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Beef production in the arid and semi-arid lands of Kenya

Constraints and prospects for research and development

A.K. Kahi, C.B. Wasike and T.O. Rewe

Abstract: *Most of Kenya (80%) is classified as arid and semi-arid. The climatic conditions in these regions are so harsh for crops that only livestock production can thrive. These regions provide the bulk of beef consumed in the country, which is produced via two main systems: large-scale dairy-meat commercial ranching and small-scale dairy-meat production. In both these systems, production is pasture-based. The animals kept are the highly adapted indigenous zebu (small East African zebu and Boran) or exotic beef (for example, Hereford, Simmental, Charolais, Angus) breeds and their crosses kept mainly by the commercial ranchers. Development of the beef industry in Kenya has lagged behind other agricultural enterprises due to policies that were unfavourable towards arid and semi-arid lands and the historically poor infrastructure development in the rangelands. It is concluded that there is potential for beef production in Kenya, given the available genetic and physical resources, although this potential can be achieved only if government policies are introduced to accelerate development in the rangelands and empower both the larger producers and pastoralists to increase their production.*

Keywords: *arid and semi-arid lands; beef cattle production; production constraints; production systems; research and development*

A.K. Kahi is with the Laboratory of Animal Husbandry Resources, Division of Applied Biosciences, Graduate School of Agriculture, Kyoto University, 606 8502 Kyoto, Japan. Tel: +81 75 753 6365. Fax: +81 75 753 6373. E-mail: kahi@kais.kyoto-u.ac.jp. C.B. Wasike is with the Animal Breeding and Genetics Group, Department of Animal Sciences, Egerton University, PO Box 536, 20107 Njoro, Kenya. T.O. Rewe is with the Institute of Animal Production in the Tropics and Subtropics, University of Hohenheim, 70593 Stuttgart, Germany.

More than 80% of Kenya is classified as arid or semi-arid. These areas are characterized by low rainfall, high ambient temperature, poor-quality feed resources, high solar radiation and high incidences of livestock diseases. However, the arid and semi-arid lands (ASALs) support at least 50% of the livestock population and more than 25% of Kenya's human population, thus forming an important avenue for rural development (Kinyamario and Ekeya, 2001). Indigenous populations living in these areas

practise pastoralism to earn a living. This is based on local cattle (small East African zebu – SEAZ and Boran), goats, sheep and camels, in order of preference, and thus constitutes a major source of Kenya's meat (Herlocker, 1999).

ASALs provide the bulk of the beef consumed in the country, which is produced within two main systems: large-scale dairy-meat commercial ranching and small-scale dairy-meat production. The large-scale commercial

ranchers keep high-yielding improved Boran and exotic beef cattle, including Hereford, Simmental, Charolais and Angus, to produce high-quality beef via modern breeding methods and targeted towards specialized local and export markets. Small-scale dairy-meat production systems use the SEAZ as a dual-purpose animal, which has comparatively low production performance (Herlocker, 1999). The Boran or its crosses with the SEAZ can also be found in this system. The wide gap in genetic and physical resources between the commercial ranchers and the small-scale producers engenders a poor mutual relationship between the two groups. But the introduction of beef ranching in the rangelands has improved the productivity of the land and offered a feasible source of breeding stock for the pastoralists.

Large-scale commercial ranching is, however, being threatened by annual human growth rates of 3% and inter-generation inheritance of land, which results in the continued subdivision of land into smaller pieces (Bebe *et al*, 2002). The efforts of ranchers to enhance good quality beef production, therefore, require bilateral support through implementation of good policy guidelines and legislation (Prettejohn and Retief, 2001).

Beef production is maintained in the tropics under a variety of circumstances, all with different production opportunities and constraints. This results in variability in output and profitability that influences producer preferences. Improvement is brought about, therefore, through proper understanding of the challenges and opportunities available in the various production systems. This paper identifies the constraints and explores the prospects and possible intervention measures for the improvement of beef production in Kenya.

Historical development of beef production

The history of beef production in Kenya can be divided into three phases: beef production pre-independence, post-independence with market controls, and post-independence with market liberalization.

Pre-independence

This period covers the colonial period from the turn of the nineteenth century. Before the arrival of the white settler farmers, the natives kept the indigenous East African zebu (Stotz, 1979) under extensive production systems, mainly for subsistence (milk and meat production). The animals sold for slaughter came mainly from the southern and northern parts of the Rift Valley and North Eastern provinces where pastoral nomadism was practised. The colonial settler farmers brought pure-bred exotic cattle, which proved unsuccessful due to their susceptibility to environmental, feed and disease problems. Crossbreeding trials identified the potential for upgrading the indigenous species for increased milk production (Bebe *et al*, 2002).

By the 1930s, a viable dairy industry had been established and with it a competitive beef industry with the improved Boran cattle as its base, crossbred culls from the dairy industry and the indigenous stock (Chirchir, 2001). The few settlers who occupied the rangelands practised large-scale commercial ranching since they had access to large tracts of land. The established input support

services and marketing organizations used to develop dairy production (Bebe *et al*, 2002) also spread to the beef industry. This included the veterinary research laboratories in 1910, the animal husbandry research station in 1935 and establishment of livestock marketing routes and zones, among others (Kilung'o and Mgheenyi, 2001). Most of the beef consumed in the country at this time, however, was from culled stock from the dairy industry and pastoral indigenous cattle.

Beef production post-independence with market controls

After Kenya's independence in 1963, the government's top priorities were poverty alleviation, rural development and food security through agricultural development (Government of Kenya, 1980; 1986). The aim was to enhance food security through intensification of cereal and milk production and to reduce the import gap for these commodities. Government policies strongly supported the subdivision of idle government land and the selling of large-scale farms formerly owned by white settlers to smallholder farmers (Government of Kenya, 1980; Bebe *et al*, 2002). This policy was favourable to the high-potential areas where land was a limiting production factor and milk production was the main livestock enterprise.

In the ASALs, however, where the major economic activity was pastoralism, land subdivision had led to a reduction in pastoral productivity and commercial beef ranching and to environmental degradation, which resulted in a decline in the number of large-scale ranches and reduced high-quality beef output. The pastoral herders also increased their stock in the marginal areas, leading to further environmental degradation due to overstocking. Some of this took place amid privatized land blocks and restricted nomadism (Government of Kenya, 1980). Indigenous stock from the marginal areas and culled dairy stock from farms in the high-potential areas, and to a lesser extent those large-scale ranches that survived subdivision, still remained the main source of beef.

The beef industry development programme proposed in 1968 that led to the establishment of the National Beef Research Centre (NBRC) was a primary step towards a well organized beef production improvement programme. In this initiative, the Boran breed was identified as the most productive beef breed for the harsh arid and semi-arid environments of Kenya. However, the programme was not fully implemented due to over-reliance on donor funding, and the breeding, production and marketing systems remained diverse and decentralized.

In 1984, the value of beef production was ranked sixth after coffee, maize and beans, milk, tea and root crops. The problems impeding beef production were identified as land subdivision, parasitic and microbial diseases, poor infrastructure and insecurity. Policies were consequently put in place to improve utilization of the ASAL through implementation of various measures, which included (Government of Kenya, 1986):

- improvement of livestock marketing systems through the provision of the trunk system on the stock routes and holding grounds to serve the pastoral areas;

Table 1. Total number of animals raised for beef and estimated output and demand in tonnes per breed from 1997–2008.

	1997	1998	1999	2001	2004	2008
Cattle population	9,824,500	9,956,200		11,000,000	12,000,000	13,600,000
Output from zebu cattle	182,560	189,000	195,615			
Output from exotic cattle	78,240	81,000	83,835			
Total output	260,800	270,000	279,450	295,610	323,021	363,563
Total demand				329,600	360,200	405,300

Source: Ministry of Agriculture and Rural Development (MoARD), Animal Production Division Annual Reports, 1997–1998 and National Development Plan for the period 2002–2008 (NDP, 2002).

- establishment of the national marketing, reporting and information system;
- development of water supply points for nomadic herders, and fees to be charged for maintenance;
- encouragement of ranchers to develop their own water supply points;
- development of programmes to reduce tsetse fly infestation; and
- improvement of security in the pastoral areas.

The implementation of some of these policies had been started in 1979 under donor funding. Land policies were also reviewed at this time to protect the investments of holders of large tracts and encourage them towards ranching. The main players in beef cattle and beef marketing included the private livestock traders, Livestock Marketing Division (LMD), Kenya Meat Commission (KMC) and private butchers. The government controlled the market prices of beef and beef products to protect producers and consumers against exploitation. Later on, after the scrapping of the LMD and the collapse of KMC in the late 1980s, beef marketing was a fully private sector initiative. However, the government still maintained control of the market prices of beef and beef products.

Beef production post-independence with a liberalized market

In 1996, the government implemented economic and structural reforms in the agricultural sector, which led to changes in policy framework aimed at accelerating agricultural growth, increasing productivity and expanding rural employment (Government of Kenya, 1996). This was to be achieved through deregulation of domestic markets for all agricultural commodities to facilitate private sector participation in agricultural production, processing and marketing in the liberalized market system (Government of Kenya, 1996).

During this period, there was a restructuring of the Ministry of Agriculture, Livestock Marketing and Development to reorient its role and its strategic functions to facilitate private sector initiatives with an emphasis on providing improved research, extension and other services to farmers. At the same time, there was privatization of veterinary services and farm produce marketing. The aim of these measures was to increase the efficiency of production and facilitate market competition. It was during this period that policies governing land use in the rangelands and agricultural research were revised, leading to an increase in ranching activities and research

to improve beef production in the rangelands. The Kenya Agricultural Research Institute (KARI) was charged with the generation and dissemination of knowledge and technology to enhance livestock productivity through joint donor-financed research projects.

Restructuring included streamlining user charges to reflect acceptable cost sharing and cost recovery for the financing of research and to emphasize the application of science and technology to agricultural development. Rangeland research was to be aimed at increasing productivity, favouring beef production, which was also reflected in the revision of the Science and Technology Act. This led to improvements in beef output both by ranchers and pastoralists who sourced their replacement stock from the improved stock of the ranchers, thus enabling the exchange of genetic material.

Table 1 presents the number of animals raised for beef, estimated offtake in tonnes per head and projections of output and demand for the years 1997 to 2008. The average annual increase in beef output has been about 10,000 tonnes. However, the figures presented should be used with caution, given that they were calculated from hides and skins data. The figures ignore animals that were slaughtered and not inspected by the Department of Veterinary Services, thus beef output in the country is expected to be much higher than the reported figures (Ministry of Agriculture and Rural Development, 1998).

Pastoralists produce the bulk of the meat consumed domestically, supplementing that from culled stock from the dairy industry. Ranchers produce high-quality beef for export and animal genetic resources for export to other countries in the region (Prettejohn and Retief, 2001). With the current development trends and improved outlook for the beef industry, increased output of high-quality beef is feasible in the future. It can be argued, however, that the most outstanding challenge to beef production in Kenya is the poor dissemination and utilization of technologies generated from research institutions, which has often resulted in the repetition of long established research work.

Contemporary beef production systems

Kenya can be divided into seven agro-climatic zones (ACZ) based on evaporative potential. Agro-climatic zones 1–4 are classified as high-potential areas due to their high level of precipitation, while 5–7 are categorized as semi-arid and arid (marginal areas) due to the low agricultural potential (Peeler and Omore, 1997). Land use

in the marginal areas can be divided into four types: namely, agro-pastoralism and pastoralism in which 25% of cattle are kept; pastoral ranching, which supports 50% of the cattle, and commercial ranching that raises 25% of the cattle (Ouda *et al*, 2001). Within these are two types of beef production system: namely, small-scale and large-scale dairy–meat production (Peeler and Omore, 1997).

Small-scale dairy–meat production system

This system is practised in the high-rainfall areas and marginal areas producing the highest number of animals for beef. The animals kept are mainly the indigenous SEAZ and its crosses with exotic dairy breeds. These producers also raise crops, thus forming the agro-pastoral group (Ouda *et al*, 2001). The main aim of production is based on survival and risk minimization rather than increased productivity (Swift *et al*, 1996). Milk, not beef, is the main product, although animals are sold to meet domestic cash expenses. Animals in this system are either herded or tethered after milking in the morning and put in an enclosure at night. Cows suckle their calves after milking, and weaning of the calves occurs at the age of five months (Peeler and Omore, 1997; Ouda *et al*, 2001). It is a low-input–low-output system. There have been some changes in the production system prompted by the increase in human population, introduction of formal education, changes in government land policy and privatization of the rangelands. Introduction of the market economy and diversification of rangeland uses have also caused high-potential ranges to be used for other purposes, which has concentrated the pastoralists in the less productive areas (Herlocker, 1999).

Large-scale dairy–meat production system

This system occurs predominantly in the marginal areas (ACZ 5–7). The cattle kept include the zebu (SEAZ, Sahiwal and Boran) and their crosses with exotic breeds. The system can be subdivided into pastoral ranching, commercial large-scale ranching and intensive feedlot systems.

Pastoral ranching. This is practised by pastoralists in the rangelands where cattle are kept in mixed herds together with indigenous sheep, goats and camels. SEAZ cattle predominate, though some herds have the improved Boran and Sahiwal (Roderick, 1995). Commercial production of beef is the objective of this system, while the milk is meant for domestic consumption. The animals are grazed on natural pasture, in which case either transhumance or nomadism is practised (Ouda *et al*, 2001). Revenues accrued from the system are lower due to the low input levels. This system contributes 50% of the total beef consumed in the country. Major issues affecting production in this system include dry season feeding, animal health, breeding, marketing and institutional framework.

Commercial large-scale ranching. Commercial large-scale ranching has played a major role in the Kenyan beef industry, in that most of the locally marketed beef and that destined for the international market is produced by ranches owned by farmers' groups or companies (Kilung'o and Mghenyi, 2001). Most of them are located in the marginal areas of the Rift Valley, Eastern and Coast

provinces of Kenya. However, with the increase in land ownership by individuals, most of the ranches formerly with group or corporate ownership have been subdivided (Kilung'o and Mghenyi, 2001). Exotic beef breeds and the Boran form the stock raised. Under this system, disease control measures and general husbandry are much improved. Beef is the main output and its production is based on either natural or cultivated pastures as the major feed input. The main constraints observed in this system include dry season feeding, breeding management, marketing of the high-quality beef produced and invasion of the ranches by pastoralists during the dry season in search of water. There are problems associated with livestock–game interactions (Ouda *et al*, 2001; Prettejohn and Retief, 2001)

Feedlot systems. These were introduced on the government research stations and farms as finishing systems. Although there was increased output (increased final weight) of beef of high quality, the system was not sustainable because of the demand for high-energy feed from cereals that competed with that from the human population. In addition, the system required high levels of investment in infrastructure and labour so that the consequent high prices of feedlot beef could not be absorbed by the local markets.

Constraints to beef production

These can broadly be grouped into production and market constraints.

Production constraints

- Government land policy: The policies governing land ownership, especially in the beef production areas, need to be revised. Beef production in Kenya is an extensive enterprise requiring adequate areas of land. The fragmentation of land (and resultant reduction of grazing land area) in the ranges has led to a fall in beef production. Privatization and settlement of land by the pastoral communities has resulted in land degradation (Herlocker, 1999; Prettejohn and Retief, 2001).
- Institutional framework: There is no formal body that governs beef production and there is thus no mechanism for directing the flow of information about production areas and marketing (Kilung'o and Mghenyi, 2001; Prettejohn and Retief, 2001).
- Government policy on research: Currently only KARI is mandated to carry out agricultural research in the country. Consequently, other research organizations have to collaborate with KARI, a restriction which, for organizational and bureaucratic reasons, may have led to the slow generation of agricultural research technologies. Other national agricultural research systems (NARS) eg universities, with their well trained scientists, rarely receive direct funding for research from the Kenya government or from organizations (eg the World Bank, European Union) that fund KARI, for example.
- Diseases: Tropical environments are characterized by high incidences of parasitic diseases. These diseases account for the recorded high mortality rates – about 25% – resulting in reduced livestock productivity

(Herlocker, 1999; Jalang'o, 2001). Poor disease surveillance programmes, poor infrastructure, corruption and the poor economic condition of livestock farmers have aggravated the economic losses due to these diseases. The situation is worse in the small-scale pastoral production systems where disease control measures are inadequate. The most prevalent diseases include rinderpest, foot-and-mouth disease (FMD), lumpy skin and contagious bovine pleuropneumonia. More outbreaks of FMD have been reported in recent years than of the other diseases (Jalang'o, 2001).

- **Droughts:** Many livestock deaths have been recorded in the past due to starvation as a result of drought. The deaths were due to lack of disaster preparedness, especially among the pastoral communities. Prolonged droughts have also resulted in invasion by pastoralists of private land, especially commercial ranches, leading to conflicts that cause loss of livestock and life and also sour the relationship between ranchers and pastoralists (Mwanje *et al*, 2001; Peeler and Omere, 1997). Migratory behaviour observed during this time adversely affects the effectiveness of any quarantine measures put in place for disease management.
- **Feeding:** Beef production in Kenya is pasture-based and hence dependent on land availability. Continued subdivision of land and persistent droughts pose a particular challenge to beef production, especially during dry seasons. Subdivision has led to shrinkage in the grazing resource base and consequently affects the productivity of the animals (Kinyamario and Ekeya, 2001). Most of the research currently done on the nutrition of animals uses browsing stock, with little interest in grazers. Lack of willingness to exploit technologies for manipulating rumen microbes has also hindered progress on drought feeding.
- **Insecurity:** Cases of cattle rustling in the beef production areas have been reported, which have left several communities without any animals. This may, however, be attributed to traditional pastoral customs that encourage theft of stock. These incidents cause the pastoralists to move, albeit to safer places, but which are unable to support their stock.
- **Traditional pastoral production systems:** Pastoralists keep livestock for other purposes besides beef production. As a result, productivity of the animals often does not count as much as the size of the herds. Animals are kept for social purposes, inducing a reluctance amongst owners to dispose of animals for, say, beef sales.
- **Genetics:** Beef production has received little attention as far as genetic improvement is concerned in Kenya, and much potential genetic progress for the national herd has been lost. Some literature is available on beef cattle breeding in Kenya, but more emphasis has been put on dairy cattle breeding. At the Central Artificial Insemination Station (CAIS), a station mandated to store and supply semen to farmers in the country, there is more semen from various exotic dairy breeds than from beef breeds (CAIS, 2000). In 1973, a beef cattle recording scheme, the Kenya Beef Records (KBR), was established under the management of the Livestock Recording Centre (LRC) to support the improvement of beef cattle. A number of large-scale ranches, most of which are located in the ASALs, were involved in the

scheme, the main objective of which was to aid management decisions about selection based on the records (Indetie *et al*, 2001). However, this scheme has not been very successful, probably because of the involvement of uncommitted stakeholders, prevailing policies on livestock development, unclear breeding objectives and structural problems in the beef industry, such as diverse management, production and marketing systems for beef and beef cattle (Rege *et al*, 2001).

Market constraints

- **Lack of a proper market channel for beef products:** Before the collapse of the KMC, there was a defined market channel for beef animals and their products. Each player had his defined place and a role to play in the market structure. Since the collapse of the KMC, beef marketing has become dependent on individual producers' efforts and those producers that were less efficient have been forced out of the market (Prettejohn and Retief, 2001). An illustration of various beef marketing channels before and after the exit of KMC is presented in Figure 1. When KMC was operational, an extra step in the marketing of beef was required. After its collapse, some of its functions were taken over by council abattoirs. There has also been a rise in the number of middlemen, some with criminal backgrounds, whose activities have led to producer losses (Kilung'o and Mghenyi, 2001). All this is due to the lack or inaccessibility of market information for producers who live far from the market zones.
- **Accessibility of the export market:** Most of the beef produced in the country is for domestic consumption. Poor production conditions result in low-quality carcasses that cannot compete effectively on the export market. Ineffective disease surveillance and control measures have rendered areas that were once disease-free zones suboptimal for beef production, thus reducing the acceptability of Kenyan beef to the export market (Peeler and Omere, 1997). Only the large-scale, efficient, commercial ranchers produce beef for sale on the export market (Prettejohn and Retief, 2001).
- **Static prices of beef products:** The prices of beef and beef products have remained constant for a considerably long period, though the input costs have continuously increased, thereby resulting in reduced profit margins. In addition, the domestic currency has continued to depreciate in relation to most hard currencies on which the cost of the inputs is based. The result is a continuous drop in the profit margins. These low profits have led to a shift from beef production to other alternative livestock production such as dairy, wildlife and unconventional animal (eg ostrich) production.

Prospects for research and development in beef production

It is often argued that the higher the rate of generation of knowledge in the system, the higher is the rate of its development. It is also felt by some that the funding of agricultural research should be driven by the competitiveness of the scientists involved and their ability to generate

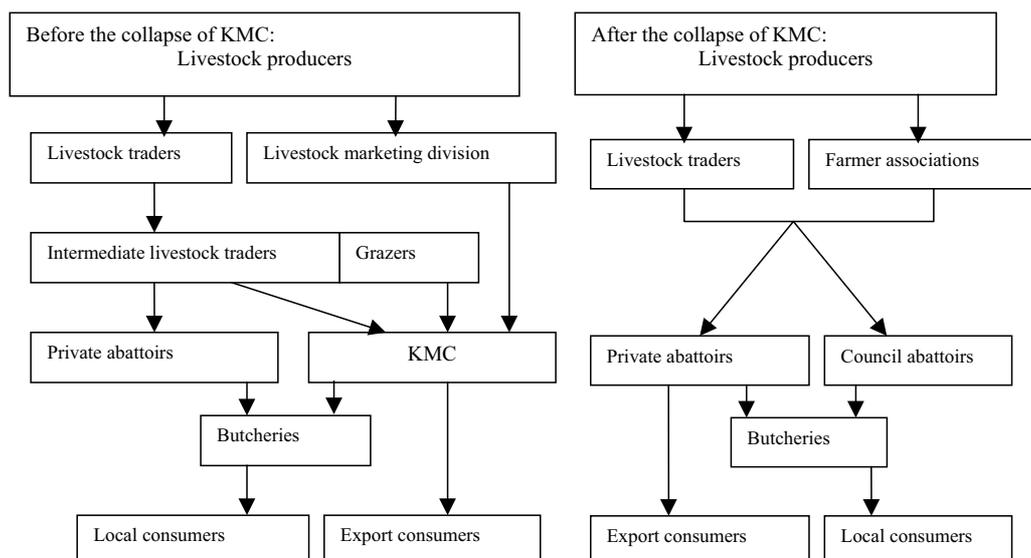


Figure 1. Beef marketing channels before and after the collapse of KMC. *Source:* Kilung'o and Mghenyi, 2001.

technologies and transfer them to the end-users. Novel technologies may not reach the intended users or, if they reach them, the rate of adoption is very low. All this pinpoints the need for the involvement of policy makers, extension workers and planners in the research and development process. Sustainable research and development programmes for beef production are those that are based on the existing practices and resources aimed at meeting the priority needs of the target groups. This calls for collection of baseline socioeconomic data from the target group.

In every system of production, failures of intervention measures stick in the memories of the producers and inhibit acceptance of any new idea. Therefore, it is important to conduct evaluation studies of the consequences of intervention measures and to encourage progressive development by providing solutions to the important impediments to beef production through participatory research and development.

Disease control

The colonial government established various veterinary research laboratories to investigate and develop vaccines for the endemic tropical diseases such as foot-and-mouth disease, rinderpest, East Coast Fever (ECF), redwater, anaplasmosis, trypanosomosis and heartwater, among others, to enhance livestock production. This was furthered by the establishment of various regional veterinary investigation laboratories after independence in different parts of the country to improve the disease surveillance (Government of Kenya, 1986). The result was reduced livestock disease incidence, which led to the attainment of disease-free zones in some production areas, a situation that enabled Kenya to export beef to the international market. Currently, it is difficult to carry out vaccination campaigns, especially in the pastoral production systems, due to the nature of the production

systems and infrastructure and climatic conditions that reduce the efficacy of the vaccines. Development of location-specific vaccines is important to overcome this problem. The roles of institutions such as national universities, KARI, the Kenya Trypanosomosis Research Institute (KETRI), International Livestock Research Institute (ILRI) and International Centre for Insect Physiology and Ecology (ICIPE) are particularly important in this regard. The sustainability of disease-free zones is questionable due to the costs involved, but improvement of disease surveillance systems could easily offer a cheaper remedy to the disease situation in the country.

Rangelands have been associated with high livestock mortalities due to prevalence of the aforementioned diseases and reported parasite resistance due to abuse of drugs amongst, but not necessarily by, the small-scale producers. Therefore it is important to develop and validate disease diagnosis, monitoring and control methods specific to pastoral beef production if mortality rates are to be reduced and to facilitate access to export markets. Poor dip management has also led to tick resistance, hence the prevalence of tick-borne diseases such as ECF, anaplasmosis and redwater (Bebe *et al*, 2002). In addition, ineffective quarantine governing mechanisms have contributed to disease spread.

The reason for drug abuse has been lack of veterinary knowledge and poor economic conditions of the pastoralists, and it is vital to ensure that only qualified veterinary personnel are allowed to offer veterinary and pharmaceutical services. A further aid to this problem could be in the provision of subsidies by the government for veterinary drugs, and proper and early disease diagnosis. Enhancement of farmers' knowledge in aspects of disease control and management through community-based animal health organizations, farmers' field days, etc, would be valuable.

There is also a need to carry out research on the methods of disease control, diagnosis and epidemiology of some diseases, eg FMD. In some communities in the ASAL, traditional herbs are used in the treatment of some diseases. Such practices need to be investigated to determine their effectiveness and whether they could be better utilized. Breeding for disease resistance is a better option for disease control, in that, once achieved, it is expected to be permanent and passed on to future generations (Kahi and Graser, 2004).

Feeding and general husbandry

Feeding constitutes a substantial proportion of the cost components of a production system. Attention should therefore be given to ensuring a sufficient supply of feed resources of adequate quality (Gueye, 2002). Beef production is pasture-based, therefore sufficient feed supply can be achieved through utilization of the available feed resources – natural pastures (Preston, 1992) – which can be preserved in the form of standing hay or hay for use during the drought period. Efficiency in the utilization of the high-roughage tropical pastures can be achieved through use of better harvesting and preservation techniques and adequate understanding of the rumen ecology so as to manipulate the rumen environment easily for the benefit of the animal. This will minimize the observed losses in body condition during dry seasons. Alternatively, attempts should be made at breeding animals that can efficiently utilize high-roughage tropical pasture (Kahi and Nitter, 2004). There is also a need to keep an optimal number of animals that can be sustained by the natural pastures and to avoid environmental degradation from high stocking rates. The national research centres involved in pasture research might also consider developing drought-resistant pasture varieties that are able to grow in the ASAL where rainfall is limited and erratic, and that have the ability to withstand extreme grazing regimes. Emphasis should be given to utilization of alternative sources of nutrients, eg legumes, as a source of protein. Institutions of learning should place emphasis on the development of appropriate husbandry technologies suitable for the rangelands and proper dissemination mechanisms for these technologies. Good husbandry skills will translate into efficient and high-quality beef production.

Genetic improvement

Genetic improvement in the major beef production breeds is the main means of improving the production efficiency of tropical beef cattle (Mackinnon *et al*, 1991). The general direction of change is described as a breeding objective that answers the question '*where do we want to go?*' In the tool kit of an animal breeder, there exist mechanisms to achieve this goal: namely, genetic evaluation, selection and mating systems, which answer the question '*how do we get there?*' Effective genetic improvement depends on appropriate selection and mating decisions for a particular breeding objective based on accurate genetic parameter estimates (Hill and Mackay, 1989).

The production system determines which beef cattle genotype is needed; pastoralists tend to keep adapted low-producing indigenous stock, while ranchers keep high-producing exotic, crossbred and improved indig-

enous stock. This is driven by the risk minimization and profit maximization strategies of the two groups of producers. The genetic variation that exists in indigenous cattle should be exploited through genetic manipulation and breeding to improve the performance of stock, without the need to compromise their adaptability or to replace them with exotic stock (Timon, 1993). Genetic improvement programmes are based on accurate estimates of variance components and genetic parameters for economically important traits described in the breeding objective on which selection decisions are made (Burrow, 2001).

In the context of ASAL, improvements in production efficiency would seem to be more likely to be achieved through the improvement of the indigenous cattle species rather than the exotics, since the former are already adapted to the tropical production conditions and have large variation. There is therefore a need to evaluate the performance of existing indigenous cattle breeds and their crosses. In addition, estimation of genetic and economic parameters for both adaptive and production traits and/or corresponding indicator traits is required, since parameters specific to particular genotypes and environments should be used in any genetic improvement programme.

The effectiveness of a genetic improvement programme lies in the accuracy of selection of the animals, which is guided by precise estimates of breeding values. Estimation of breeding values requires adequate records. Such records are scarce because of the resources required for their collection. This, therefore, calls for urgent development, evaluation and application of simple performance and genetic evaluation procedures that take into account the needs and aspirations of cattle keepers. These procedures should be affordable and simple enough to be applicable across a broad range of producers. Active participation of farmers in the activities of the KBR should be encouraged, as is the case with the dairy counterpart, the Dairy Recording Service of Kenya (DRSK). Such active participation by farmers seems to be the strongest attribute that determines the success of any livestock improvement programme (Kahi *et al*, 2005).

Any genetic improvement programme should consider and address how superior animals will disseminate their genes quickly throughout the whole population. This could be expensive, but nucleus breeding schemes have been suggested to circumvent the high costs arising from performance recording and selection in the whole population (Smith, 1988; Bondoc *et al*, 1989; Bondoc and Smith, 1993). In such schemes, the best males are kept for breeding in the nucleus, while the remaining selected males are used for breeding in the commercial herds. The question is how such schemes can be established and made to work. It has been suggested that they may work within a framework of a community-based organization (Kahi *et al*, 2005). The success of such an organization is dependent on the fact that it is owned by farmers who are expected to benefit from concerted efforts. The challenge would be to investigate the actual genetic progress and problems that may arise when operating a community-based nucleus breeding scheme under the conditions prevailing in Kenya.

Marketing, information dissemination and credit

Beef production from pasture forms the main economic activity of the populations in the ASAL (Kinyamario and Ekeya, 2001). Consumers' fears of the residues that are found in beef when animals consume feeds containing additives or feeds manufactured from contaminated products, or from the extensive use of veterinary drugs (Rege *et al.*, 2001) are minimized, a market scenario that favours the Kenyan beef industry. But disease prevalence presents a significant limitation. Some attempts at setting up disease-free zones for livestock exports in the ASAL have been made, however, and some animals were exported recently to Mauritius; and enquiries have been received from other countries within the region, eg Saudi Arabia and Kuwait. While this is a good sign for the beef industry, the ineffective beef marketing systems within the country have led to the exploitation by livestock traders of the less efficient pastoral producers. This can be alleviated through the establishment of market information systems as a consumer good, and by reducing the number of players in the marketing channels through turning the many profit market points into cost transfer points alongside effective disease control (Kilung'o and Mghenyi, 2001).

Small-scale producers should be encouraged to form groups to enhance their market bargaining power, to access credit by the provision of group collateral, and to develop interaction between the farmers, thus enhancing information transfer. This will improve the production levels through credit incentives. There is a need for the government, non-governmental organizations, international agencies and donors to provide interested people with institutional support by providing easy access to information relating to beef production. This calls for sufficient stakeholder training in matters related to beef production. Regional information exchange centres should be introduced to provide appropriate information on beef production for the benefit of Kenya and other countries in the region.

Producer training and education

Although training of pastoral producers in the marginal areas is difficult, this remains the only reliable way of improving the skills of the producers. Lack of education hinders efficient communication, limiting bargaining potential during trade and the ability to become expert in animal management and other related aspects. It also reduces the rate of technology adoption, thereby limiting progressive beef production. When deciding on which training to offer, it is therefore important to consider the mode of communication and the gender targeted, besides the traditional customs. Unconventional teaching methods such as songs, theatre and learning by doing are preferred for passing on simple extension messages (Gueye, 2002). Training packages should include information about disease management, feeding, breeding management and marketing. Training sessions should be tailored to involve men, women, the elderly and youth. The training should be aimed at solving the priority problems of the producers. This requires a bottom-up approach to farmer training with an emphasis on group learning.

Policy revision to enhance beef production

Beef production has been hindered by land subdivision, which strangles the carrying capacity of rangelands, leading to uneconomical production systems. Land policies should prevent undesirable land fragmentation and protect holders of large tracts of land (Government of Kenya, 1986). To enhance land utilization, taxation on land holdings should be encouraged. This will result in reduced idle land and increase production per unit of land. Policies governing livestock trade and marketing should also be reviewed to protect producers from extortion and exploitation by middlemen and to enhance market competition. This is now possible with the revival of KMC. The government should also emphasize ASAL development in its development plans as a means of empowering the communities living in these areas (Kombo, 2001). Furthermore, the agricultural policy should revise the classification of production potential of land on the basis of crop productivity, in which the ASALs are considered low potential due to their inability to sustain major cash and food crops. These areas have high potential for beef production.

Infrastructure development

The ASALs are characterized by poor infrastructure, road and telecommunication networks. Installation of these services will open up these areas for development (Kilung'o and Mghenyi, 2001). There is a need to reorganize the livestock routes and for re-establishment of the livestock production zones. There is also a need to renovate the watering systems in the pastoral areas and livestock holding grounds to make livestock trade and marketing easier. A shift from beef production to other livestock enterprises is associated with stagnation in the price of beef and its products. The cause of this has been related to poor market information and the oligopolistic tendencies of the meat retail markets. This can be alleviated through the establishment of an efficient market information system as a public good that will be charged with the responsibility of collection and dissemination of price information (Kilung'o and Mghenyi, 2001).

Conclusions

Beef production plays an important role in the Kenyan economy by increasing household income and income distribution. The industry supports the livelihoods of a large part of the population of Kenya, especially those living in the ASAL. However, the industry has continued to perform below its potential for many reasons. A multisectoral and interdisciplinary approach is required to increase the production of beef. It is important that the role of participants in the production chain is clearly defined and their positions well established. This calls for the reorganization of the beef industry to facilitate private sector participation and market competition. It is important that proper feeding and good husbandry practices are maintained to enable animals to exploit their full genetic potential. Properly designed breeding programmes are critical for improved animal performance.

For any feasible increase in self-sufficiency in beef production or improvement in the current status of the beef industry to be achieved in the foreseeable future, there will need to be concerted individual and national efforts from all stakeholders in the industry.

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