Livestock and Biodiversity: The Case of Cattle in Africa

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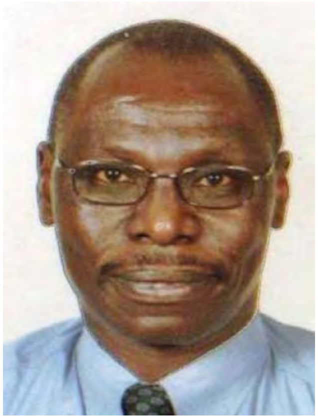

Livestock and Biodiversity: The Case of Cattle in Africa

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Africa is home to diverse and genetically unique ruminant livestock and wildlife species. The continent, however, faces huge food security challenges, partly due to low productivity of the livestock. As a centre of cattle domestication, Africa hosts genetically unique cattle, being products of generations of co-evolution with diverse people, each selecting for different attributes under different production systems and environments.

Over millennia, this diversity of purpose has led to rich and unparalleled blends of indigenous and exotic cattle. Different parasites and pathogens, whose vigour has been buoyed by variable but generally favourable tropical conditions, have co-evolved and served as critical drivers, making African cattle some of the world's most scientifically interesting and valuable populations. This diversity is being lost at an alarmingly rate, and in-situ conservation will not significantly save it.

These cattle can potentially provide adequate food and income to their keepers. First their genetic and phenotypic diversity should be understood, and then carefully tailored to specific production systems to improve their productivity.

To realistically conserve these cattle, for which no conservation plans currently exist, available modern bio- and information technologies are needed to assemble and analyse complex sets of information on them. As the climate and pathogens all change, by smartly conserving (ex-situ*)* those at risk the genetic attributes critical for the world's future food security challenges would be saved.

This paper discusses the diversity of the African cattle and the need for their system-wide characterisation in order to allow their keepers to cope with the changing system, and minimise the loss of these unique genotypes.

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Introduction

Globally about one billion people keep livestock, while up to 60% of rural households (i.e. more than 1.3 billion people), most of whom are poor, draw income from livestock and livestock products value chains (Pica *et al.* 2008; ILRI 2009). In sub-Saharan Africa, unlike in the developed west, livestock play significant and multiple roles (Rege and Gibson 2003; FAO 2009; Hanotte *et al.* 2010). Livestock provide food (meat, milk, etc.) of high nutritional value (nutrient density and composition), especially important to women and children; generate income; store wealth (i.e. are a 'living bank'); provide safety nets against risk; and are critical and essential components of mixed farming systems, where they provide traction, are used to transport goods, thresh grains and turn crop wastes into useful organic manure, thus helping in recycling nutrients that support crop agriculture (Anderson 2003). In addition, livestock have a role in maintaining rangeland health and turning poor-quality herbage into valuable meat and milk as long as appropriate stocking rates are maintained.

Although Africa is home to more than 275 million head of cattle, which equates to 21% of the total world cattle population, this large population produces less than 2% of annual total world beef (FAO 2009). No wonder the per capita meat consumption is an appalling 30 kg y^{-1}; a similarly low per capita figure is recorded for milk. In a region (sub-Saharan Africa) where 556 million people earn less than $2 US per day and hence are too poor to afford livestock products—which, together with fish, are the main sources of protein and essential micronutrients for human nutrition—such low meat and milk intakes are catastrophic (Pica *et al.* 2008; FAO 2009).

Unlike in developed countries, especially the United States of America, in sub-Saharan Africa, livestock products are not hazardous to health of the poor people. To the contrary, nutritional status and health of the many poor mothers and children would significantly improve through relatively marginal increases in daily milk and meat intake. Such improvements, however, are currently undermined by low productivity (Mwacharo *et al.* 2009; Rege and Gibson 2009). Sub-Saharan Africa's cattle numbers need to be substantially reduced in order to allow their productivity to improve. Such intervention would not only mitigate current environmental degradation caused by overgrazing, but also help reduce environmentally harmful methane emissions (Herrero *et al.* 2008; Herrero and Thornton 2009).

However, given:

- sub-Saharan Africa is home to unique cattle diversity of peculiar evolutionary background (Hanotte *et al.* 2002; Freeman *et al.* 2005; FAO 2007a; Hanotte *et al.* 2010)
- these livestock directly support more than 70% of the rural poor—in terms of daily food supply, crop production through manure supply, draft power, income and savings as well as social–cultural satisfaction (FAO 2008),

any intervention must be guided by well-informed conservation programs or unique genes could be lost forever. Thoughtless replacement of Africa's cattle with fewer but potentially more productive ones could—and often has —ended up as an expensive failure.

The threat to genetic diversity of Africa's cattle—the need to conserve it

Recent estimates suggest Africa hosts 180–200 million cattle of 150 indigenous breeds, of which 47% are under threat while 22% risk going extinct (FAO 2007a). Given the complex history of African cattle breeds, such losses would be undesirable. Although global institutional arrangements for sustainable management of animal genetic resources are in place (FAO 2007b; Boettcher and Akin 2010; FAO 2010) and while tools for effective monitoring of threats are generally available (Martyniuk *et al.* 2010), threats to their continued existence are real (FAO 2000; Seré *et al.* 2008; Mwacharo and Scherf 2009) and continue to rise.

The reasons for the escalation of threats to Africa's indigenous cattle are varied, but include:

- unfair competition from vigorously promoted commercial European breeds, even where such genotypes are inappropriate (King *et al.* 2006; Hanotte *et al.* 2010)
- unplanned crossbreeding with commercial European breeds (Rege and Gibson 2009)
- globalisation and the supermarket revolution, where standards of livestock products are made to mirror the developed world's tastes and requirements (Seré *et al.* 2008; Pilling 2010)
- absent or poor breeding program design and implementation plans (Philipsson *et al.* 2006; Nimbkar *et al.* 2008)
- lack of infrastructure (e.g. recording systems, breeders organisations etc) and policy frameworks to support sustainable breed improvement programs (Scholtz *et al.* 2010; Wasike *et al.* 2010; Zonabend *et al.* 2010). In addition, a general lack of human capacity (Ojango *et al.* 2010) remains a huge hindrance to full implementation of the FAO's Global Plan of Action (GPA) on animal genetic resources, however well-intended the plans are (FAO 2007b; Boettcher and Akin 2010).

Examples of unique African cattle breeds include the Sheko of Ethiopia, with less than 3000 now left, and the N'Dama of West Africa (DAGRIS 2007; DAD-IS 2010), which can withstand high levels of trypanosomosis challenge and remain productive, whereas other breeds do not (Lemecha *et al.* 2006; Stein *et al.* 2011). Trypanosomosis is a fatal un-vaccinable disease that hugely limits livestock productivity in Africa.

Trypanosomosis is the largest single disease that greatly constraints livestock, especially cattle production in sub-Saharan Africa. Kristjanson *et al.* (1999) and Swallow (2000) indicated that the potential benefits of improved trypanosomosis control, in terms of meat and milk productivity alone, are $700 million to $1.3 billion per year in Africa. This disease costs livestock producers and consumers an estimated $1340 million annually, excluding indirect livestock benefits such as manure and traction. Others have put the annual losses due to the disease in Africa even higher (US$ 4–5 billion). In the absence of a vaccine, and given that the only drugs against the parasite were developed over 25 years ago and are no longer effective, the potential role of genetically trypano-tolerant cattle breeds is enormous.

Hanotte *et al.* (2003) and Orenge (2010) have mapped trypano-tolerant quantitative trait loci (QTLs) in N'Dama and Boran cattle that are functionally transmissible to their back crosses, although each QTL has relatively little effect.

Ankole cattle that are indigenous to Uganda have unique features, notably extremely large and long horns that compare to no other livestock breed in the world; well marbled meat cuts and milk that is rich in protein and lactose (DAGRIS 2007; DAD-IS 2010). In the last 10 years, however, through rampant crossbreeding with the Ayrshire or Holstein-Friesian European commercial dairy breeds, a significant fraction of Ankole herds is disappearing. The driver of change here is the increasing demand for processed milk in the main Ugandan cities, and lucrative prices offered for this product. In herds where only a few years ago pure Ankole cattle were predominant, today only small proportions are pure Ankole cattle and the bulk of the young stock are crossbreds. If the current trend continues, in 50 years or so the gracious Ankole breed could be no more. Similar scenarios and trends are common elsewhere in Africa. For example, the indigenous Nandi cow, which at the turn of the last century was kept by the Nandi people of Kenya and could produce more than 10 kg milk daily from unimproved tropical pastures of western Kenya, is now totally extinct, and so are the indigenous Kenyan highland zebu cattle (FAO 2007a, Kenya Country Report).

Unless and until the Global Plan of Action (GPA) on animal genetic resources is mainstreamed in national and regional livestock improvement plans and implementation programs (Peters and Zumbech 2002), indigenous breeds will continue to disappear before their true values are known. Global efforts aimed at identifying and conserving the useful genes therefore require urgent action. More importantly, we must not expect poor African farmers to sacrifice their incomes and livelihoods by keeping relatively less productive but potentially valuable indigenous cattle breeds in order to preserve potentially important diversity for posterity.

The origin and depth of Africa's cattle diversity

The genetic diversity of Africa's cattle is unmatched (Hanotte *et al.* 2002; Freeman *et al.* 2005; Hanotte *et al.* 2010). The complex nature of African cattle has, over several millennia, been influenced by:

- original domestication in Africa (Hanotte *et al*. 2002; Gifford-Gonzalez and Hanotte 2011)
- human migration—leading to multiple admixes from other centers of domestication in the Near East—and including north–south migration to the southern part of Africa (Hanotte *et al.* 2002)
- more recent introductions of European, mainly commercial, breeds following colonisation (Hanotte *et al.* 2000; Freeman *et al.* 2005), coupled with unparalleled co-evolution in a rich mix of variable, but generally favourable, tropical conditions.

Any loss of resultant unique genes would be lamentable and should be prevented from happening at all costs.

Hanotte *et al.* (2010) have further observed that in Africa disease and parasite challenges occur hand-in-hand with the rich grasslands. These factors, together with the wide variety of their keepers' preferences (breeding objectives) and constant human and animal movements and exchanges, have moulded these animals into a complex mix of genotypes whose values cannot and should not be underestimated.

Potential for increased productivity and better match to unpredictable future production environments

Although only a few African cattle breeds are currently being raised commercially for beef and none for commercial dairy production, there are notable cases where these breeds have contributed to improved beef and milk productivity, and continue to be of significant commercial value. Examples include the Kenya Boran and the Tuli from Zimbabwe that have been successfully introduced in Australia (http://dagris.ilri.cgiar.org) and parts of the USA. These introductions have significantly improved herd fertility, calving ease, tolerance to heat and water stress, and ability to efficiently convert relatively low-quality forages into good-quality beef.

Where recording and breed development through sustained selection programs have been appropriately implemented (Philipsson *et al.* 2006), huge progress has been made. Examples include the Nguni cattle in South Africa (Scholtz and Ramsay 2007), the Kenya Boran (Okeyo *et al.* 1998; Wasike *et al.* 2006, 2007) and the Tuli cattle of Zimbabwe (Ntombizakhe 2002)—now all world renowned for commercial beef production.

In planned beef cattle crossbreeding programs, especially as dam breeds under relatively challenging local ranching conditions, the Boran, Tuli, Ankole and Nguni have all performed very well. The Nguni breed has also been instrumental in the successful development of synthetic beef breeds such as the Bonsmara in South Africa. In general, where crossbreeding involves the use of European dairy breeds and the indigenous African breeds, it has been observed that the first cross (F1) exhibits the highest levels of heterosis and complementarity for milk production and adaptability (Cunningham and Syrstad 1987; Rege 1998; Gibson and Cundiff 2000; Goshu 2005). The F1s best combine the tolerance traits of the indigenous zebu or Sanga cattle breeds with the productivity of the exotic temperate traits, and thus are best suited the low-input commercial mixed crop–livestock production systems that characterise most of the sub-Saharan Africa (Rege and Gibson 2009; Mwacharo *et al.* 2009).

Opportunities for informed conservation programs

Opportunities for applying old and new sciences to exploit the desirable attributes of African cattle breeds are huge (Mwacharo *et al.* 2009; Marshall *et al.* 2011; Rege *et al.* 2011). New genomic, information and communication technologies provide untapped potential for quick and more accurate characterisation of populations to better inform conservation and breed improvement programs (Hanotte *et al.* 2010; Martyniuk *et al.* 2010; Marshall *et al.* 2011). Great advances in computing power and the science of genomics and bio-informatics, combined with current telecommunication technologies (IT), allow collection and real-time remittance of such data for safe storage and management. These advances provide opportunities for fast turnover and feedback, potentially to a wide variety of stakeholders. If aptly and smartly used, these technologies, either singly or in combination, permit timely and informed decision making—in this case, for better sustainable management of animal genetic resources (Rege *et al.* 2011).

The speed and power of today's computers allow in-depth analysis of extremely large and complex datasets. In contrast to what was available to the developed world 50 or so years ago, the above scenarios and tools allow simultaneous synthesis of environmental variables, phenotypic and genotypic data, and results for better probing of livestock systems and populations to better inform conservation and genetic improvement programs (Martyniuk *et al.* 2010; Hanotte *et al.* 2010).

Available suites of advanced reproductive technologies, such as sexing of semen, embryos, ovum pick-up and in-vitro fertilisation and embryo transfer, if smartly practised, will allow better use of indigenous cattle breeds for specialised and planned crossbreeding programs (McClintock *et al.* 2007; Mutembei *et al.* 2008; van Arendonk 2011). In Africa today, however, lack of a supporting policy framework, poor infrastructure, shortages of skilled staff and inadequate budgets for agricultural science continue to limit the impact of these technologies (Martyniuk *et al.* 2010; van Arendonk 2011). Field application of technologies such as genomic selection are, in our view, currently inappropriate for most African situations—hence in this case a waiting brief is the best strategy (Marshall *et al.* 2011). In the meantime, more efficient and wiser application of

IT, computing and bioinformatics will enable great progress in sustainable cattle conservation and improvement programs.

Conclusions and recommendations

Africa's indigenous cattle breeds are unique and harbor genes that are likely to be of future value, especially in view of the on-going climate change and unpredictable scenarios for future production systems—new disease may emerge, currently less-important pathogens and diseases may become more important and broader system-type approaches may be required.

Existing and emerging information, computing, telecommunication, genomic and reproductive technologies offer potential solutions to conservation's current dilemma—how to save the unique global public good that African cattle breeds represent. Resources should be mobilised for this task now—not later, by which time losses will surely occur, as poor African livestock keepers, who are the current custodians of this great world heritage, cannot be expected to forgo income and better livelihoods to provide in-situ conservation of these cattle.

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