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Genetic Diversity and Climate Change: Implications for Animal Production Systems in Africa

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ABSTRACT

Genetic selection of farm animals can lead to a reduction in genetic diversity through the elimination of individual or populations deemed to be undesirable. Genetic diversity is the basis for population change through selection and any reduction in diversity reduces the potential for future genetic change. Climate change would have great impact on animal production systems in the near future, as such the conservation of genetic diversity would form a basis for mitigation measures. Genetic diversity would increase the chances that animal populations exist and could be selected to suit the present and future environmental changes due to climate change. It is more pressing than ever to put in place strategies that would ensure the sustainable use of animal genetic resources and limit biodiversity erosion.

Key words: Climate, genetic diversity, conservation, bio diversity

INTRODUCTION

Farm animals have been subjected to many years of selection for increased productivity with progressive elimination of animals with the least desirable traits. In many instances the gains from this selection have been extremely profitable (Munro and Adams, 1991). Along with other aspects of man's activities, agriculture is now being appraised in relation to its ecological sustainability and environmental changes occasioned by climate change.

One of the most important aspects of sustainability in animal production systems is the desire to preserve genetic diversity in populations of domestic animals. The appraisal of animal production systems in relation to the varied climate change issues and ecological sustainability is a challenge that requires changes in approach from the traditional production oriented ethos. The challenge of climate change raises the possibility of dramatic environmental changes. The changes that would be required in animal production systems to maintain previously existing levels of adaptation and productivity could be equally dramatic (Munro and Adams, 1991).

The need for genetic diversity to accommodate these changes is of great concern. However, in Africa genetic improvements or evaluation schemes on indigenous livestock resources are either rare or non-existent. Thus, there is an alarming rate of loss of genetic resources in the region (FAO, 2000; Dessie *et al.*, 2011).

Livestock genetic diversity is a major building block for food security and livelihoods and its conservation is essential if animal production systems are to respond to challenges such as population growth and climate change. The variety of livestock species available to farmers are dwindling rapidly but some traditional livestock communities are taking steps to protect their genetic patrimony (Anya *et al*., 2011). Other changes to the environment of farm animals are already occurring as a result of changing agricultural practices. Such changes may even modify the agricultural environment with consequences on genetic diversity (Cunningham, 1996). Various techniques can be used to preserve genetic diversity and the merits of some of these techniques and their relationships with the social and economic environments as it relates to animal productivity and livelihoods must be explored.

Genetic diversity and animal production systems: The vast range of ecological niches for animal production and the variety of adaptations of animals and husbandry systems need maintenance of genetic diversity to support animal production systems. Selection has often occurred within the context of specific agro-ecological environments. These environments have often been made more conducive to animal production by improvements in the quality and quantity of feeds, control of diseases and reduction in bio-climatic stress (Munro and Adams, 1991). Many animal production systems now use relatively favourable and static environments to allow high levels of production and efficiency. There is concern that livestock selected in these situations may lose the ability to adapt to new and probably less favourable environments due to climate change and may certainly be less efficient producers (low productivity) under new environmental conditions.

If production from animals is to be maintained at present levels, then both the suitability of genotype and environment need to be given priority. The various histories of the introduction of 'improved' European livestock breeds to harsh environments, including Sub-Saharan Africa (SSA) have fully illustrated the consequences of mis-matching genotype and environment. Currently there is a general consensus (Sere *et al*., 1996) that introducing high yielding livestock breeds developed under specialized modes of production into traditional and extensive production systems can lead to a loss of genetic diversity in indigenous animals. Even where animals have been kept in the regions in which they evolved, their exposure to pathogens and other stress factors has often been increased by changes in their environment. Studies and other reports show that the development and existence of many traditional livestock systems are now threatened more than ever due to climate change (Schoubroech Van *et al*., 2009).

The opportunity to manipulate the environment of livestock may diminish in the near future especially when climate change related environmental changes are considered. Development of resistance to chemotherapeutics by parasites is now widespread in many production systems. However, many serious diseases of livestock, such as those caused by blood-borne protozoa may not be amenable to control by vaccines. In addition, new disease agents can emerge and effective vaccines may not be developed quickly or easily due to climate change.

There is no guarantee that current standards of nutritional and husbandry will be sustainable in the future. Increasing competition between man and animals for high-quality feed ingredients and other inputs to agriculture (fossil fuels, mechanization and fertilizer use) all contribute to green house gas emissions implicated in the climate change dilemma. This may lead to a return to simpler systems of animal production as a mitigation strategy to cope with climate change. Thus, strains of animals adapted to high levels of nutritional and other inputs may no longer be the most appropriate. Concerns about real or perceived environmental issues and climate change may also create a demand for products from low-input systems such as organic systems that contribute to diversity.

A practicable problem that arises from these considerations of matching genotype to environment is how the match should be measured. This challenges conventional agricultural science to move from a mindset of short term gains to a more holistic understanding of interactions in the agricultural ecosystem. This understanding should involve soil-plant-animal interactions and extend to the endogenous, cultural and socioeconomic aspirations of the communities with the genetic patrimony in which these practices occur.

Conservation of genetic diversity: There is a need to conserve genetic material from animals able to produce efficiently and organically without the battery of supports currently employed in some production systems (Munro and Adams, 1991). In developed countries with monocultures, large sections of particular animal systems can be controlled by one management group. Given such scenarios, the selection of animals in controlled environments may result in the loss of particular genotypes or particular genes from large parts of the population. This may be through reductions in the population sizes of minor breeds and strains and to a lesser extent, through loss of alleles within breeds subjected to intensive selection. The concern is that this loss is irreversible. Small isolated populations are more affected because they cannot maintain the same allele frequencies as large populations. Such small populations can lose alleles more which results in reduced diversity as evident now in most livestock species in Africa. Therefore to maintain the natural evolutionary processes, large populations are often seen to have an advantage for conservation efforts to maintain diversity.

Developing countries are the principal custodians of the planet's biological wealth. Tropical regions are home to 70% of the world's biodiversity but they are also the most threatened (CTA, 2008). Developed countries are less blessed by nature, but have the means to develop the resources including biotechnologies that use and manipulate plant and animal genes (CTA, 2008).

In developing countries, there is enough room for improvement of domestic livestock because of the abundant gene pool that still exist. For example, almost all of the cattle, sheep and goats in Nigeria are in the hands of the nomads (Udedibie, 2010). This complicates meaningful planning for introduction of improvements or adoption of new technologies to boost production. Despite the meat deficit in Nigeria, estimated in excess of 500 million metric tons in beef and dairy products, the future of the livestock production systems is bright because of the rich gene pool that has remained unexploited.

Across Africa, indigenous sheep and goat breeds constitute over 95% of the entire ruminant population (Rege, 1993). The population of sheep in Sub-Saharan Africa (SSA) is estimated at 127 million head, while that of goats is estimated at 147 million (Winrock International, 1992). The arid and semi-arid zones (Africa's drylands) together hold the majority of sheep (57%) and goat (64%) populations of SSA (Peters, 1988). It is estimated that there are more than 35 million goats and 30 million sheep of various breeds in Nigeria. They contribute 35% of the meat eaten in the country (Udedibie, 2010) and 30% of the total red meat output and 21% of the total milk produced in SSA. Unlike cattle, they are widely distributed throughout the country and various surveys have indicated that about 60% of rural households keep them. It provides livelihood for a significant proportion of families and accounts for about 24% of the sectorial contribution to the Gross Domestic Product (GDP). However, these species are an important livestock component in all agro-ecological zones. They are found in all production systems ranging from pastoral and agro-pastoral systems to ranching, free range systems to smallholder mixed crop-livestock systems where they are critical for nutrition, insurance against crop failure and income.

Low genetic potential is often quoted as a major constraint to meat and milk production in SSA. Consequently, most livestock improvement programmes in the region have resorted to crossbreeding with imported exotic breeds or directly replacing the indigenous genotypes. However, sustainable livestock improvement cannot be guaranteed for some environments without the adaptive traits of these genetic resources (Rege, 1993). Breeds already endangered need to be conserved as a matter of urgency even if their economic value is not presently apparent as a strategy to cope with unforeseen circumstances (climate change) in the future. The rate of developments so far suggests that it should be possible to identify, isolate and entirely characterize these animal genetic resources. Information should be compiled on biological performance and adaptive characteristics of these animal genetic resource populations to aid the development of rational utilization and conservation programmes.

The role of institutions in the conservation of diversity: Loss of genetic material may hamper the ease or the extent to which animal breeders in future generations can adapt their animals to new environments or alter the nature of their products in the face of climate change. The role of biodiversity is therefore essentially one of insurance (gene bank) to provide future generations with the greatest array of genetic material possible. As with all insurance, the question arises, would the cost of preserving genotypes exceed the possible benefits? Most commercial enterprises do not always survive to realize their long-term plans, nor would they necessarily have sufficient capital or expertise to respond to what could be major problems on a national or international scale (Munro and Adams, 1991). Government assistance in this regard is very necessary. Selection of genotypes that would yield benefits in the future must also carry considerable risk because the nature of future environment is not known due to these sometimes extreme phenomena (climate change).

Responsibility for maintenance of genetic diversity is communal. Traditional livestock-keeping communities are the stewards of livestock diversity. This crucial and essential role of traditional livestock keepers in sustainably managing animal genetic resources has been officially acknowledged (Anya *et al.*, 2011). The notion that natural resources (genetic diversity) will only be protected effectively if the community involved can benefit from it and in so doing improve its livelihoods has begun to take hold in recent years (CTA, 2008). Bio-cultural community protocols (BCP's) present the foundation for endogenous livestock development where communities take charge of their patent or natural resource management and cut out commercial groups which are subject to short-term market forces. Local communities are now aware of the value of wild and domesticated animals they have manages and protected for centuries and the knowledge of which they are the custodians. Nevertheless, BCP's would safeguard the long term wellbeing of animal production systems that contribute to the livelihoods of people in the community.

Conservation of genetic diversity and implication for developing countries: In many developing countries, environmental manipulation has not occurred to the same extent as in developed countries (Munro and Adams, 1991). The accelerating demands of a growing human population and the pressures of economic developments are affecting the security and survival of many indigenous African breeds which until now are a stable part of their particular ecosystem for hundreds of years (Rege, 1993). This trend will certainly continue as the human population and the demand for animal products increases. As previously isolated communities intermingle, indigenous animal populations can interbreed. This, combined with increasing animal movements through trade, presents additional pressures on those populations. In some parts of Africa, the effect of drought, flooding and famine, compounded with prolonged civil wars, have taken their toll (Rege, 1993). Consequently, indigenous African breeds are at risk in the face of global climate change challenges. The social and environmental consequences of climate change variation gravely compromise the livelihoods of more than 70% of the population of ACP countries, who depend on the agricultural sector (CTA, 2008).

The potential global contribution of the genetic resources of indigenous small ruminants in Africa is enormous. It would be tragic if these unique genetic resources resulting from centuries of natural and adaptive selection were lost. The rate of erosion of indigenous animal genetic resources therefore threatens the prospects of providing the livelihoods of present and future generations in the face of changing global climate trend. African governments, policy makers and other development agencies need to recognize the role these genetic diversity or resources play in today's production systems. Programmes should be set up to conserve, develop and protect these reservoirs of exceptional genes in line with the evolving animal production systems that are sustainable, improve livelihoods and are environmentally friendly. It is therefore important to identify, characterize and evaluate existing genetic resources (Sere *et al*., 1996). This needs to be done for sustainable use of the existing genotypes and ecotypes that have adapted to the production environment in which they evolved and to be able to make appropriate adjustments as the climate changes. Indigenous breeds are crucially important today in developing countries and will continue to be valuable in the future as mitigation strategy towards the impact of climate change on animal production systems.

CONCLUSION

The issue of conservation of genetic diversity is multi-dimensional. It involves many aspects of the agricultural, social, economic and trading policies/arrangements of nations. Present attitudes to genetic improvements need to be reviewed in light of concerns over sustainability of animal production systems and the need to maintain a reservoir of genetic diversity in the face of climate change challenges. The direct and indirect costs involved peculiar animal production systems need to be assessed to determine the level of diversity needed. Justifying the diversion of funds to genotype conservation from other pressing social, economic and environmental problems and especially in developing nations requires careful consideration. Conservation does not require ambitious or grandiose projects. It can start with support and encouragement for household and communities to keep priority species in their backyards or on common plots of land. However, problems preventing extensive utilization and improvements of African genetic resources in the face of an increasingly vulnerable environment need to be identified and appropriate policy framework put in place to address such challenges. Because of the multi-dimensional facets of genetic diversity and climate change, wise decision making that tend to adopt a holistic or integrated approach will aid the development of rational utilization and conservation programmes that will be appreciated.

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