

## A review of studies on breed evaluation and genetic improvement of cattle in Ghana

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### ABSTRACT

A review of some major cattle breed evaluation and genetic improvement experiments, particularly in the post-independence period up to 1990, was made. There was no clearly defined policy on genetic improvement of livestock during the period; hence, breed improvement efforts were uncoordinated. The Ministry of Food and Agriculture, the Faculties of Agriculture at the universities and the Animal Research Institute were the major organizations that showed interest in breed evaluation and genetic improvement of cattle in Ghana. The programmes involved the use of Zebu × Taurine (e.g. White Fulani × West African Shorthorn) crossbreds, exotic × local (e. g. Friesian × Sanga), or purebred exotics (e. g. Friesian). The exotics and their crosses had better growth rates and milk yields than the local or indigenous breeds. The former genetic groups also had poorer adaptation to the local environment. It was concluded that the very elaborate breed evaluation and genetic improvement experiments conducted by the universities were limited to stations, resulting in little or no impact on the production system. The experiments of the Ministry of Food and Agriculture were the most successful, as the Sanga progeny from the Zebu × Taurine crossbreeding projects was adopted by farmers in all cattle-rearing regions in the country. It was also concluded that, from point of view of adaptation and expenditure required for importation, genetic improvement of cattle should be based on the available adapted indigenous breeds, namely West African Shorthorn and the Sanga. Within breed selection and crossbreeding, including the use of exotics, were available options. The need for clear breeding objectives was emphasized.

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### Introduction

The Republic of Ghana lies on the Greenwich Meridian, between the 5th and 12th parallels north of the Equator on the coast of West Africa. The country has an area of 238,540 km<sup>2</sup>, with a human population of 14.2 million (Ghana Statistical Service, 1987). There are an estimated 1.3 million head of cattle in Ghana (FAO, 1988). The ratio of cattle to man (1:11) clearly reflects low availability of cattle products.

A range of vegetation, from Sudano-Guinean savanna woodland and coastal scrub grassland, through moist semi-deciduous forest to tropical rainforest, occurs in Ghana (Benneh, 1986). The transitional and forest zones support a biomass production of 2.9 to 17.5 tonnes DM per ha (ARI, 1972). Annual rainfall ranges from 750 mm in the savanna zones to 2000 mm in the forest zones. Internal and external parasites are the major causes of livestock mortality. Contagious bovine pleuro-pneumonia (CBPP) and Brucellosis have been the major epizootic diseases (Boadu, 1971; Annan, 1984; Yeboah, 1977). The West African Shorthorn (WAS or WASH), the indigenous breed, constituted about 79 per cent of cattle in Ghana (MOFA, 1987).

Livestock contributes about 10 per cent of agricultural GDP and offers opportunity for expansion. Livestock research, particularly ruminants, has remained in the fields of health and nutrition, whilst there is a widely held belief that indigenous or local livestock in Ghana, for example cattle, are of poor genetic potential. The paper attempts to review some major cattle breed evaluation and genetic improvement experiments undertaken in Ghana, particularly in the post-independence period up to 1990. The information collated would serve as hindsight for future cattle breed improvement programmes in Ghana. Similar reviews have been reported for La Cote d'Ivoire (Lenteneur, 1978) and Nigeria (Ngere, 1982; Osinowo, Ikhatua & Ehoche, 1982), while Okantah (1990) provided a selected review for the West and Central African countries of The Gambia, Cameroon and Ghana.

### Materials and methods

Officials of the Ministry of Food and Agriculture (MOFA) and Amrahia Dairy Station were interviewed in 1989 in Accra. A lot of the information reviewed was grey literature in microfiche format at the Library of the International Livestock Centre for Africa (ILCA) in Addis Ababa, Ethiopia, in 1989. A microfiche reader was used to access the grey literature originally collected by ILCA.

### Policy

In 1992 a workshop was held to develop livestock breeding policy for Ghana; and by 1995, Breeding Policy and Animal Breeding Plans (Okantah & Boa-Amponsem, 1992; Ahunu *et al.*, 1995) had been worked out for the Republic of Ghana. The main thrusts of the cattle breeding policy of 1992 and breeding plans of 1995 were to select and develop the West African Shorthorn as a beef animal, to develop the Sanga as dual-purpose cattle, and to develop Exotic (dairy) × Sanga crossbred cattle for milk and meat production.

Previously, the general government policy on livestock production in Ghana was to increase domestic meat production to reduce imports and move toward self-sufficiency in animal protein. The policy was loose and only provided some general guidelines.

There was no clearly defined policy on genetic improvement of livestock (Okantah, 1989) for the period under review. Thus, cattle breed improvement efforts were uncoordinated, and institutions interested in genetic improvement pursued individual goals. In general, there were two cattle breed improvement proposals with different objectives in Ghana by 1990.

The Animal Research Institute (ARI) favoured development of the traditional system into a proper dual-purpose system. The goal of the ARI proposal was 50:50 local to exotic dairy breed genotype with continuous selection to support the milk production system in agropastoral herds on the Accra Plains (Okantah, 1980a, 1980b). The project was started in 1989 in collaboration with

the Ministry of Food and Agriculture which maintained a pure Friesian herd at its Amrahia Station. A smallholder herd milk recording scheme was started by the ARI in 1988 to aid selection (Okantah, 1990a, 1990b).

The objective of the breeding programme of the University of Ghana was to improve beef cattle production. The final genotype envisaged was a composite of four breeds, comprising 37.5 per cent local (1 breed) and 62.5% exotic (3 breeds). At the time to this review, the N'Dama, Red Poll and Santa Gertrudis had been used in two exotic sire breed lines (Anon., undated).

The Ministry of Food and Agriculture also had its own breeding work on the ground. The Ministry frequently imported exotic breeds from Europe and Australia. Trypano-tolerant cattle, N'Dama, were imported from other West African countries, Gambia and Guinea. The Ministry of Agriculture maintained cattle breeding stations in strategic regions of the country (E. P. Mallet, 1989; personal communication). The functions of the breeding stations were provision of extension services, production of improved breeding stock, and multiplication and supply of improved breeding stock to farmers.

#### **Cattle management systems in Ghana**

The traditional cattle-rearing areas in Ghana are the northern and coastal savannas. In the northern parts of Ghana, cattle are held by one or several families and herded by migrant Fulani people. On the coastal plains, cattle belong to individual absentee owners who hire the services of Fulani herdsmen. The Fulani husbandry practices on the Accra Plains have been described by Okantah (1974, 1990a). The cattle are held in smallholder farms of 20 to 250 head. A few Fulani herdsmen have large herds up to 1000 or more. The cattle are grazed extensively over communal natural pastures.

Adult cattle are kept in separate kraals from calves overnight. The calf kraal is usually adjacent to that of the adult cattle. Kraals are close to the dwelling places. The separation of cow and calf

overnight effectively prevents calves from suckling their dams and, therefore, facilitates milking the next morning. The Fulani herdsman is partially paid in kind through extraction of milk. Practically, all herds managed by Fulani are milked partially. Milk let-down is induced by a brief period of suckling by calf, which is then tied to one of the forelegs of the cow. During the dry season, milking is done early in the morning and cattle sent on long treks for grazing, returning late in the evening (Okantah, 1990a). In the north the practices are similar, and cattle graze around the outskirts of village farming communities. Mating is uncontrolled as bulls run with cows all year round. Excess males are usually castrated.

#### **Breed evaluation and improvement experiments**

The Ministry of Food and Agriculture, the Faculties of Agriculture, and the Animal Research Institute are the major bodies that have been interested in breed evaluation and genetic improvement of cattle in Ghana. In general, three approaches to breed improvement recognised are programmes involving the use of Zebu × Taurine crossbreeds, exotic × locals, or pure-breeding exotics.

Breed improvement projects undertaken by the Department of Animal Husbandry of MOFA are not well documented. During the 1960s, there were 40 livestock breeding stations spread countrywide across all ecological zones in Ghana (H. H. Hesse, 1989; personal communication). The breeding stations were reduced to 12 in 1989. The breeding stations undertook crossbreeding of the Taurine breeds, N'Dama and West African Shorthorn with imported Zebu breeds, Gudali and White Fulani (Bunaji). The crossbred Sangas and some pure Zebras were distributed to farmers. The derived progeny are found in the production system on the Accra Plains and around stations all over the country. The programme was not systematic and so there were no proper data collection or documentation. The programme collapsed following the downturn of the economy during the 1970s.

The Ministry of Food and Agriculture and the universities imported various cattle breeds into the country for their breeding projects. Table 1 presents the percentage composition of breeds in the national herd, based on Ministry of Food and Agriculture census figures from 1982 to 1987.

Table 1 shows the predominance of the indigenous breed, the West African Shorthorn, accounting for almost 80 per cent of cattle in Ghana during the period of review. In this paper, distinction is made between indigenous breed (which is a landrace) and local breed, which implies a tropical breed from the West African sub-region; for example Shorthorn is indigenous, whereas N'Dama, Gudali and White Fulani are

cows were evaluated from birth to 18 months by Animal Research Institute and their performance compared within station with contemporary calves of Gudali bull with N'Dama and Sanga cows. The cattle were grazed on pasture without any supplementation. Table 2 shows the mean live weights at different ages.

The SG × WF calves were heavier at birth, and the weight advantage over their contemporaries increased through 18 months. Differences in liveweight for age between N'Dama or Sanga crosses were not significant. Thus, SG crossbred had higher growth rate than their contemporary Gudali × N'Dama and Gudali × Sanga crossbreeds.

The above result suggests that either of the

TABLE 1  
*Population Percentages and Types of Cattle Breeds in Ghana, 1982-1987*

<i>Breed</i>	<i>Type</i>	<i>Population 1000 head</i>	<i>Percent national herd</i>
WASH	Beef	936	79
Sanga	Dual-purpose	189	16
Zebu	Dual-purpose	33	2.6
N'Dama	Beef	25	2.1
Friesian & Exotics	Dairy	3	0.3

locals. Exotics are imported breeds from outside Africa. By these definitions, the West African Shorthorn (WASH) is both indigenous and local. Okantah (1980a) suggested that any cattle breed improvement programme should be based on the indigenous breed, as importation of cows to replace the national cowherd was not economically prudent.

#### ***Beef cattle improvement***

The potential of crossbreeding for improvement of beef cattle in Ghana was evaluated by Kahoun (1970) using data from the Ministry of Food and Agriculture. Santa Gertrudis (SG) semen was imported by the Ministry of Food and Agriculture in 1966 for crossbreeding at the Animal Husbandry Station, Nungua. The first eight crossbred calves out of white Fulani (WF)

two breeds, N'Dama or Sanga, could be used as dams in a crossbreeding project. N'Dama, however, is an imported breed. The superiority of the exotic SG sire breed is also evident.

A report on the evaluation of crossbreeding of local cattle with exotic cattle at the Agricultural Research Station (ARS) of the University of Ghana was provided by Ngere & Cameroon (1972). The Beef Breeding Programme was started at the ARS, Nungua, in 1966 and transferred to ARS, Kpong, in 1968.

The performance of indigenous cattle, West African Shorthorn (WAS) and N'Dama (ND), was compared with the crosses of Santa Gertrudis and Red Poll with WAS obtained by ARI. In the absence of purebred exotic parentals, heterosis was estimated as percentage increase over performance of local breeds. This definition tends

TABLE 2

*Mean Liveweights from Birth to 18 Months of Age of Exotic and Local Crossbred Cattle ( $\pm$  SD) (kg)*

Age	Crossbred group		
	<i>S. Gertrudis</i> $\times$ <i>W. Fulani</i>	<i>Gudali</i> $\times$ <i>N'Dama</i>	<i>Gudali</i> $\times$ <i>Sanga</i>
Birth	24.38 $\pm$ 3.23	15.33 $\pm$ 2.83	17.67 $\pm$ 1.90
3	79.12 $\pm$ 19.98	55.67 $\pm$ 14.09	64.50 $\pm$ 12.12
6	120.62 $\pm$ 27.15	78.00 $\pm$ 16.19	92.17 $\pm$ 18.37
9	145.88 $\pm$ 31.66	90.67 $\pm$ 20.72	111.00 $\pm$ 27.34
12	155.75 $\pm$ 30.70	98.83 $\pm$ 19.92	114.83 $\pm$ 26.12
15	165.33 $\pm$ 29.89	120.50 $\pm$ 20.11	131.67 $\pm$ 24.67
18	213.25 $\pm$ 22.02	149.67 $\pm$ 16.22	166.00 $\pm$ 18.05

Source: Kahoun (1970)

to exaggerate gains from crossbreeding. Table 3 shows the growth performance for the various genotypes. Average daily gain from birth to weaning, and weaning weight adjusted to 210 days were influenced by maternal effects, particularly milk yield of dam. Sex and breed had significant effects on birth weight. Breed  $\times$  Sex interactions and within breed variation were not significant. Growth rate was not affected by any of these factors, and only the effect of sex was

highly significant on weaning weight (Ngere & Cameroon, 1972).

According to a review document probably prepared in mid-1980s, the project title was changed from "Beef Breeding Programme" to "Beef Cattle Improvement Programme" (Anon., undated). Whether this represented a shift in emphasis from a station-limited breeding programme to a more extensive cattle improvement programme was not clear. The

TABLE 3

*Growth Characteristics of Indigenous and Crossbred Cattle*

	WAS	ND	WAS $\times$ ND	SG $\times$ WAS	RP $\times$ WAS
Birth weight (kg)	14.9	14.6	14.4	23.8	22.4
Number	(52)	(26)	(5)	(25)	(14)
Weaning weight (kg)	109.3	108.8	109.3	116.6	96.1
	(33)	(21)	(4)	(18)	(8)
Prewaning growth rate (kg/day)	0.39	0.36	0.45	0.44	0.39
	(14)	(9)	(4)	(19)	(8)
Postweaning on pasture (3)	0.14	0.12		0.20	
Pasture supplies (3)	0.09	0.17		0.50	
Weight at 2½ years	184.1	241.7		258.0	286.2
	(2)	(3)		(2)	
Weight at 3 years	227.7	254.4		321.1	316.5
	(6)	(8)		(5)	(6)
Weight at 3½ years	205.4	276.6		331.5	357.4
	(3)	(8)		(3)	(3)
Weight at 5 years	316.1	311.1			
	(5)	(1)			

Source: Ngere &amp; Cameroon (1972)

review was critical on the lack of properly defined objectives for the Beef Breeding Programme and the lack of selection criteria. Selection had been based on birth weight and visual appraisal, which were unreliable. No justification had been provided for the choice of the exotic sire breeds, Santa Gertrudis or the Red Poll. The review suggested a breeding programme for improvement of beef production through exploitation of heterosis in the cow by crossbreeding to improve reproductive traits, and selection to improve rate of gain and cross merit.

Introduction of a third exotic breed was recommended. The final genotype would be three parts local (N'Dama) and five parts exotic blood contributed by the three exotic breeds, Santa Gertrudis, Red Poll and Brown Swiss. N'Dama is not indigenous to Ghana, and breeding programmes based on N'Dama imply importation of the basic breed. ILCA (1979) provided other estimates of liveweights of male and female WAS, N'Dama, Sanga and Gudali breeds of cattle in Ghana (Table 4). The birth weight figures for WAS and Sanga were higher than those reported by Ngere & Cameroon (1972).

#### **Dairy cattle improvement**

The cattle indigenous to Ghana are generally poor milkers (Table 5). Poor calf growth rates (Table 3) in the country have been attributed to the poor milk yields and poor quality nutrition (Montsma, 1960; Montsma, 1962; Okantah, 1974). Therefore, various attempts have been made to

improve the dairying capability through crossbreeding and breed substitution. Most reports were from one-station studies, but partial milking lactation curves have been described by Okantah (1990b).

In Table 5 the reproductive performance of some cattle breeds and crosses have been assembled from reports by Ahunu & Acquah (1987), Gyawu, Asare & Karikari (1988), and Okantah (1989). The preponderance of estimates collected from studies on-station, is a probable reflection of paucity of on-farm studies, particularly during the period under review. The age at first calving between 35 and 39 months is long for local breeds and their crosses with Jersey or Friesian bulls. The imported lactation length of local breeds, WAS, Sanga, N'Dama and Gudali, was also short. The calving intervals and lactation yields of these breeds and their crosses were also poor (Table 5), particularly when viewed as on-station results.

According to Graham (1968), the Gold Coast Veterinary Department was established between 1909 and 1910, with its headquarters at Pong Tamale. The earliest attempt at breed improvement was in 1909 when two bulls were imported from the United Kingdom to upgrade the indigenous Taurine cattle. Both bulls died on their way to Tamale. Another attempt in 1919 was also unsuccessful. Many exotic breeds, since then, have not survived because of poor adaptation (Hamidu, 1980). The main constraining diseases (Table 6) have been skin and tick-borne

TABLE 4

*Liveweights of Females and Males of Some Cattle Breeds in Ghana (kg)*

<i>Breed</i>	<i>Birth wt</i>		<i>Weaning wt</i>	<i>Mature wt</i>	
	<i>Male</i>	<i>Female</i>		<i>Male</i>	<i>Female</i>
WAS	20	18	154	256	229
N'Dama	19		138	311	260
Sanga	24		122	328	306
Gudali	27		214	520	520

TABLE 5  
*Reproductive Performance and Milk Yield in Cattle Breeds and Crosses*

<i>Breed</i>	<i>Location</i>	<i>Location yield (kg)</i>	<i>Lactation length (days)</i>	<i>Calving interval (days)</i>	<i>Age at 1st calving (months)</i>
Sanga	On-farm	210	240	540	
WAS	On-station	384	182	444	35
N'Dama	"	460	182	457	39
Gudali	"	604	182	465	39
Jersey × WAS	"	1120	251		37
Jersey × Gudali	"	1555	295		39
Jersey × Gudali × Jersey	"	1879	323		37
Friesian (imported)	"	4437	305		31
Friesian (born in Ghana)	"	2478	305		30

Source: Okantah (1989)

TABLE 6  
*Disease Problems in Exotic Breeds*

<i>Breed</i>	<i>Country of origin</i>	<i>Year of introduction</i>	<i>Problems encountered</i>
Hereford	Great Britain	1970	Skin diseases
Friesian	Great Britain	1970	Skin diseases
Friesian	Holland	1964	Skin diseases
Droughtmaster	Australia	1970	Heartwater
Nilores	Brazil	1978	Skin diseases

Source: Abimbila (1980), Hamidu (1980) and Annan (1984)

diseases (Abimbila, 1980; Hamidu, 1980; Annan, 1984).

Heat stress, possibly compounded with high humidity, is another problem of adaptation. The comparative data on tolerance of cattle to heat stress in Africa are scanty. Okantah (1985), in collaboration with Aggrey (1985), and subsequently with Amoako (1986), studied the reaction of purebred exotic (Friesian and Brong Swiss), purebred locals (Gudali and WAS), and crossbreds (Jersey × N'Dama and Jersey × WAS) to diurnal changes in ambient temperature (Amoako & Okantah, 1986).

The highest change (elevation) in rectal temperature was observed in the Friesian, and

the lowest change was recorded in the Gudali. There was no significant difference between the crossbreds and WAS. The correlation between change in rectal temperature and milk yield was negative, while the correlation with fat content was positive. It was concluded that the crossbreds were as tolerant as the indigenous WAS, but known to be more productive in milk production and carcass yield (Awuma, 1976; Osman, 1983; Okantah, Aggrey & Amoako, 1993) and, therefore, would be useful in the production system on the Accra Plains.

Hutchison (1963) provided one of the rare accounts of the cattle crossbreeding projects which were aimed at improving dairying in Ghana.

The cattle indigenous to Ghana is the West African Shorthorn. The N'Dama was imported from Guinea and Mali. Both breeds were found to be poor milkers, though trypano-tolerant. Zebu breeds, White Fulani (WF) and Adamawa Gudali, were imported from Nigeria and Cameroon for upgrading of the Taurine breeds. The crosses made were Gudali  $\times$  N'Dama and White Fulani  $\times$  WAS. The Gudali  $\times$  N'Dama crossbreeding was carried out in the Tongu District in the Volta Region, and was considered a better animal in comparison with the WF  $\times$  WAS (no comparative figures were provided). Purebred herds of Adamawa Gudali, WF and N'Dama were maintained at the Ministry of Food and Agriculture Breeding Station at Nungua for supply of bulls. A crossbred Sanga herd was also maintained at the station. N'Dama bulls were supplied to farmers in tsetse-infested regions (Hutchison, 1963). Some of the data were evaluated by Kahoun (1970) as shown in Table 2.

Another experiment involved crossing of the imported WF with Sahiwals imported from Pakistan and India for upgrading. The WF were also crossed to Israeli Friesian by ARI. Bulls from the various crossbreeding projects were sold or issued to farmers on loan. Bulls were used only after 2.5-3.0 years of age and changed after 3-4 years to control inbreeding. Government-operated Sahiwal dairy farms were envisaged. These would supply breeding bulls to farmers. The objectives of the projects were to provide more milk to children and also for rearing of calves.

The Amrahia Dairy Farm was established in 1967 with 200 Friesian heifers imported from the Netherlands. The objectives included supply of improved bulls to smallholder agropastoralists on the Accra Plains. The last objective had not been implemented by 1989 (E. P. Mallet, 1989; personal communication).

The University of Ghana has undertaken the most extensive experiments in dairy cattle crossbreeding. According to Danbaro (1990), the dairy crossbreeding project was started at the Agricultural Research Station of the University

of Ghana (ARS, Legon) in 1958, with Jersey semen on three local breeds, WAS, N'Dama and Sokoto Gudali, by ARI. In 1967, Friesian germplasm was introduced. The aims of the project were to identify the best introduced breed, the optimal level of introduced germplasm and the performance of crossbreds under local environmental and management conditions. Segments of the data have been examined intermittently (Ahunu & Aquaah, 1987) for within genotype and environmental effects on milk yield. However, Danbaro (1990) analyzed the data set collected over 25 years for genotypic and environmental effects.

Cows were bred from April and calving was spread throughout the year. Cattle were grazed on natural and cultivated pastures from 7.00 a.m. to 7.00 p.m., and were supplemented with sorghum or maize silage in the dry season. Lactating cows received concentrates at milking. Water was offered *ad lib* (Danbaro, 1990). A rigorous health routine involved weekly spraying and fortnightly drenching against ecto- and endo-parasitic infestation. The record-keeping system included a dairy calves' register, individual cow record cards, dairy cattle herdbook, artificial insemination record book and diary.

Calf birth weight in Danbaro's (1990) study was influenced by breed, sex, period of recording, and age of dam. Crossbred calves had heavier birth weights than locals. Weaning weights were also influenced by breed, birthweight, lactation length, lactation number, breed of cow, and period of recording. Gudali crossbreds yielded more milk than WAS crossbreds, which, in turn, produced more milk than N'Dama crosses. Milk yield increased with level of exotic inheritance. Season effects were not important, a reflection of good nutrition management.

The prospects for dairying in Kumasi, a humid zone, were elaborated by Tuah (1973) indicating the potential for pasture and fodder production. In 1974, the Faculty of Agriculture of the Kwame Nkrumah University of Science and Technology established the Boadi Cattle Project with 35



Holstein-Friesian heifers and five bulls imported from Canada. Aspects of the project have been described by Alhassan & Owusu (1980) and Kabuga (1980, 1981). The area is hot and humid throughout the year. Initially, the animals were confined to barns and later transferred to pasture. Following the loss of seven heifers on pasture, the cattle were confined in barns and grazed only in the night. The forest vegetation was cleared to establish pastures for the cattle. Mating was all year round on pasture. Forage was provided *ad lib*, and lactating cows were given supplementary concentrates.

Disease control and prevention measures included drenching, vaccination and chemotherapy for trypanosomiasis. Breeding and production records were kept. According to Kabuga (1980), conception rates in the herd were generally low, with 56.2 and 61.2 per cent of cows getting in calf after the third and fourth services, respectively. Days open and calving interval were also long in the herd, being 167.5 and 450.7 days, respectively. However, age at first calving was low for the tropics at 30.9 months (Kabuga, 1980). The 305-day milk yield was high with a mean of 4,731 kg and a range of 3,082 to 6,059 kg. Lactation number and age at calving significantly influenced milk yield, but season effect was non-significant.

### Discussion

The information collated in this review supports the general view that productivity of local cattle is low in terms of milk and meat. On-station experiments usually carried out under improved environmental conditions gave poor growth rates and milk yields (Montsma, 1960; Ngere & Cameroon, 1972; Ahunu & Acquah, 1987). There is, therefore, a need for genetic improvement of indigenous cattle. Despite the long absence of well-defined policy guidelines on cattle breed improvement, a significant number of experiments have been undertaken in the normal pursuit of academic interest. As usual with station-limited breed improvement, there have been very little or

no impact on the production system in the country.

As at the time of this review, there was not a single offspring from the extensive experiments undertaken at the University of Ghana, Legon. Well laid-out experiments to identify breeds suitable for crossbreeding, as well as levels of exotic blood have not yielded palpable results in the form of improved stock. Nevertheless, some useful information has been collected. Notably, the improvement of milk yield with exotic inheritance (Danbaro, 1990) is an interesting result, which seems to be at variance with most experiences reported from the tropics; for example, McDowell (1985) and Syrstad (1985). However, in the University of Ghana experiments, environmental factors such as nutrition and health care were well catered for. Therefore, with the improved environment, the high potential genotypes were well expressed in phenotypic performance. This result is encouraging and indicates that the achievements in dairy improvement made in Israel (Turton, 1981), and possibly Cuba, could be replicated in Sub-Saharan Africa, provided the right environment are created.

The humid zone experiments on dairying at the Kwame Nkrumah University of Science and Technology also provide interesting results. The milk yields under those conditions were reported to be higher than those usually reported from the tropics. This reflects the availability of abundant high quality feed resources such as forage and fodder. The 31-month age at first calving possibly indicated early approach to mature weights also due to nutritional factors supporting high potential genotypes. Disease challenge is arguably the most important problem in the humid zone. A possible solution would be the production of fodder in the high primary biomass potential zones for feeding in the rearing environment, where cattle occur in large numbers and the environment is less stressful in terms of disease challenge.

The University experiments have been limited to stations and as such have had no impact on the national production of meat and milk. Viewed in this light, the experiments of the Ministry of

Food and Agriculture have been the most successful. In spite of initial mistakes in choices of crossing breeds (exotic × exotic), the Sanga progeny from the Zebu × Taurine crossbreeding projects are found in their numbers in the cattle-rearing regions all over the country. Farmers have adopted and continued Sanga breeding nationwide for milk and meat, making the Sanga second in numbers only to the landrace West African Shorthorn in Ghana.

The above experience underscores the need to have a wide outlook in designing and implementing breeding programmes. The project of the Animal Research Institute, started in collaboration with the Ministry of Food and Agriculture, aims to improve cattle on the Accra Plains. The outlook is wide enough and unrestricted to station. It should benefit from these previous experiments by combining their good points whilst avoiding their pitfalls. Opening up of the selection programme to cattle farmers should facilitate modern open nucleus breeding system for rapid genetic gains and dissemination of improved cattle genotypes in the production system over a wide area.

From the evidence in this review, it can be concluded that exotic cattle, whether of European (e. g. Friesian, Jersey) or tropical (e. g. Sahiwal, Droughtmaster) origin, lack adaptation to the local production environment, and can only survive under very good improved rearing conditions. From points of view of adaptation and expenditure required for importation of cattle, genetic improvement in Ghana should be based on the available adapted local cattle breeds, namely West African Shorthorn and Sanga. Within breed selection and crossbreeding, including use of exotics, are available options. Implementation of the National Livestock Breeding Policy and the National Animal Breeding Plans should provide Ghana with cattle strains that have high genetic potentials for milk and meat production within the shortest possible time frame.

The lack of focus in previous breed improvement programmes should be avoided

through definition of the breeding objectives. Future breed improvement programmes must have objectives that reflect social, biological and environmental requirements for sustainability. Socio-political objectives of the breeding plan must have national requirements of milk and beef in view. Economic objectives should take into account efficiency of production. Finally, biological objectives must take into account productivity and environmental adaptation for sustainable production of cattle milk and meat.

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