise and Pie Noire cattle from the French Alps were taken to the French colonies of Algeria, Morocco and Tunisia early in the twentieth century (Sraïri, 2011). The first exotic dairy cattle in Cameroon were Brown Swiss and were imported by the French colonial administration in the 1930s but they were replaced at the end of the Second World War with Holstein Friesian cattle and Austrian Pinzgauer at one location whereas the Montbéliard was introduced at two other stations for crossbreeding with local cattle (Tambi, 1991). French colonial influence was also evident in Senegal and Mali where the Montbéliard was the animal of choice (Tamboura et al., 1982).

**Figure 2. Imported sires (Krishna Valley Indian Zebu, Aberdeen Angus, North Devon, Friesland [sic], Ayrshire and Afrikander) used at the Tanganyika Territory Government Stock Farm at Puku, Dar es Salaam in 1926 (Source: DVSAH, 1926)**

The rapid onset of independence for African countries in the 1960s did little to deter the former colonial powers from attempting to maintain their vested interests and the status quo ante. In 1967 Brown Swiss heifers were again imported to Cameroon for crossbreeding with N'Dama (Njwe, 1984) and Montbéliard semen was imported in 1975 for crossbreeding with Gudali (Bos indicus) females in the northern part of the country (Tawah et al., 1999). Montbéliard semen was still being used in Senegal in 1999-2000 (Alhassan, 2003) as was that of the Abondance, another French breed (Madalena et al., 2002). In spite of being a Belgian colony Burundi imported Brune des Alpes and Montbéliard from France after it gained independence (Berahino, 1993). Botswana has used Simmental bulls to up-grade its indigenous Tswana cows for milk production (Bopitumelo, 1993).

In the post-independence period, however, new players were substituted for old and participated in the game. The Soviet bloc thought it saw an opportunity to increase its influence in Africa and many students, amongst them would-be veterinarians, received tertiary education in Russia and Eastern Europe and on the other side of the world in Cuba. This resulted in yet other exotic breeds joining the African panoply, notable amongst these in Mali being Red Steppe (Rouge des Steppes) from Russia, Black Pied (Pie-Noire Allemande) from the German Democratic Republic and Bulgarian Brown (Brune de Bulgarie) from Bulgaria (Tamboura et al.,1982). Not to be outdone in the Cold War era the USA flooded much of Africa with Peace Corps who, at least in the case of Mali, travelled with their waggon train of American Brahman cattle. In Cameroon the American approach was somewhat different and was via Heifer Project International and its "Heifer in Trust" programme which imported Jersey and Holstein Friesian cattle and semen (HPI, 1999; Bayemi et al., 2005). Even little Ireland climbed on the waggon and exported Holstein Friesians to Cameroon from 1994 (Tawah et al., 1999).

Senegal presents a rather anomalous situation in that in addition to its ties to France it has imported Kankrej cattle, not from Guzerat (which is an alternative name for the breed and the name of its home tract in India) but from Brazil (Figure 3) (Dénis and Thiongane, 1974). Senegal is also peculiar in that it is at the root of a convoluted train of events. N'dama cattle were exported from Senegal to St Croix in the US Virgin Islands at an unknown time in the nineteenth century. By 1889, however, they were well established with one herd comprising 250 head.

In the second decade of the twentieth century N'dama cows were put to Red Poll bulls (why were they in St Croix?) with the result that a new breed – the Senepol – was formed (Hupp, 1981).

**Figure 3. Kankrej (Gujerat) bull imported to Senegal from Brazil at the Dahra Research Station of the Institut Sénegalais de Recherche Agricole (Photograph: Trevor Wilson, February 1986).**

In a somewhat bizarre turn of events the Senepol breed has found its way from the Caribbean back to its African roots. Senepol are now found in Zimbabwe (Figure 4) and South Africa where there is a breed society. Senepol have also arrived in Australia where there is also a breed society. In one experiment carried out on St Croix, Senepol x Senepol calves had heavier ($P < 0.01$) birth weights and heavier ($P < 0.01$) 205-d adjusted weaning weights than Hereford x Herford calves. Birth weights of S x H calves were heavier ($P < 0.01$) than the mean of the purebred calves but 205-d adjusted weaning weights did not differ ($P > 0.10$) (Chase et al., 1998).

**Figure 4. Senepol bull at Annual Bull Sale in Harare, Zimbabwe (Photograph: Trevor Wilson, July 2000).**

It is not only Bos taurus that have been used in crossbreeding on native African cattle as Red Sindhi and Sahiwal were imported to Tanganyika Territory from India in the 1920s (DVSAH, 1928). In present day Africa, however, Kenya is the only country with major resources of this recognised Bos indicus dairy breed. In Kenya they have been used both for upgrading of local East African Zebu and for crossbreeding with Bos taurus breeds and they have also served as an important source of breeding material for the whole continent (Trail and Gregory, 1981). Sahiwal have been used in several African countries including Burundi (Berahino, 1993), Rwanda (Sibomana, 1992), Sierra Leone (Carew et al. ,1986), Somalia (Aria and Cristofori, 1980), Tanganyika (Macfarlane and Worral, 1970) as an already-adapted but more productive breed.

There have been fewer imports of beef cattle but one example is that of a private ranch in Kenya where Charolais, Ayrshire and Santa Gertrudis bulls were crossed on Boran cows (Gregory et al., 1984). Another long standing private initiative with little relevance to anything else is the use of Simmental cattle (looked after by Lay Brothers from their German homeland) at a Benedictine ecclesiastical foundation in southern Tanzania (personal observation).

## 3. Early attempts at crossbreeding

### 3.1 Sanga

Africa boasts what is probably the earliest of all cattle crossbreds in Sanga cattle which are a mixture of Bos taurus and Bos indicus. Although the genetic history of African cattle pastoralism is controversial and poorly understood recent microsatellite analyses apparently show that the earliest cattle originated within the African continent but there are also indications of Near East and European genetic influences (Hanotte et al., 2002; Freeman et al.,2004). The initial expansion of African Bos taurus was probably from a single region of origin and reached the southern part of the continent by following an eastern route. The indicus genetic influence shows a major entry point through the Horn and the East Coast of Africa and two modes of introgression into the continent. Some variation in the African herds is also attributable to European influence although this has taken place in the past few hundred years, during Europe's colonial influence in Africa.

Spreading out from their likely origin in the Horn of Africa Sanga breeds now predominate over much of Africa. Many types have long to very long horns. They include the Danakil of the Ethiopian lowlands and the Dinka of the Republic of South Sudan. Farther south are the Bahima of southern Uganda and western Democratic Republic of Congo and the Ankole of Burundi, Rwanda (Figure 5) and western Tanzania. South again another subgroup of Sanga still with long but not so spectacular horns includes the Barotse and Tonga of Zambia and Angola, the Ovambo and Kaokoveld of Namibia, the Tswana of Botswana, the Mashona and Tuli of Zimbabwe, the Nguni of Zimbabwe, Mozambique and Swaziland and the Basuto of Lesotho (Felius, 1985; Mason, 1996).

**Figure 5. Sanga cattle exemplified by the Watusi breed in Karama Village, Rwanda (Photograph: Trevor**

**Wilson, July 1983).**

### 3.2 Tanganyika Territory/Tanzania

Tanganyika, then a German colony, was amongst the earliest of African countries to attempt to improve the production of native cattle although these activities, begun in 1905, were mainly to control epidemic and endemic diseases including Foot and Mouth Disease, Contagious Bovine Pleuro Pneumonia, East Coast Fever and Trypanosomosis. Cross breeding in Tanzania became an important strategy in when it became a League of Nations Trusteeship under British tutelage with imports of Zebu from India, Afrikander from South Africa and Angus, North Devon, Friesian and Ayrshire from the United Kingdom as early as 1926 (DVSAH, 1926). The intention was to improve the local Tanganyika Shorthorn Zebu (TSZ) – but more particularly the Iringa Red variety (Figure 6) considered to be the "North Devons of Tanganyika Territory" – in respect of both milk and meat, as the local people had "paid more attention to the size of the humps of these indifferent milkers than to the shape of their rumps" (DVSAH, 1926).

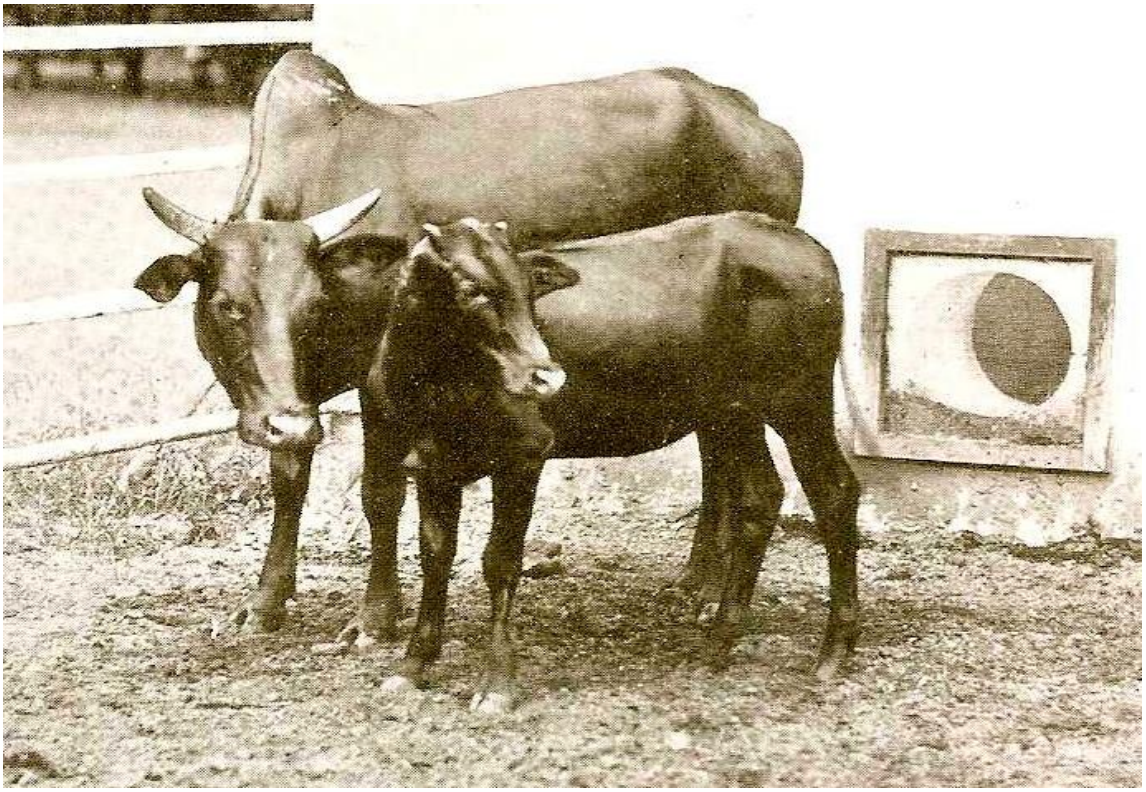

**Figure 6. Native Iringa Red cow with halfbred Afrikander calf at the Tanganyika Territory Government Stock Farm at Puku, Dar es Salaam in 1926 (Source: DVSAH,1926).**

What should have been a structured programme began in 1935. Bos taurus bulls, mainly UK Ayrshires, were used on local cows with the aim of producing a new breed adapted to the local environment but of higher output than the native stock. Some five years into the programme it was realized that upgrading to Bos taurus was failing to produce such an animal. The breeding plan was thus modified to introduce blood of Red Sindhi and Sahiwal, imported from South Asia (now India and Pakistan) to replace at least partly the B.taurus genes. This resulted in an animal exhibiting Indo-African Zebu type morphology with traces of its taurine inheritance. Changes in research personnel were invariably accompanied by changes in the breeding scheme which is "not well documented" (Kiwuwa and Kyomo, 1971). In spite of this, however, the resulting animal was accorded breed status as the Mpwapwa in 1958 when it was said to comprise 35 per cent Red Sindhi, 20 per cent Sahiwal, 20 per cent TSZ, 10 per cent Boran, 5 per cent Ankole and 10 per cent B.taurus "mainly Ayrshire"!!. A breed improvement programme was instituted at the same time as breed status was declared with the intention of producing a dual purpose animal for the semiarid environment of central Tanzania capable of producing 2300 kg of milk in 305 days and a steer carcass of 230 kg in less than four years.

In 1963 (when the author of this chapter was very familiar with the work at the Mpwapwa Research Station although he did not work there) the animal was still very variable in physical type (Figure 7) and in production traits.

**Figure 7. Mpwapwa cattle at Mpwapwa Research Station central Tanzania five years after declaration of breed status in 1958 (Photograph: Trevor Wilson, November 1963)**

Over the succeeding half century there have been multiple further changes in the breeding plan. In 1968, 10 years after the declaration of breed status, individual animals varied in genetic background carrying from 3 to 88 per cent Red Sindhi inheritance, 0-69 per cent Sahiwal, 0-63 per cent TSZ, 0-59 per cent Boran and 0-34 per cent Ayrshire (Mchau, 1988; Syrstad, 1990). From 1968 to 1971 some Mpwapwa females were mated to Friesian, Ayrshire and Jersey bulls to produce a crossline and the crossline females were backcrossed to Mpwapwa bulls (Mkonyi, 1982). The number of animals has never exceeded 1000 and most of these have been kept on the station of origin and another government station with very few individuals having "escaped" into the real world. The Mpwapwa has never, in fact, been a "breed" but its credentials are enhanced by its being recorded by FAO as 'Endangered' (Scherf, 2000).

### 3.3 South Africa

A composite Sanga-taurine, the Bonsmara, became a recognized breed after many criss-cross matings, fixed at 5/8 Afrikaner (Figure 8), 3/16 Hereford and 3/16 Shorthorn blood (Bonsma, 1980).

**Figure 8. Afrikaner cow (constituting 5/8 of the Bonsmara breed) at Bokspits Ranch in Southwest Botswana (Photograph: Trevor Wilson, July 1986).**

Begun in 1947 by Professor Bonsma at the Mara Research station in the then Transvaal (now South Africa's most northerly province of Limpopo) it is claimed that – unlike the Mpwapwa just cited which was arrived at largely by chance – the Bonsmara is the only beef breed in the world created through a well documented crossbreeding programme with the aid of objectively recorded performance data. It now benefits from a database of approximately one and a half million performance tested animals recorded since 1937 which is used to calculate breeding values (Bonsma and Skinner, 1969). The breed was developed for the hard dry conditions of southern Africa based on the use of the adaptability of the Afrikaner, the meat production of the Hereford and the milk production of the Shorthorn. The Bonsmara has a much less sloping rump than the Africander, a reduced hump in the male and reaches marketable weight much earlier than its progenitor. The colour is a uniform red-brown, the skin is thick and pigmented (resistant to the sun and ticks -- although in the case of the latter not so much as pure bred Nguni (Marufu et al., 2011)) and these docile animals weigh about 800 kg as mature males and 500 kg as pure females. The Bonsmara is the front runner in the stud and commercial beef industries of southern Africa as well as in other parts of Africa and is a well-regarded and well-adapted breed in Argentina, Uruguay, Paraguay, Brazil, Mexico, the USA, Canada and Australia.

Among the claims made for the Bonsmara are:

- very well adapted to most climatic and environmental conditions (bushveld, savannah and sourveld or equivalent ecologies outside southern Africa);
- very fertile with short intercalving periods;
- early maturity;
- low birth weights and therefore easy calving with high reconception rates;
- well developed udders with adequate milk to wean a strong calf;
- good growth ability which can be used good effect in a crossbreeding program;
- advantageous feed conversion ratio; and
- excellent carcass and meat qualities with notable tenderness.

## 4. Recent crossbreeds

### 4.1 French and Soviet influences on Malian cattle

Mali, the former Soudan français (French Sudan) carried out crossbreeding trials both during the colonial period and after it achieved independence. Most of these experiments were for dairy production with beef being considered a by-product (Wymann, 2005). Halfbred Jersey-N'dama cattle were slightly heavier at 12 months at 137 kg against all other genetic types which averaged 126 kg. Average milk yield for 187 lactations of all genotypes was 1178 kg in lactations of 283 days of lactation with both lactation length and total yield being influenced by type. The apparent best milk results were obtained with Red Steppe x Zebu crossbred cattle which gave 1782 kg of milk in 367 days but only nine lactations for this genotype did not allow any conclusions to be drawn on the superiority of this cross bred over all others. Age at first calving was 3-4 months earlier in crossbred cattle and the calving interval was shorter but total lifetime offspring for crossbreds with the exception of Montbéliard x N'Dama and Red Steppe x Zebu halfbreds was lower than for local purebreds. For all parameters studied the environment (and particularly the year) was a determinant factor. The difficulty of programming the import of improved breed males, the absence of selection in the locally bred herds used and the lack of control over management were among the reasons that prevented adequate interpretation of the results.

The conclusions of a thorough review of experimental work were rather negative. The disorderly import (l' importation anarchique) of various European breeds in to a population hardly capable of maintaining itself served to accentuate the variable performance. In effect the outcome of 20 years of crossbreeding experiments at the Centre National de Recherches Zootechniques de Sotuba was that no solutions had been found to the problem of increasing the production of milk and meat in Mali but provided some pointers to the future policy on improving production. The lifetime production of 3.1 calves per female, taking into account the sex ratio and the high mortality, did not allow any selection among the females. Crossbred weights at 12 months were heavier than either N'dama or Zebu under the same management conditions but it did not seem advisable to proceed past the F1 generation in order to avoid problems with genetic dispersion and in order to maintain a level of adaptation to the local environment.

Milk yield was not substantially increased in crossbreds but there was some advantage as they let milk down without the calf being present. Crossbred females also produced their first calf eight months in advance of the native animals but it was not clear whether this was due to the crossing or to environmental conditions as the data refer to two different periods. These positive aspects were not, however, a sufficient argument for crossbreeding as the same results could be achieved through within-breed selection of local animals and by better management. In addition crossbreeding often requires better management conditions. Problems associated with recording and the multiple objectives of the experiments at Sotuba (improvement of crossbreds by backcrossing to Rouge des Steppes or Montbélliard, increased meat production by crossing with Brahman and increased milk production by infusions of Jersey blood) resulted in the limited usefulness of the work. What was clear was that crossbreeding per se was not a miracle solution. In the future it would be better to improve the animal environment (health, feeding and reproductive management) and general management of the stock. If improvement were to be achieved on station it would still be necessary to ensure better management in the village situation and to provide adequate extension services (Tamboura et al., 1982).

**4.2 Urban and periurban dairy production in Ethiopia**

Crossbreeding is likely to be, and in Africa has been, more successful in areas where environmental conditions most closely approximate those of the exotic breed. Examples are the subtropical areas of southern Arica and highland areas, among others, in Tanzania, Kenya and Ethiopia. Major systems of dairy production in Ethiopia are lowland pastoral systems, rural highland small-holder system, large scale commercial production and urban and periurban systems (Desta, 2002). The last system developed in and around major cities and towns, especially in the highlands, where there is high demand for milk. Farmers use all or part of their land for home grown feed and purchase agro-industrial by products (oilseed cakes, bran) and additional fodder. The system comprises small, medium and large farms and has the primary objective of producing milk for sale;

Studies have shown that milk production per cow per lactation is increased by crossbreeding but some of these benefits are offset by variable reproductive performance and cow longevity. In Addis Ababa the proportion of cows with 50 per cent or less exotic blood increased as the farm size decreased while those of 75 per cent or more exotic blood increased with the increment of farm size. The lowest proportion of exotic cows was found in the small scale farms and it was comparable in the medium and large scale farms. Lack of livestock feed was the most important constraint identified by all farm scales: 92.0 per cent of small, 85.7 per cent of medium and 83.3 per cent of large scale farms considered lack of feed as a constraint. Studies showed that on all farm sizes about 90 per cent of the required energy was actually fed to cattle. Disease was the second most important constraint and cited by 68 per cent of small, 57.1 per cent of medium and 83.3 per cent of large scale farms. Some 32 per cent of small scale farms considered lack of labour as a constraint. Lack of veterinary services was considered a constraint by 12 per cent of small scale farms whereas lack of livestock development services was cited by 28.6 per cent medium scale and 16.0 per cent of small scale farms.

Breed improvement programmes for dairy production in Ethiopia date to the 1930s when the Italian occupation administration imported pure temperate breeds. Crossbreeding of temperate and indigenous breeds has since been practised by several governmental and non-governmental institutions. These efforts have met with little success due to technical, organizational and socioeconomic constraints. There has been no formal breeding policy with regard to choice of exotic breed types, no defined breeding objectives, no indication of the optimum level of exotic blood and performance recording has been difficult. Activities have not focussed on the smallholder producers who are increasingly dominating the dairy industry. Estimates of breeding value and selection for improved productivity have therefore been difficult. Artificial insemination is meant to have an important role in upgrading local stock but its activities have been unsatisfactory (conception rates are only about 25 per cent) and largely limited to Addis Ababa and a few other major urban areas. Natural service for dairy breed improvement is promoted by some governmental and non-governmental institutions (including the Smallholder Dairy Development Project) in rural areas but the sustainability of this option is in doubt due to the uncertainty of the ability (or unwillingness once the "project" is completed) of farmers to replace bulls (Desta, 2002). The prospects for dairy production depend not only on the market (undoubtedly with high and increasing demand) but on the availability of self sustaining improved animals, feed resources, anima health and extension services and future government support (Azage and Alemu, 1997) in practice and not just in parliament.

### 4.3. Other recent crossbreeding activities

On-station research in Zimbabwe with three indigenous Sanga breeds (Tuli, Nkone and Mashona) crossed with exotic breeds for milk production showed that the use of a small dairy breed such as the Jersey produce F1 females that were prolific and milked better than their pure bred indigenous contemporaries but supplementation and/or adequate rainfall were the major determinants of reproductive performance and yield. In an on-station trial in which indigenous and crossbred cows were supplemented with medium quality silage, daily yield and lactation length were higher in the crossbreeds and resulted in a more than doubling of lactation yield. Calf birth weight, growth and survival rates of the F1s were comparable to the indigenous calves and, in the females, conception was at a younger age under station management. Results on small holder farms were less encouraging, however, and it was concluded that cross-breeding of indigenous cattle with exotics to increase production could not be recommended for resource poor farmers because of the relationship between breed, level of inputs and the environment, and the consequent loss of control of the composition of a communally managed herd. It was further concluded that indigenous breeds should be subjected to selection (Smith et al., 2003).

A programme based on artificial insemination of N'Dama cows using deep-frozen semen of Jersey and Holstein-Friesians was initiated in the Gambia in 1994 (Diack et al., 2005). Preliminary studies were conducted on the adaptation, health and productive performances of this new population, kept on-station "under vigilant health surveillance and improved nutrition conditions" in this area which is an endemic trypanosomosis area. Prophylactic treatment against gastrointestinal parasites was given twice in the rainy seasons (June to October) to calves and heifers. Acaricides for tick control were applied to all categories of stock throughout the year and all animals were vaccinated against anthrax, black quarter and haemorrhagic septicaemia (all also endemic to the area). All clinical cases were treated. The results suggested "an important potential for increased lactation performance in crossbred cattle in the West African context, in comparison to the local N'Dama breed". The main features of the crossbreds were:

- F1 cows produced up to five times more milk than the purebred N'Dama;
- the N'Dama always required the presence of the calf to let down milk whereas the F1 continued lactating even after the death of its calf; and
- F1 cattle were strong enough to survive under the prevailing environmental conditions and did well with reasonable management.

The authors said: "a forthcoming socio-economic evaluation of these performances will enable a more definitive assessment of the crossbreeding strategy". And here is the truth – the crossbreds had much more than "reasonable management" in the Gambian village context. Much remains to be done before definitive conclusions can be drawn on the suitability (and sustainability, especially of frozen semen imports and its use off station of this type of production for Africa's tropical humid coastal areas.

Crossbreeding for beef has been less than that for milk production. In one study in Zimbabwe, however, beef production was the aim. Cow genotypes comprised Mashona (Figure 9), Nkone, Tuli, Afrikaner, Brahman, Sussex, Charolais and various crosses amongst them. These were mated annually from 1979 to seven terminal sire breeds which were Afrikaner, Tuli, Brahman, Aberdeen Angus, Hereford, Simmental and Holstein-Friesian.

**Figure 9. Shona (Sanga) cow on communal grazing in Masvingo District in Southern Zimbabwe (Photograph: Trevor Wilson, February 2000).**

Maternal productivity was calculated as annual weight of calf weaned per 100 kg metabolic weight of cow based on calving rate, weaning weight and cow weight at weaning. Annual production was 162 kg for the exotic Sussex cows, 203 kg for Nkone and 206 kg for Mashona. Among purebreds, calving rate of indigenous Mashona cows was highest, followed by Tuli, Brahman and Nkone. Sussex and Afrikaner had the poorest calving rates. The superior fertility of the indigenous Sanga breeds was demonstrated. Among crossbreeds, Charolais x Brahman had the highest calving percentage and highest weaning weight. Highest efficiency (per 100 kg metabolic body weight of cow exposed to the bull per year), was in Mashona and Nkone cows whereas Charolais x Brahman performed best within the crossbreeds. High Mashona and Nkone fertility contributed significantly to their superior efficiency. Exceptional performance of Charolais x Brahman was consistent with theoretical expectations of greater heterosis in more genetically diverse types (Bos taurus x Bos indicus) than in the more closely related indigenous Sanga x Sanga breeds. The contribution of indigenous and adapted genotypes to southern African beef production and their potential role in industry were clearly demonstrated (Mayo et al., 1996).

Types of Bos taurus cattle including the N'dama (Figure 10) and the West African Shorthorn group have been indigenous to Central and West Africa for some 7000 years. Over this period they have co-evolved with tsetse flies and trypanosomes (Matthiola and Wilson, 1996) and have developed resistance to trypanosomosis. Constituting less than 6 per cent of the total African bovine population they are nonetheless of supreme importance in that they occupy areas in which non-tolerant stock cannot survive and they contribute substantially to human welfare in at least 18 African countries (Wilson and Hammond, 1994). Trypanotolerant cattle are able to survive in tsetse infested areas without drug treatment but they are generally of small size and have relatively low output. The larger zebu breeds have greater output and with the widespread availability of trypanocidal drugs small holder farmers now often prefer to cross their trypanotolerant breeds with zebu or even replace them altogether. Many taurine types are thus under pressure with reducing numbers of purebred animals. Their unique quality of trypanotolerance – which is free and unlike drugs which have to be paid for and may also have a negative effect on the environment – needs to be preserved for future generations.

**Figure 10. Mixed group of N'dama cattle at Teko Research Station in central Sierra Leone (Photograph: Trevor Wilson, November 1986).**

## 5. Discussion

The Sanga group of breeds is living testament to the ancient practice of crossbreeding in Africa. Thus for thousands of years livestock farmers have improved and adapted their livestock by selectively breeding animals with the various traits perceived necessary by the owners. Simple improvement since the advent of the Sanga still predates the arrival of European colonialists by many centuries.

Traditional cattle keepers are well known for improving the quality of their stock through retention for breeding and exclusive use of "alpha" animals of both sexes. Formal and probably better organized genetic improvement of domestic livestock arrived, however, in many African countries in the early years of the twentieth century when colonial settlers with their own traditional knowledge of the performance of their home breeds attempted to add some special attributes into animals native to their new residences. It is thus no surprise that the recent history of animal genetic modification in Africa has concentrated on "improvement" of local cattle for milk and meat production via crossbreeding introduced males (usually) on indigenous females. Crossbreeding was perceived as a more rapid route to improved output than the slower (and ultimately uncertain) process of direct increases through within breed selection. The justification for the introduction of exotic cattle during colonial times was primarily to supply beef and milk products to Europeans in the urban areas so these animals were husbanded close to these areas for ease of access to the markets

Crossbreeding was rapidly adopted across the whole continent as a panacea to increase the output of animal products. In most cases, however, the objectives of improvement (if indeed there were any objectives) were usually restricted to one trait, principally milk but occasionally meat, which failed to take account of the multipurpose nature of African livestock husbandry. In addition improvement programmes were almost invariably restricted to research stations where general good management could be rigidly imposed and adequate nutrition and health care could be assured, factors which again failed to take into account the reality of traditional production systems. Gains realized on station – which in any case were often illusory – were therefore not transmitted to smallholder producers' herds. It was only very late in time that the concept of improvement schemes involving farmers or producers was acknowledged and that these people should participate in defining the breeding goals and selection criteria and especially in the actual field management.

The overall experience from crossbreeding as a strategy to improve meat and milk production in Africa has not been strongly positive and, as succinctly stated by Malian scientists, is not a miracle cure nor is it likely to be if "anarchic" use of exotic breeds continues. In the main crossbreeding involving exotic and indigenous cattle has failed due to lack not only of biological or technical adaptation but also to lack of socio-economic considerations.

Public administration problems including policy issues, weak managerial capacity and excessive bureaucratic constraints have compounded the lack of success. There are fewer crossbreds in Africa than might be expected in part due to the foregoing and also due to the closure of many publicly funded selection and multiplication programmes being deprived of money and manpower and due to lack of adaptation of the crossbreds to poor feed and health environments.

These considerations raise serious doubts on the sustainability of widespread and indiscriminate crossbreeding. It is generally accepted, however, that under certain market and economic considerations crossbreeding programmes are useful and justifiable. Crossbreeding does have a role when resources and market demands allow the potential of such stock to be exploited. There are areas where the greater management, nutritional and welfare demands of exotic breeds and their crosses can be met. In the context of dairy cattle there are practical limitations to the possibilities that can be considered. It seems that in most cases only two breeds should be involved and there are advantages to continuing access to artificial insemination to maintain the exotic blood. Grading up above 50 per cent exotic blood is seldom worthwhile and the advantages of involving a third breed may not be substantial. Creating a synthetic may be operationally easier than the organization of a rotational breeding structure. Indeed, the optimum proportion of Bos taurus genes has long been an important issue in discussions on crossbreeding for milk production in the tropics. Reviews of many reports show improvement in almost all traits up to 50 per cent (i.e. first cross) but further grading towards taurus cattle has given variable and often disappointing results (Cunningham and Syrstad, 1987).

Most cattle in Africa remain in the traditional sector in which indigenous breeds and types predominate and the few exotic cattle are found mostly on commercial farms. In this context some studies have shown that whereas exotic breeds produce more milk individually, grow faster and attain heavier weights at maturity, annual cow productivity is lower in many exotics and crossbreds due to lowered reproductive performance and higher mortality rates. Private investment by smallholders is slowly increasing in some regions and could be accelerated by demonstrating to them the economic benefits of using truly improved stock. Most smallholders will not, however, be able to buy crossbred or exotic stock and will not attract external private investment.

For progress to be made, therefore, funding will be needed from other sources such as cooperatives, governments and international organizations but this must be assured and adequate for the long-term nature of cattle breeding operations. Active involvement of breeders and producers and continuous participation of scientists and breeders will be prerequisites of success. So far, unfortunately, the combination of large scale investment and the managerial and commercial organization required for optimal results has not yet materialized in African breed development (Madalena et al., 2002).

Crossbreeding and breed substitution programmes promote fast genetic changes but because of this they can be particularly risky if based on empirical trial and error. The genetic resources used should match the climate and the feed, health, management and other production circumstances. Various strategies (such as breed substitution, crossbreeding, new breed development and/or improvement within local populations) may be used for particular cases. Each strategy needs to be assessed according to the particular biological, socioeconomic and logistic circumstances. This has too often been overlooked in the past and has been responsible in large part for the lack of success or outright failure of many so-called development programmes. Imports of live animals or genetic material have been and will continue to be an important option but must be sensibly assessed in each case.

As a penultimate statement, some conclusions made 30 years ago (McDowell, 1985) are still valid. The use of European breeds for grading up of local cattle in tropical areas has been underway for almost one century but few countries yet have definitive policies on use of crossbreeding systems. Crosses with European breeds have excelled local types in age at first calving, milk yield, days in milk and calving interval and in general crosses by Holstein sires have proven superior to crosses from other breeds. Contrary to findings in temperate areas, addition of a second improved breed (three-breed cross) has tended to reduce rather than to improve performance. The cross of 5/8 one breed has performed as well or better than two-breed crosses but few evaluations have been on farms. The cross of 3/4 European usually exceeds the two-breed cross slightly in milk yield but reproduction is poorer. Mortality losses in 3/4 crosses up to 3 mo often have been high in the range 14 to 29 per cent. Experiences with inter se matings of two-breed crosses have proved similarly disappointing. Milk yield of ½ crosses of two-breed progeny has been 30 to 60 pr cent lower than for first generation two-breed crosses. Numerous attempts have been made to form synthetic groups from crossbred foundations with most of these gene pools of breed combinations being approximately 5/8 improved and 3/8 local. Evidence has shown that with high dependence on tropical grasses and crop residues best sustained milk yield is 1800 to 2200 kg per lactation.

This means that more attention should be given to breeding plans to raise animal productivity from low to intermediate rather than providing genetic potential for productivity that cannot be supported economically in tropical areas. That penultimate conclusion now leads to a final one and that is that the value of native livestock in Africa is not always fully appreciated. In many parts of the continent and especially in very difficult production environments the use of pure indigenous breeds is often the best production strategy. Within-population selection programmes have lower rates of change but they are appropriate in endowing their offspring with valuable combinations of traits. One example among very many is the case of trypanotolerance. Bos taurus in Central and West Africa are resistant to the effects the parasite has on non-tolerant stock. The number of animals with the protective adaptation is dwindling as local farmers cross and replace their taurine herds for large zebu animals. This highlights the importance of efforts to prevent further dilution, not only of African taurine breeds but also of other African indigenous breeds with unique adaptive traits.

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