

*From left to right: Dr Christian K. Tiambo, Dr Christine Kamidi, Ms Triza Tonui, Mr Moses Ogugo, Ms Sally Katee, Dr Hussein Abkallo, a team of young talented scientists from the International Livestock Research Institute (ILRI) in Nairobi that is working on a programme to demonstrate the importance of stem cell and genetic engineering technology to meet the growing demand of animal source food (ASF) and to conserve livestock biodiversity through biobanking in Africa.*

*Photo Credit: ILRI*

# Stem cell research and gene editing: the new frontier in livestock breeding

By Dr Christian K. Tiambo, Dr Christine Kamidi, Ms Triza Tonui, Mr Moses Ogugo, Ms Sally Katee & Dr Hussein Abkallo

**T**HE demand for animal source food, including meat, milk and eggs, continues to rise amid a rapid population growth, changes in consumption patterns and urbanisation.

Some estimates show that milk production will need to increase by 63 percent, and meat production by 76 percent to meet the demand.

There is a clear need for African livestock production systems to be improved through genetic gain to sustainably feed the continent's growing population.

Options to address the challenges associated with the demand for animal source food in Africa are varied, but the adoption of modern biotechnologies applied to locally adapted breeds is cross cutting among them and unavoidable.

This endeavour requires reliable animal seed systems, germplasm conservation and harnessing their genetic potential using biotechnologies.

Stem cell technology has recently brought high hopes of improving animal husbandry, production and veterinary health problems. It is applied in restoration and regeneration of tissue, animal cloning, and transgenic animal production, this technology carries the high promise for 1) increased (ASF) production and feed efficiency, 2) disease-free or disease-resistant animals and 3) production of climate-resilient livestock.

A team of young talented scientists from the Centre for Tropical Livestock Genetics and Health

(CTLGH), the International Livestock Research Institute (ILRI) in Nairobi and the Kenya Agricultural and Livestock Research Organization (KALRO), are working on a programme to demonstrate the importance of stem cell and genetic engineering technology to meet the growing demand of animal source food and to conserve livestock biodiversity through biobanking in Africa.

Biobanking is the storage of living cells in a manner that allows them to be retrieved and used to develop viable, living organisms. Biobanks for animals usually involve cryopreservation (controlled freezing) of sperm, eggs and embryos. Repositories such as these play an important role in agriculture (e.g. genetic management in the dairy and other livestock industries).

Dr Christian Tiambo, who leads the Cellular Resource, Functional Genomic and Biotechnology Programme, said the stem cells biobanked in national facilities in the regional Africa AU-ARSCoEs and with potential back-up in ILRI biorepository (Azizi Biorepository) are setting the stage for future development of a living, accessible, biobank to archive the genetic and phenotypic diversity of the African animal breeds from which the cells are derived.

“Our platform will provide a source of differentiated cell types, of appropriate genetic backgrounds, with desired phenotypes (e.g. increased growth, resistance to pathogens or metabolic stress) for use in the identification of causal variants, the implementation of large scale CRISPR/Cas9 genetic screens in cells of defined genetic backgrounds. Additionally, these efforts will provide resources and technical capacity for accelerated reproductive technologies”, said Dr Tiambo.

Dr Christine Muhonja, who is in charge the African chicken biobanking activities at CTLGH/ILRI and oversees the chicken breeds restoration and multiplication activities at KALRO, is looking forward to using the genome edited non-transgenic surrogate

chicken to accelerate conservation and restoration of the local kienyeji (indigenous) chicken.

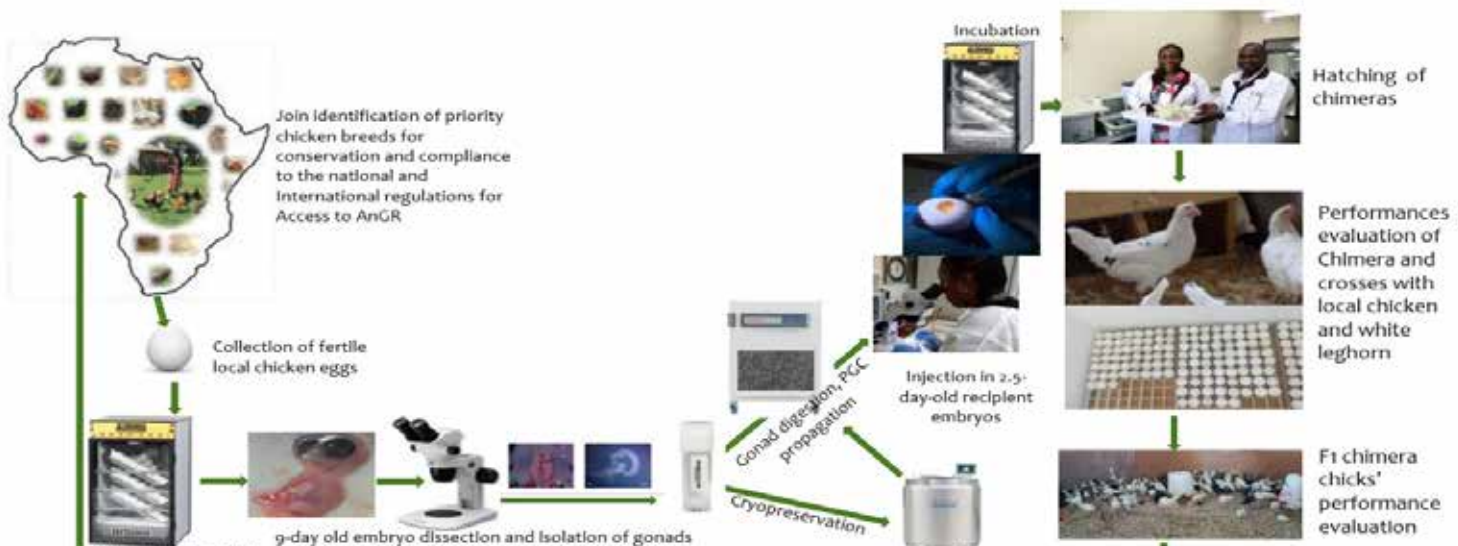
“Poultry genetic resources especially the indigenous breeds are being lost irreversibly and at an alarming rate, thus collection of this germplasm and conservation via primordial germ cells (PGC) will not only drastically reduce this risk but will also allow scientists and the national research systems to conserve the entire gene pool and give back to communities. This technique will offer the benefits of being able to store a lot of diversity in a small area, by keeping the genetics in an environment free of pathogens and safeguarded from dangers and be able to revive a lot of chicken preferred breed lines when needed to meet the demands of the farmer. This innovation of PGC preservation, in conjunction with sterile surrogate use, will revolutionise the preservation and future use of diverse poultry genetics. It will also enable ongoing efforts to conserve chicken genetic diversity for both commercial and smallholder farmers, and to preserve existing genetic resources at poultry research facilities,” said Dr Muhonja.

The development of cattle stem cell resources at ILRI are spearheaded by Triza Tonui, a research associate in genomic and reproductive technology.

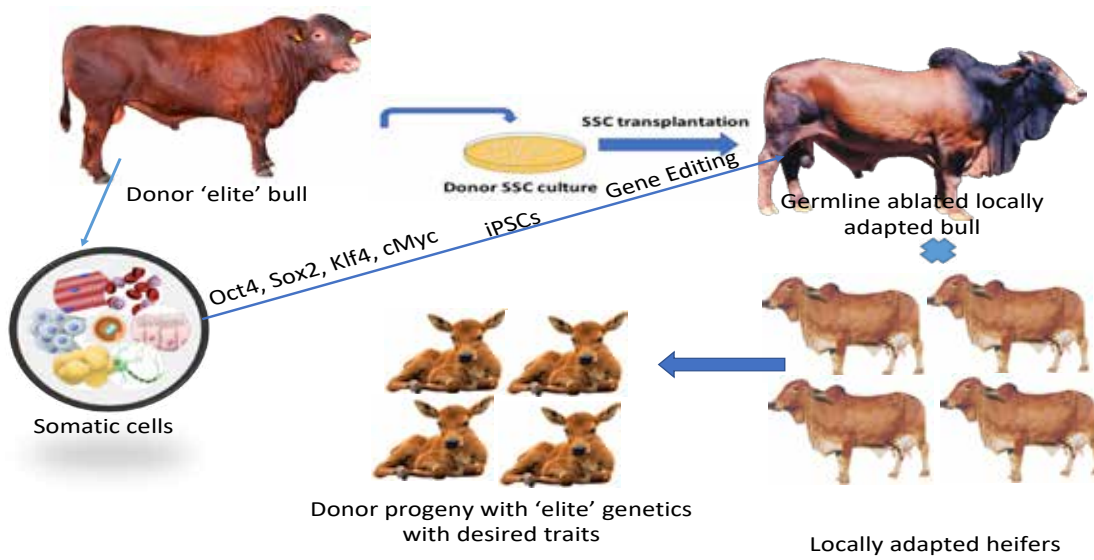
“The focus will be on selected cattle breeds indigenous to Kenya, Ethiopia, Uganda, and Tanzania. The utility of cattle stem cells will offer a promising opportunity to deliver improved germplasms with the desired genetic and phenotypic traits,” she said.

Moses Ogugo, the research officer, says the conservation of locally adapted domestic and wild pig genetic resources using the most accessible biological material and non-invasive biotechnologies will increase the capability to respond to present and future needs of the global livestock production, and affordable and accessible biological material for further research on health threats like the African Swine Fever.

Livestock biobanking in Africa will provide investigators with a comprehensive selection of animal cell lines with desirable scientific backgrounds. The ILRI/CTLGH programme could also be of tremendous support to the livestock and potentially wildlife conservation communities with a wide range of services, extending from collection, processing, quality control, shipping, and endangered population restoration. It could also offer training to the regional gene banks established by African Union-InterAfrican Bureau for Animal Resources (AU-IBAR).



**Embryonic day (ED) 9 gonads are isolated from embryos, pooled by sex, and cryopreserved in liquid Nitrogen, and retrieved for restoration of the breeds.**



Schematic adapted from Oatley et al. 2017

**Conservation of tropical indigenous Suidae genetic resources using the induced pluripotent stem cells (iPSC) derived from somatic cells.**

Potential applications of stem cells for African livestock development include conservation and restoration of breeds, reproduction, transgenic technologies, gene therapy, translational and regenerative medicine, drug's evaluation and disease modeling, and in vitro meat production.

Dr Hussein Abkallo, a scientist under the ILRI Animal and Human Health Programme, is harnessing the vast potential of gene editing to enhance food security, alleviate climate-related vulnerabilities, and ultimately promote sustainable livelihoods.

Dr Abkallo applied CRISPR/Cas9 technology to generate live-attenuated vaccines against the African Swine Fever virus. His efforts have yielded multiple vaccine candidates which are now undergoing trials at ILRI. Dr Abkallo has since extended the application of CRISPR/Cas9 technology to attempts at editing the genome of Theileria parva, the parasite responsible for the deadly East Coast Fever (ECF) disease in cattle.

Genome editing tools can be used to improve livestock productivity and profitability of associated industries in many ways. Livestock genome editing offers an opportunity to make specific and precise changes

to the genome of an animal to increase productivity, disease resistance, adaptability, to produce efficient and environmentally friendly animals.

Private-public partnerships between CTLGH/ILRI and its farmers facing programmes (TPGS, AADGG), the African National livestock research centers (e.g: KALRO) and livestock industries, with support and funding from the Bill & Melinda Gates Foundation and other donors seek to improve African livestock. Numerous opportunities exist for editing African local and locally adapted breeds of livestock for improved adaptability and productivity.

Gene editing is being used to edit virulence genes of Theileria parva to increase the immune response of cattle when they are vaccinated against East Coast Fever. To confer protection against the Avian Influenza Virus (AIV) infection in poultry, researchers are

using gene-editing tools to generate variations in ANP32A, a gene that affects AIV replication. This will enable them to predict which of these targeted changes on the ANP32A gene will make the most significant restrictive effect on avian influenza virus replication.

While most gene editing product development is at the proof-of-concept phase, the tools present many opportunities to potentially reduce the amount of time it takes to bring improved animal breeds to the market in sub-Saharan Africa. Countries like Kenya and Nigeria have made adequate provisions in their biosafety framework to ensure that these gene edited products will not be treated differently from conventional livestock. Many other African countries are taking the same path to take advantage of the science breakthrough from ILRI and partners institutions.



**Conservation of tropical indigenous Suidae genetic resources using the induced pluripotent stem cells (iPSC) derived from somatic cells.**