Choice of genetic types for specific production environments and production systems

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The problem

Sub-Saharan Africa has been experiencing increased population growth and high rates of urbanisation. This has resulted in high demands for food, including livestock products. Animals indigenous to sub-Saharan Africa are well adapted to the various ecological zones, but have low potential for high levels of production. Efforts were made to increase animal output through breeding programmes. These efforts involved importations of exotic breeds from both tropical and temperate countries, and promotion of these breeds and their crosses, particularly in the commercial sector, which supplies food to the urban centres. In many instances, programmes did not include genetic improvement of the indigenous stock. Instead, they were designed to upgrade the indigenous breeds to the exotic breeds, at the risk of disappearance of the former. Performance of the imported breeds, however, varied with varying environments and, under certain conditions, it was either worse or not significantly different from that of indigenous breeds. These findings raise the question as to what the most suitable genetic types and breeding systems in any specific environment are.

The environment

Sub-Saharan Africa lies in the tropics and subtropics. Typical climatic conditions include high ambient temperatures, high humidity and erratic and/or low rainfall. The climatic conditions influence the quality and quantity of feed and result in a wide variety of diseases. On this basis, the region can be divided into the following five ecological zones: very arid, arid to semi-arid, semi arid to humid without tsetse, temperate highland and humid tsetse infested. The very arid, arid and semi-arid rangelands are characterised by pronounced seasonal changes in forage supply and quality, frequent shortages of water and high ambient temperatures. The humid zones are characterised by large quantities of fodder, high temperatures and high humidity. Each ecological zone has endemic diseases.

Within the ecological zones, there are subdivisions based on level of intensification of agriculture. These are extensive, semi-intensive and intensive production systems under the communal and commercial sectors. Generally, the level of management and production inputs is higher in the commercial sector than the communal one and in intensive systems than in the extensive systems. Such inputs usually aim to modify the production environment and can result in higher production outputs. Modification of environment includes provision of housing or shade, extra water and feed, disease control and improved management. Lack of knowledge and costs of interventions usually limit such modifications to commercial and intensive farming systems.

The genotypes

Livestock populations in the world occur in a wide variety of environments to which they have been well adapted through natural and artificial selection. Consequently, there are many genotypes which vary a great deal in their physical and functional characteristics as well as in their levels of productivity. In sub-Saharan Africa there are breeds that are indigenous to Africa, as well as breeds that have been imported into the continent.

Indigenous breeds

Sub-Saharan Africa has many indigenous livestock breeds. These breeds are mainly owned and used by smallholder farmers and they represent over 90% of livestock breeds. Studies to characterise indigenous breeds have been carried out in many African countries. These studies have shown that, generally, existing indigenous livestock are well adapted to local production conditions. Survival rates for the indigenous breeds are higher than survival rates for the foreign breeds; this is primarily because many indigenous animals can tolerate local diseases. Examples of disease resistance and tolerance include tolerance to trypanosomiasis by the N'Dama cattle and Djallonke sheep of West Africa; tolerance to ticks and tick-bone diseases by Nguni cattle in southern Africa and tolerance to internal parasites by Red Maasai sheep in East Africa. Furthermore, due to their anatomical and physiological attributes, local cattle are less sensitive to heat stress when compared with foreign breeds. They are better able to utilise low quality feeds and can walk longer distances searching for water and food than their temperate counterparts, and can tolerate dehydration for extended periods. They are also fertile and have good mothering ability.

Indigenous breeds are usually late maturing, have poor growth rates and low milk yields, and produce small carcasses. It has also been shown that few indigenous breeds respond well to good feeding management, such as that for intensive feedlot beef production systems or intensive dairy production systems. Low production or small size by itself is an adaptive attribute as it is an advantage in hot climates. However, the effect of their low genetic potential is, at times, confounded by the low standard of management under which indigenous livestock are usually kept. Many studies (e.g. in Botswana, Namibia, South Africa, Swaziland and Zimbabwe) have shown that when a productivity index, which combines fertility, survival and yield traits, is used to compare breeds, indigenous breeds raised under range conditions outperform foreign breeds.

The exotic breeds

Exotic livestock introduced into Africa fall into three broad groups–imports from other tropical countries (e.g. Sahiwal and Brahman cattle); composite or synthetic breeds developed using local and foreign breeds (e.g. Dorper sheep and Bonsmara cattle); and temperate breeds (e.g. Landrace pigs, and Hereford and Holstein cattle). The foreign breeds have been proven to be highly productive in their countries of origin. In sub-Saharan Africa, however, they have been shown to perform poorly when the environment is harsh, the main problem being their lack of adaptation to local production conditions. Nonetheless, they outperform indigenous breeds when the environment is improved substantially. For example, Holstein cows can produce more than 10 thousand kg of milk per 300-day lactation yet indigenous breeds produce less than 2000 kg per year. Moreover, exotic beef animals reach slaughter weights at two years of age compared with three to four years for indigenous breeds. The low production potentialities of indigenous breeds, the increasing demand for animal products as populations grow and urbanisation increases, and the improvement in management and control of diseases have all

encouraged the importation of high producing temperate breeds. However, capital costs and production costs are usually so high that the industry has to be subsidised. When the subsidies are high, it is questionable whether the use of purebred exotics provides cheap food to urban centres. Nevertheless, foreign breeds have been crossed with local breeds and the crosses have been found to be more tolerant to production conditions in sub-Saharan Africa than the purebreds.

Matching genotypes with environment

There are, two possible approaches to adopt for livestock production in sub-Saharan Africa. The first approach is to select and use breeds that can survive, reproduce and produce in the local production environments. The second approach is to realise that foreign breeds were bred in a certain environment and for a specific purpose or purposes. In order that these breeds should retain the qualities for which they were bred, it is necessary in transferring them to other countries, to provide them with an environment as similar as possible to that in which they originated. Otherwise, in adapting themselves to the new environment the breeds may lose many of their performance characteristics that distinguish them in their native lands. Both approaches have been adopted, but to differing levels by the various production sectors in sub-Saharan Africa.

Selecting and using an appropriate breed

Low levels of production inputs and management characterise traditional livestock production systems in Africa. Such production systems cannot support specialised temperate breeds. Most farmers using low-input production systems, e.g. subsistence farmers, pastoralists and ranchers, use indigenous breeds. They do this with the knowledge that these breeds are adapted to local production conditions and thus require low inputs and less pampering than foreign breeds. Trail (1981) recommended the use of indigenous breeds in sub-Saharan Africa, particularly in the very arid, arid to semi-arid and humid tsetse infested areas. Exotics and their crosses were recommended for use in semi-arid to humid and temperate highlands (see Table 1).

Table 1. The cattle genotypes recommended for various specific environments in sub-Saharan Africa.

Zone	Type of cattle
Very arid	Indigenous
Arid to semi-arid	Indigenous, improved indigenous
Semi-arid to humid	Indigenous, improved indigenous, exotic/indigenous crosses
Temperate highlands	Indigenous, improved indigenous, exotic/indigenous crosses, pure exotic
Humid, tsetse infested	Trypanotolerant indigenous

Source: Trail (1981).

Trail (1981) also recommended the improvement of indigenous livestock by selection as, in the long run, and considering the limited financial resources available in most countries, it is more rational to put greatest emphasis on improvement of the well-adapted local stock. This policy may pay the greatest dividends when the most promising breeds in the region are identified,

studied and improved. The improved indigenous breeds can then be introduced in the temperate highlands, the arid to semi-arid and semi-arid to humid ecological zones.

Modifying the environment

As the environment improves, either by natural factors (e.g. farming in the temperate highlands) or through good management and increased inputs, the improvement of local breeds through selection and the introduction of exotic breeds can be considered. Most commercial enterprises and intensive production systems modify the environment in several ways. Water is made available *ad libitum*, livestock health services which include dipping and vaccinations are introduced to prevent and control diseases, and farmers provide extra feed to their animals. Depending on the size of the enterprises and costs, feed is bought in, grown on farm or prepared from crop residues. When the environment is modified, the tendency has been to introduce specialised foreign breeds. The level of modification of the environment determines to what extent foreign breeds are used and the level of exotic inheritance. Such commercial systems are usually set up to serve nearby urban centres or to produce food for export to other countries.

In most African countries, commercial pig and poultry production is based on foreign breeds and crosses or hybrids, while indigenous breeds are used mainly for subsistence production under traditional systems. The major production costs are feed (constituting up to 80% of total production costs), labour and veterinary costs.

Commercial beef and goat meat production is usually carried out under extensive systems, the main modification to the environment being disease control. Under such circumstances, it may be better to use local breeds. When winter supplementation is practised, improved indigenous breeds can be used as pure breeds or as dam lines to be crossed with specialised breeds. Exotic breeds and their crosses can be used in highland areas or under intensive beef production systems, such as feedlots and improved pastures.

For dairy production (from both small stock and cattle), foreign dairy breeds imported from temperate climates (e.g. Saanen goats or Holstein cattle) and some from tropical climates (e.g. Sahiwal cattle) have been used as most indigenous African breeds have poor dairy yields. Pure breeds have been used under highly intensive systems by large-scale and some smallholder commercial farmers. However, most smallholder farmers have used crosses of exotic temperate breeds with indigenous cattle. Walshe et al. (1991) came up with specific recommendations for genotypes to be used in various dairy production systems:

1. If resources (climate, feeding, disease control and management) can sustain a lactation yield greater than 4000 kg/cow (high production environment), pure temperate dairy breeds or 75% purebred crosses should be used.
2. If resources can sustain a lactation yield of 3000–4000 kg/cow (medium production environment), the preferred type of animal should be a 50 to 75% temperate-type dairy cross, or a suitable composite breed.
3. If resources can sustain a lactation yield of 1500–3000 kg/cow (low production environment), the type of animal used should be a 25 to 50% dairy cross or a synthetic breed.
4. For a very low production environment, whose resources can sustain a lactation yield of less than1500 kg/cow, there is little justification for upgrading. A local breed should be used and productivity improved through within-breed selection.

Conclusion

The level of production required, costs of production inputs and level of management determine what genotype should be used. The use of specialised livestock should be restricted to being complementary rather than being the basis of the production systems. Use of animals that require little or no change in the environment they are found in is recommended. This of course does not mean that the environment should not be improved, but rather that the genotype and the environment should be considered in unison. The choice of genotype is an important step in planning or adopting a production system and it must be carefully matched to the other available inputs. The first step may, therefore, be to characterise breeds and production environments and then match genotypes appropriately to the environment. With the present scarcity of animal products, the resultant high prices and the high prices of imported products, the cost of environment amelioration and improvement can be economical in certain areas. However, these interventions have to be evaluated and such evaluations should consider subsidies if there are any.

Knowledge gaps

To make correct decisions, about which breeds are used in which environments, there is a need to understand the unique characteristics of the breeds and to describe and evaluate production systems. Knowledge gaps in this field include:

- Some adaptation can be phenotypic and not genetic. For example, disease resistance may be due to immunity passed on to offspring by its dam through suckling. This adaptation is phenotypic as the offspring did not inherit the resistance but got its immunity through suckling. There is need to evaluate some adaptive traits to determine whether the adaptation is phenotypic or genetic.
- The characterisation of indigenous breeds and production systems is not yet complete. Biological and economic criteria have to be used jointly in the evaluation of breeds and the production systems in which they are used, so that appropriate decisions can be made in allocating breeds to environments.

Study questions

- Why is a low level of production or small body size an advantage in the tropics?
- Which anatomical and physical attributes make indigenous breeds less sensitive to heat stress when compared to temperate breeds?
- Are differences between tropical and temperate breeds of livestock necessarily of adaptive significance?
- Is adaptation a necessity under improved management conditions or can adaptation be regarded as antagonistic to improvement in livestock production?

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