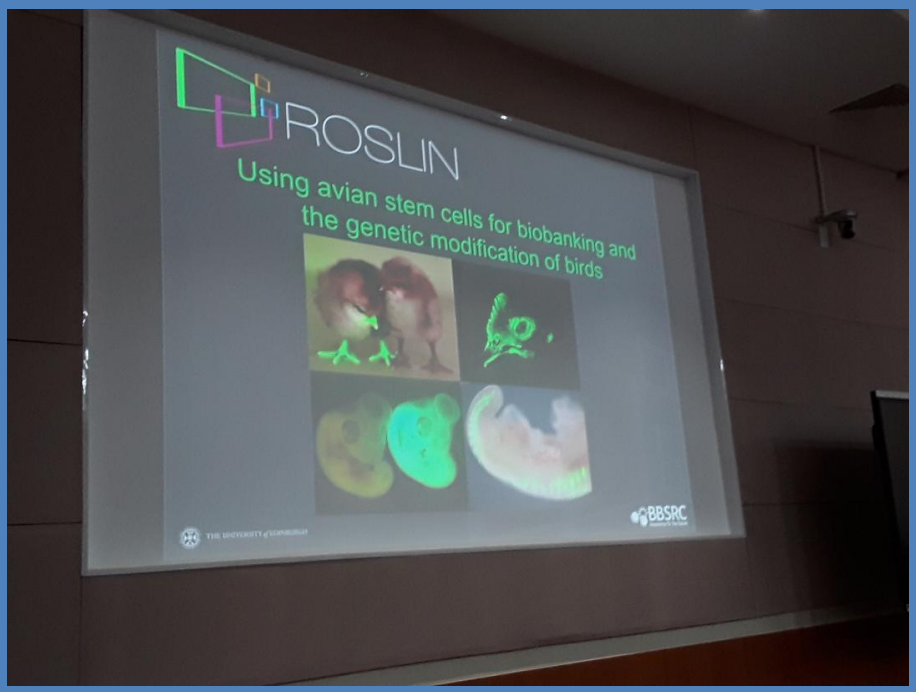
Training on reproduction technologies for cryo-conservation of African Animal Genetic Resources 16th - 20th July 2019 in Nairobi, Kenya.

This is a brief report detailing the content of collaborative training of technical staff from member state and regional gene banking. The trainings were conducted for AU-IBAR from 16th July to 20th July, 2019 in Nairobi, Kenya.



By: Christian K. Tiambo, Yue Yaojing, Paul Egesa, and Steve Kemp

WORKSHOP INFORMATION:

Title: Training on reproduction technologies for cryo-conservation of African Animal Genetic Resources

Dates: 16th - 20th July 2019

Venue – Nairobi/Kenya

Host Institutions: CTLGH/LRI Campus and KAGRC Campus

Funded by: AU-IBAR Genetic Project.

Format of the training course: The 5-day residential training includes lectures and practical sessions on specific aspects of mammals and poultry reproductive biotechnology for biobanking. This should be followed by in-depth targeted training and field experiential learning in the five regions of Africa where the gene banks are implanted, with technical support from the trainers, collaborators from ARIS (the Roslin Institute) and local expertise.

PARTICIPATING COUNTRIES

- **Eastern Africa**: Rwanda, Tanzania, Uganda, Ethiopia, South Sudan, Burundi, Kenya
- **Central Africa**: Democratic Republique of Congo, Equatorial Guinea, Republique of Congo, Central Africa Republique, Cameroon.
- **Western Africa**: Niger, Nigeria, Ghana, Togo, Cote d'Ivoire, Burkina Faso,
- **Southern Africa**: Malawi, Namibia, Botswana, Zambia, Swaziland, Madagascar.
- **Northern Africa**: Tunisia, Egypt, Algeria.
- **International Partner**: The Roslin Institute-The University of Edinburgh-The United Kingdom.

BACKGROUND

The rationale/justification for the workshop:

Transfer of the successful experience seems to be one of the most effective ways to solve the problems faced by the livestock sector. North-South and mostly South-South knowledge exchange can be part of the solution for the lack of information, capacity building for both scientists and practitioners, as well as facilitate scaling up of successful solutions.

Avian reproductive biotechnology is the application of scientific techniques to modify, conserve and improve poultry genetic resources and to enhance their value. Therefore, avian reproductive biotechnology can help African countries enhance chicken productivity while preserving the genetic resources.

The "Training on reproduction technologies for cryo-conservation of African Animal Genetic Resources" will be the first training organized including the Avian reproductive Biotechnology in sub-Saharan Africa in the framework of the partnership initiative on South-South Cooperation jointly supported by the International Livestock Research Institute (ILRI), the Centre for Tropical Livestock Genetic and Health (CTLGH) though their Poultry Genomics and reproductive technologies research

components, the Kenyan Animal Genetic Resource Centre (KAGRC) and supported by the African Union – InterAfrican Bureau for Animal Resources (AU-IBAR) through its genetic project component.

The training is designed in respond to the demand from the participating countries and the Regional Gene banks established under the Genetic project.

The training will provide an opportunity for experts in livestock and poultry biotechnology, managers of the five regional gene banks, the regional and Sub-Regional Focal Point for Animal Genetic Resources in Africa, the members of the Chicken CoP at BecA-ILRI Hub, and the members of the AU Animal genetic resources taxonomy advisory group (AnGR-TAG) to improve their capacities and get acquainted with techniques in breeding and conservation of Animal Genetic resources.

The production of an efficient culture method for the propagation of chicken PGCs in vitro represents a useful system for the study of PGCs biology. The chicken PGCs ability to form functional gametes after long-term culture is useful to develop a cell-based system for the conservation and genetic improvement of the chicken genome. To successfully propagate avian PGCs, it is useful to understand the mechanisms how they arise and the genetic pathways that regulate germ cell survival, proliferation, and migration in the early embryo. Avian stem cells have been a promising tool for biotechnology. The long-term PGC cultures are presently seen as one of the most promising tools for maintaining the avian genetic biodiversity across Africa without moving the genetic material from their regions of origin.

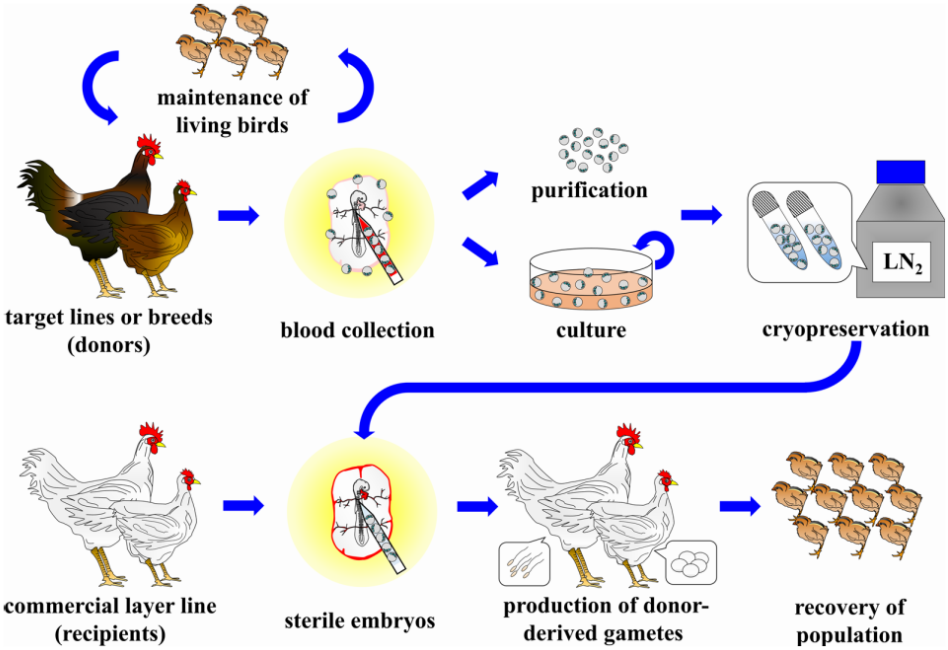
In the frame of this course, participants will be acquainted with technique on semen collection from ruminants, processing and storage, isolating of primordial germ cells (PGCs) from chicken embryos, cryopreserving and thawing of cPGCs with serum-free medium, checking the viability of the cultured PGCs, their re-injection back to the blood circulation of a developing embryo and evaluation of the integration ratio of the injected cells in the gonad

Relevance:

Most lost African livestock genetic resources are maintained in situ in living populations. However, in situ conservation always carries the risk of loss owing to pathogen outbreaks, genetic problems, breeding cessation, or natural disasters. In addition to these risks, the periodic reproduction of in situ populations makes them costly to feed, and requires special facilities including a animal house and farm. On the other hands, cryobanking of germplasm in birds has been limited to the use of semen, preventing conservation of the W chromosome and mitochondrial DNA. A further challenge is posed by the structure of avian eggs, which restricts the cryopreservation of ova and fertilized embryos, as contrarily done for mammalian species. As an alternative, avian Primordial Germ Cells, the first germ cell population established during early development, can be incorporated into the gonads (Yasuda et al., 1992) and differentiated into functional gametes following transplantation to recipient embryos (Tajima et al., 1993; Ono et al., 1998). This technological development of avian PGC transplantation provides insight into ex situ conservation because PGCs enable the capture of the entire genetics of the stock.

The production of an efficient culture method for the propagation and conservation of chicken PGCs in vitro will not only provide a useful system for the study of PGC biology, mostly, this is an opportunity for conservation of the valuable African indigenous chicken and other livestock genetic resources. This is particularly relevant in the scenarios of operationalizing the five African regional gene banks created

by the AU-IBAR. The chicken PGCs ability to form functional gametes after long-term culture is useful to develop a cell-based system for the genetic modification of the chicken genome. This is a valuable tool for research and industry. To successfully propagate avian PGCs it is useful to understand the mechanisms how they arise and the genetic pathways that regulate germ cell survival, proliferation, and migration in the early embryo. The training intends to refresh the participants on these fundamentals of chicken embryology, and transfer to them the skill of using these techniques for conservation and improvement of chicken genetic resources. The figure below illustrates the outline of a chicken PGC-bank program.



Outline Illustration of a chicken PGC-bank program

The procedures of ex situ conservation of chicken genetic resources consist of five steps

1) collection of embryonic tissues containing PGCs from target lines or breeds
2) purification or culture of PGCs,
3) PGC storage in liquid nitrogen,
4) PGC transplantation to sterilized recipient embryos, and
5) recovery of populations by mating of male and female recipients

OBJECTIVES:

The overall objective of the training was to refresh the participants on the gene banks management and equip them with knowledge and skills reproductive technologies for livestock cryoconservation, in chicken Prinordial Germ Cells (cPGC) isolation, long-term cultivation and re-injection for conservation of African chicken Genetic Resources.

TOPICS COVERED

- Basics of chicken embryology and primordial germ cell (PGC) development.
- PGC isolation from chicken Blastodisc HH2 stage）
- PGC isolation from circulating embryonic blood of chicken embryos （HH14/16 stage）
- PGC isolation from gonad of chicken embryos （HH 28 stage）
- Long-term culture technique for cPGCs.
- cPGC freezing, thawing
- cPGC chimera production
- Preparation of Males for Semen Production
- Semen collection and Processing
- Safe handling, storage, labeling,
- Recording and transport of samples

ACTIVITIES CARRIED OUT:

day-by-day summary of activities carried out:

- **Day 1**: opening ceremony by the DDG/ILRI, Dr Dieter Shillinger, followed by introduction of participants as well as the host institutions. Overview of the training programme and beginning of the presentations on the ***Status of conservation of local Animal genetic resources in Africa: Overview***. The day was closed with a presentation on ***Access and Benefit-sharing of Animal Genetic Resources in Africa***, by Christian K. Tiambo
- **Day 2**: the second day of the workshop was focused on Lectures and discussions on: Preparation of Males for Semen Production, semen collection and processing, Safe handling, storage, labeling, Recording and transport of samples, Bio banking African poultry breeds, Cryopreservation of indigenous chicken in Africa using cultured primordial germ cells (PGC).
- **Day 3**: the 3rd day was marked by Practical training Sessions in two major groups.
  Group A: working on mammals at the Kenyan Animal Genetic Resource Centre (KAGRC)'s farm and laboratories. Their practicals focused on Semen collection using different methods, semen and Processing, Safe handling, storage, labeling, recording and transport of samples.
  Group B: working on the conservation of poultry genetic resources using the Primordial germ cell approach at the Centre for Tropical Livestock Genetic and Health (CTLGH) Laboratory at the International Livestock Research Institute (ILRI). Their practicals focused on Isolation of PGC from different chicken embryo stage, Isolation of PGC from different chicken embryo stage, Injection of PGC back to Chicken Embryos.
- **Day 4**: on the 4th day, the two groups switched their training sites and practicals, for all the trainees to benefit from al the techniques for all livestock conservation
- **Day 5**: the last day of the training workshop was reserved for regional group discussion and presentations of the Operationalization of the Regional gene banks for AnGR conservation. The group discussion and report included the weaknesses and suggested actions for the followings:
  a) Status of the regional Genebank: Weaknesses, Alternatives and suggested actions

b) Rationalization of the System and regional Coordination of AnGR conservation
c) Prioritization of species' conservation
d) Utilization as a Strategy to Encourage Germplasm conservation
e) Storing Information in Biological Libraries and Digital Formats
f) Funding of Gene Banks, their sustainability and reliability.

WORKSHOP ACHIEVEMENTS AND IMPACTS

Those who participated to the course got insight into a new technology, which allows the preservation of Animal Genetic biodiversity. The training raised participants' awareness on modern biotechnology approaches in livestock and poultry development, and they acquired practical knowledge on applying specific technics for ensuring preservation of Animal Genetic Resources.

The long-term PGC cultures are presently seen as one of the most promising tools for maintaining the African livestock genetic resources. There is a tremendous opportunity for the use of the regional gene banks established to conserve poultry and mammals' genetic material across the African continent.

It is now expected that from this training, conservation actions will be launched and successfully ran by the trainees with minimal support, using the five regional cryo-banks established by AU-IBAR

POST WORKSHOP EVALUATION RESULTS

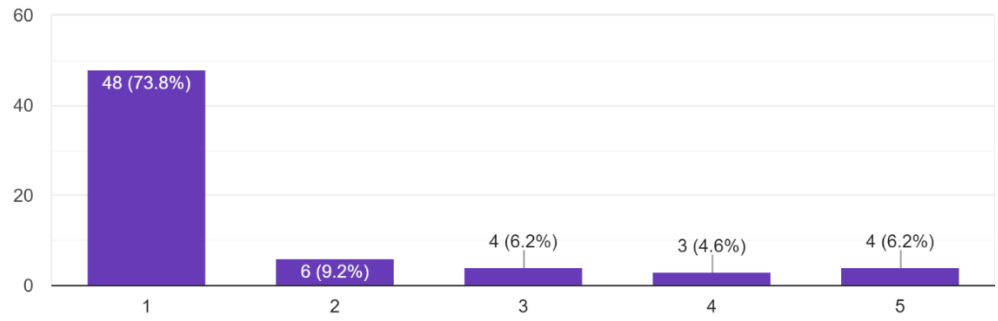
A post workshop evaluation was accrued out, to access the perception of the trainees and envisage the way forwards. The major results of the evaluation are as follows:

All species of interest to the trainees are: Cattle (indigenous, some focus was made on the Bakosi, Ankole long horn, Angoni, Nguni, Fogera,Tswana, Mosi cattle), Chicken (with focus on indigenous ones, tillili), guinea fowl, rabbit, fish, pig (emphasis made on the Bakosi pig), non-conventional livestock ( ), goat (Mubende and Kigezi breeds), sheep, Camels and Buffalo, etc.

93% of the trainees declared the training highly relevant to their current job and research, and could recommend further trainings to donors, 87.7% of the trainees wanted the workshop to be replicated at the regional levels within the five regional gene banks, with more focus to the region's priority species, and 89.2% wanted this cohort of trainees to be maintained and developed into a community of practice, and to form the core team for African Animal Breeding Academy for conservation. 75.3% of the trainees declared the program was well paced within the allotted time, that the instructors were good communicators (86.1%), and that the material were presented in an organized manner (84.6%). The instructors were knowledgeable on their topics (87.7%). Respectively 84.6 % and 81.6% would be interested in attending a follow-up, more advanced workshop on this same subject for mammals and poultry conservation. 58,5% of the trainees found the workshop duration too short, while it was termed as of introductory or intermediate level by 47.7% and 43.1% of attendants respectively.

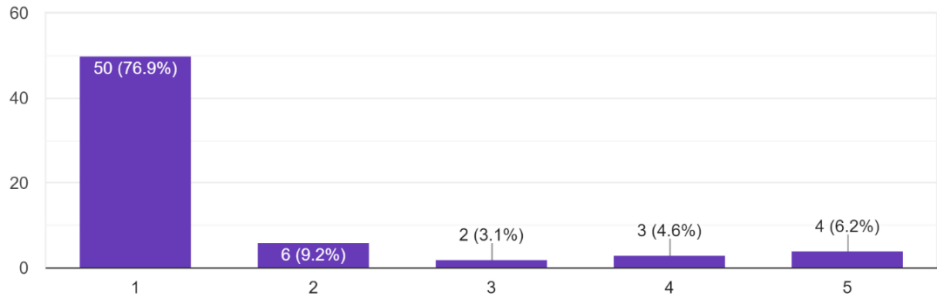
The workshop was applicable to my job

65 responses



I will recommend such workshops to donors

65 responses



I will recommend such workshops within the regional gene banks

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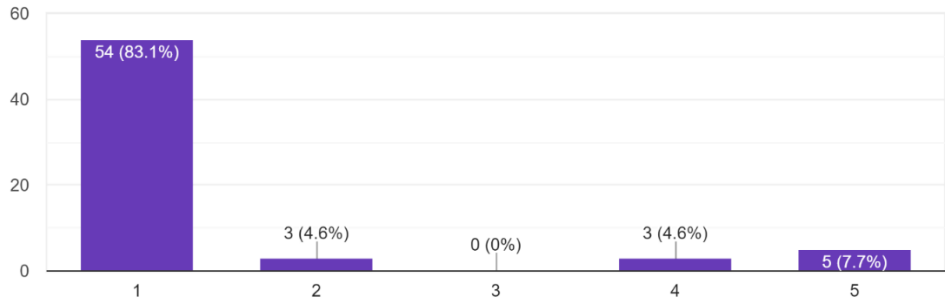

I will recommend such workshops for specific breeds communities of practice

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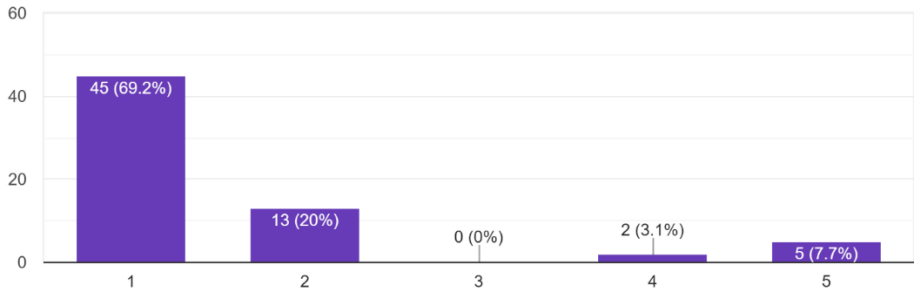

The program was well paced within the allotted time

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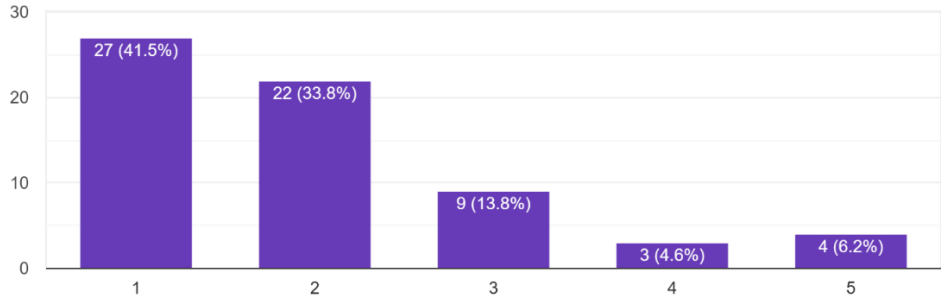

The instructors were a good communicators

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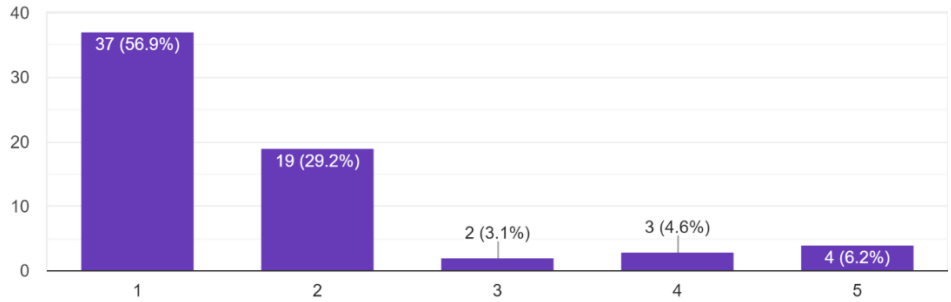

The material were presented in an organized manner

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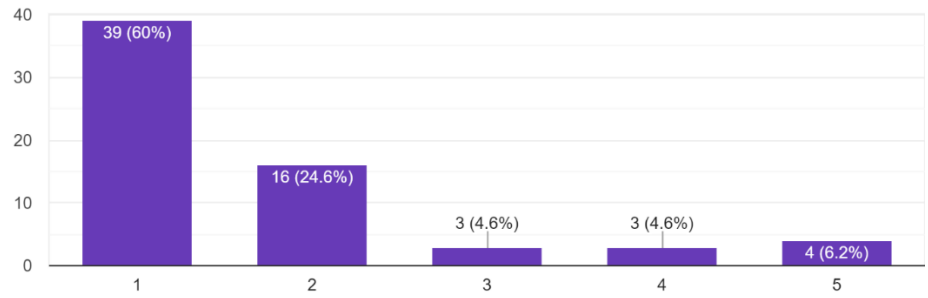

The instructors were knowledgeable on their topics

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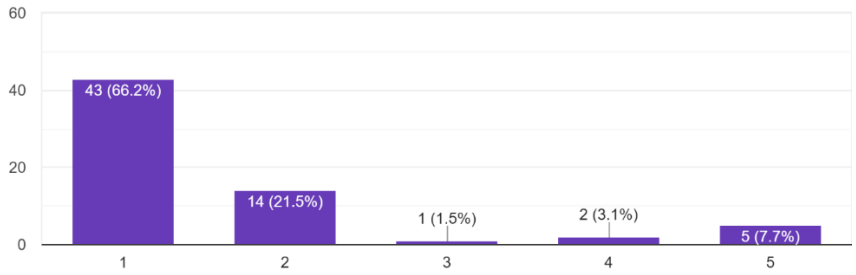
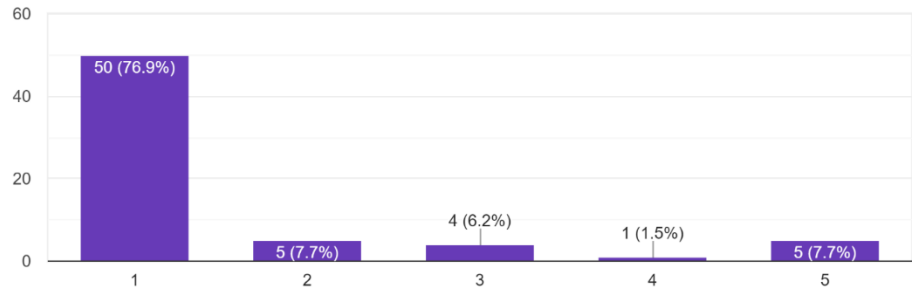


I would be interested in attending a follow-up, more advanced workshop on this same subject for mammals conservation

65 responses



I would be interested in attending a follow-up, more advanced workshop on this same subject for poultry conservation

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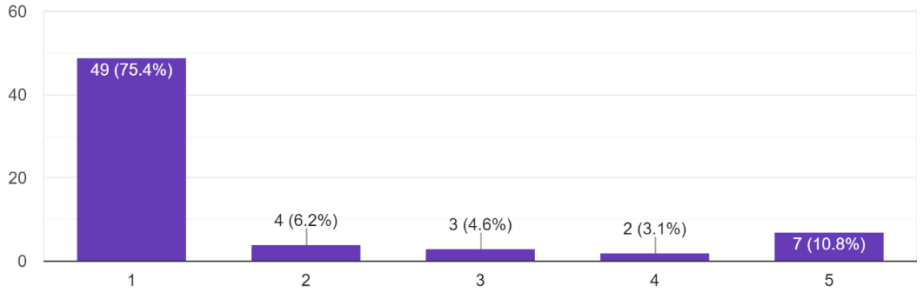
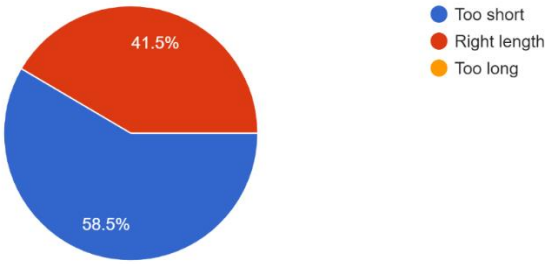


Given the topic, this workshop was

65 responses



In your opinion, this workshop was

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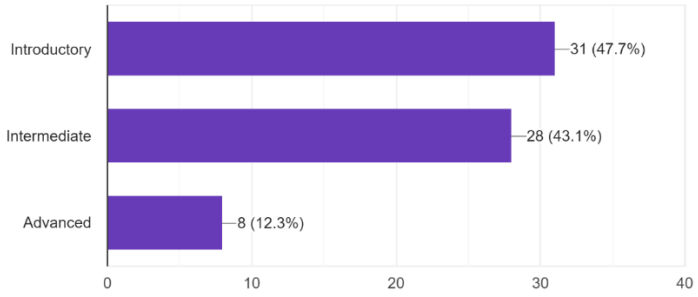
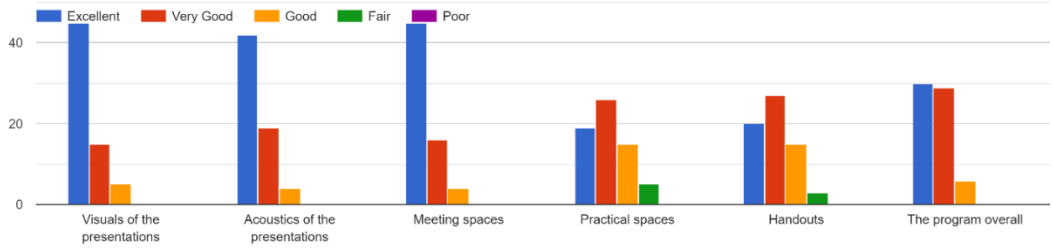


Please rate the following



On the question on What did a trainee most appreciated/enjoyed, or thought was best about the course? and suggestions for improvement? the answers were of broad range and could be bulleted as follows:

- Personal care and respect, the unity on African countries coming together in something to help the future generations in terms of preservation of animal genetic and i would like to thank AU-IBAR, ILRI and KAGRC for bringing us together from west, east, south and north with an aim of conservation of animal genetic,
- Most appreciable is the Organization, best communications, the atmosphere in which this training took place, the explanations and the exchanges
- All purpose or objectives of workshop we well organized and well implemented and instructors were good in teaching.
- The novel solution to the conservation of Poultry genetic resources: use of Primordial Germ Cells methods is wonderful, practicals improving our capacity
- I appreciated the technologies used for conservation PGC of poultry and semen for mammals
- To know the fact that genetic organs of a chicken can be preserved through this interesting method. To learn about the use of electro ejaculators to collect semen from a bull and to learn about how semen is processed until stored in liquid nitrogen.
- The best of the training was for me, the trip to the Insemination Center (KAGRC) where we were in direct contact with the animals and the seed treatment and conservation laboratory.
- IA programme at KARGC and Primordial germ cell at ILRI. The PGC extraction and related technology which was new for me
- Interaction and networking between trainers and trainees
- The quality of the training, the scientific information obtain from the tutorials/presentations and laboratories was high
- I enjoyed the semen analysis and processing, but I think next time more time should be given for practical.
- The competency of all presenters and the ability to cryoconserve indigenous African chicken
- The training was very well organized. The course was well structured and the instructors well very knowledgeable, The contents were meant to address our felt need problems
- I appreciated human resources cares and their manner of explanation shows that they do what you know.
- Very active participants
- The practical aspects and discussions

- Very useful to discuss practical problems, interactive, very useful practical approaches. role play and discussion in small groups.
- The practical sessions were precise, elaborate and to the point
- Participants were given an opportunity to share their field experiences. This aspect enriched the training program
- I have appreciated and enjoyed the new technologies in poultry germplasm collection and conservation. also liked the technics being used in cattle semen collection, processing, packing and storage.
- I really appreciated the behavior of the organizers, mainly the sense of cooperation.
- The facilitators were very capable

Suggestions to improve:

- I suggest that for the coming courses the practical session should take a bigger part because it is the best part that we all learn by practice and understand
- There is a need to call different people from the same country not only focal point or coordinator.
- The practical will be done by participants too. because we need it to go to our country and practice and teach these technologies
- if you can send a translator so that the different courses are more interesting
- the lab was small, the number of people during practicals should be reduced to size of space in a laboratory
- assign more practicals time for the PGCS
- Suggestion is to increase time because this was like just introduction and time was limit.
- Ma suggestion est de proposer la traduction en français
- I suggest more practical sessions
- For future training, more time should be allocated for the training to enable trainees have hands-on experience of the techniques being shared
- More practical on semen collection, treatment and AI
- It will be nice during workshop to provide to participants documents explaining different lab procedure we want teach. This will make course clearer and followable
- The sharing of the various on-going conservation activities in the region by different countries.
- Start a single subject during the training, give more time to brainstorming sessions between countries
- To improve the progress of the next events, I propose to send the program to the participants and especially if they will present something so that the presentation will be up to the event
- cryoconservation of AnGR with germplasm was a very interesting topic for me. I think that should be extended to other species and not only poultry

When asked to describe the top two topics they would like to learn more about in the next 12 months, the participants responses could be summarized as follows.

Most common First choices:

- Cryoconservation of African Animals Genetic Resources (chicken and *Numida meleagris*)
- Mammal ex situ conservation with embryo transfer

- PGCs collection process, poultry germ plasm collection, processing, conservation, re-introduction and utilization
- Application of these technics to effective Animal breeding and conservation.
- in-depth isolation of primordial germ cells (PGC) and know the characterization of gene of high interests
- Reproductive Health in Livestock: Impact on Productivity and homeopathic solution.
- Legal framework in genetic conservation
- Automatic semen processing
- animal reproduction and genetic improvement (bovine)
- Collection of PGCs and injection of the PGCs into the host
- Molecular characterization, conservation and re-introduction of genes of interest
- Run breeding and improvement by selection programs in developing countries
- Management of Data bases on AnGRs

Most common Second choices:

- Semen collection and processing.
- Using in situ management to conserve biodiversity under climate change
- Decision tools for family livestock/poultry development
- Cryo conservation of avian(poultry) species and conservation of non-conventional animals.
- practice of artificial insemination, genetic data collection and statistics.
- Practice of poultry sexing
- fish and bee reproduction and conservation in Africa
- Practical work on characterization of animals on the field and protocol used in A.I
- Monitoring embryos with new PGCs
- More Practical Training on Cryopreservation of Primordial Germ Cells
- Nitrogen liquid plant management
- Embryos production and transfer in mammals
- PGCs technologie and cryoconservation on other species,
- Genomics technologies of conservation
- management of genbank/ Tools necessaries for setting up and security of genbank
- Cryopreservation of chicken semen.
- Semen collection from goats and sheep and further processing to storage in the liquid nitrogen tanks.
- Organisation and motoring of an AnGR gene bank
- Automated gene-banking operations; Collection and transportation of samples for gene banking; Genomic characterization of indigenous AnGRs; Semen collection, processing and Artificial insemination in Small Ruminants.
- How to use stored genetic material from genebank
- How to know which species is disappearing
- Cattle, sheep and goat selection, breeding and genetic improvement and conservation

WHAT IS THE STATUS OF YOUR REGIONAL GENEBANK: WEAKNESSES?

- Lack of Funds, legal texts and programs, and limited specialists in gene banks

- Lack of professionalism in decision making at national or regional level (most of our leaders do not see importance of this)
- There is not well-organized SOP operating
- The future funding of the gene bank is not well known as the project phases out
- No proper channel of communication among the member states of the gene bank.
- facilities need rehabilitation
- Not all animal or breeds are preserved
- the delay in the delivery of equipment, or no equipment
- I was not aware of the existence of the regional gene bank, No sharing of information about the update of genebank with the member countries
- Unaware of the status.
- No synergy with National centres (case of Nigeria National Centre of Genetic Resources and Biotechnology, FMST, Ibadan, Oyo State)
- No implementation of ABS regulations guiding AnGR
- No in-situ conservation programme for the breeds exploited
- We don't have one yet
- It has not been strong in developing partnerships and networking activities, there has not been a lot of cooperation with local or regional RGA or universities
- Absence of network made up of national focal points on the setting up genebank activities
- Lack of advocacy with government on the obligation of setting up of national genenank
- Inadequate operationalization of gene banks
- Lack of electricity, Lack of liquid nitrogen production unit
- It still at the setting point with limited resources
- Lack of coordination among the countries of the region; Lack of permanent staff to run the genebank, Lack of database in Genebank.
- New launched/non communication to universities and research center of those countries
- Unpredictable funding options to sustain the gene bank.
- No clear policies and guidelines on sending materials to gene banks and the assurance of safe keeping at regional gene banks.
- No Political will among the member states and is not guaranteed
- Not yet functionning
- Capacity building is inadequate among technicians for operation of the gene bank.
- The gene bank was assigned to a person who do not know exactly the importance of Genebank for the region, and has personalize it
- Member countries lack the facilities to collect and ship materials to regional gene bank
- The institutional and human resource capacity to properly utilize and conserve the country's animal genetic resources is very limited.
- Diagnosis of diseases and pathogens prior to conservation is totally ignored yet its key to preserve disease free germ plasm
- SOPs need to be standardised across the region; The regional gene bank needs to embark on full automation of the gene bank operations.
- Management system not defined
- Lack of appropriate legislations.

SUGGESTED IMMEDIATE ACTIONS TO BE TAKEN

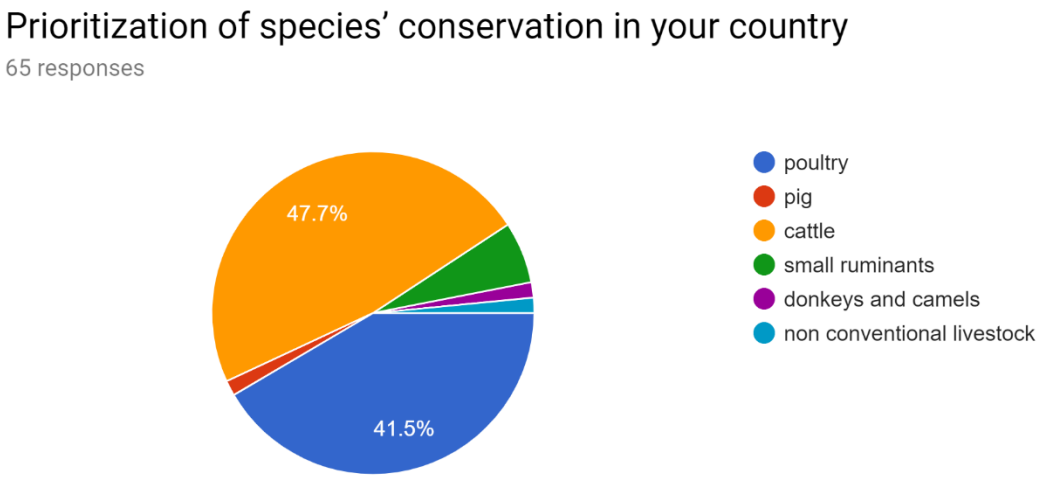
- Organize targeted training in the five gene banks and take that opportunity to upgrade them, reorganize the management and assign tasks to competent persons
- Go back to the policies and remind them of the assets of this bank and involve other countries of the region
- Funding for data collection (sample to be stocked), help in inventory and characterization of animal genetic resources and populate AAGRIS
- Staffing should be developed with capacity building.
- disseminate Technic of AnGR in the community.
- Create mini gene banks for countries
- Equip more personnel and add more gene banks to enhance maximum conservation of animal genetic in the gene bank.
- development of regional programs and legal texts
- Facilitate meeting of the appropriate officials including the Directors/CEOs for briefing of the goals of the regional gene banks
- Assist countries in the implementation of the regulations of ABS guiding AnGR
- Training the different regional actors on bio-banking. Also giving the information about the existing of the regional biobank to all countries
- Setting up of AnGR and genebank network and make sure of their operationalization
- Each country should have a focal point, and there should exist a national body which governs the bank, It should be accessible for every member of the sub-region
- A national coordination within each country, and a regional coordination engaging all countries;
- Stakeholders engagement and defining priorities at national and regional level for breed conservation
- Implement ascendant en descendant information within the region ;
- Create policy for commercialization of gene bank resources
- create a back-up biobank
- Accelerate the installation of materials and raise the awareness of member country of the regional GenBank.
- All member states should commit staff to the regional gene bank to satisfy her labor needs
- SOPs and other related quality assurance documents should be developed and harmonized within the member states as an effort to operationalize the gene bank
- Assess the capacities of member countries and harmonize it through the development of infrastructure and Human capacity
- Mobilization of Countries and stakeholders to contribute to the gene bank
- Harmonization of laws and regulations between partner states for access and transfer of genetic materials across borders
- Capacity development to undertake gene banking activities such as Embryo technologies, In vitro fertilization, and field genetic sample collection and processing,
- Strengthening collaborations between national, regional and international institutions to effectively manage the animal genetic resources in the region.
- Create an ad hoc committee for advocacy to the governments to solicit their engagement.

- Increasing awareness of breeders to conserve local breeds suitable for northern African climatic changes
- APRI collaborate with universities & research centers to offer AnGR conservation in their training programmes.

PROPOSED ACTION FOR RATIONALIZATION OF THE SYSTEM AND REGIONAL COORDINATION OF THE GENE BANK FOR ANGR CONSERVATION

- The different countries must be truly involved.
- There should be the organizational structure to perform different rules so as ensure that everything is in place.
- all stakeholders of regional gene bank involved in the program of AnGR
- make policy and laws within Africa about how all the gene bank can be used by all country without restriction.
- One Focal Point per country.
- Implementation of the ABS regulations guiding the AnGR for facilitation of exchange of animal genetic material
- Engage the Directors/CEOs of such centres and discuss goals and strategies
- develop Procedures for harmonizing gene bank operations and rationalizing collections; Conservation and reproductive biotechnologies; A central information system to connect available data on germplasm and genomic collections
- Tuning at regional level as programm on AnGR conservation and a projet in all the states.
- Create markets and promote AnGR on restocking and stocking activities
- Establish regional advisory committee, national coordinators,
- The manager and coordinator should not be from the country hosting the gene banks
- Give the information of gene bank to all member
- Coordinators from member countries to spearhead the operations of the gene bank.
- Strengthening of breeders societies
- Should give technical backstopping to the national gene banks in the region
- Need for development of the staffing structure
- supporting national breeding and conservation programs
- Establishment of National Coordinators for proper operation of the Regional gene Bank. Formation of protocols for the proper running of the Regional Gene Bank.
- AU-IBAR should assist member states to acquire a center for the collection of germplasm develop a common protocol for transfer of material to the regional gene bank through infrastructure and capacity development
- AU IBAR have to visit the Regional Bank and have a clear picture of the investment made
- There is need to form governance structure for effective management of the regional gene banks.
- Rotating coordination of the management between states
- Present To all members the person in charge of the gene bank in our sub-region
- Establishment of the Regional advisory/coordination committee on AnGR to guide and oversee the operations of the Gene Bank.
- Develop procedures for harmonizing gene bank operations and rationalizing collections; Conservation and reproductive biotechnologies;

- A central information system to connect available data on germplasm and genomic collections
- Regional project to establish a system of gene banking in member countries that will harmonise all systems and procedures for transfer of genetic resources to the regional gene bank
- Establishing gene banks and application of AnGR conservation practices specially, cryo-preservation. Also, Molecular genetics techniques.



WHAT IS YOUR STRATEGY TO ENCOURAGE ANGR GERMPLASM CONSERVATION?

- To mobilise funds and strengthening collaboration and capacity building .
- Setting priorities for AnGR conservation requires a process that enables the identification of breeds that contribute most to global genetic diversity and have the greatest potential to contribute to efficient future utilization and further development of that diversity.
- Identification of in danged species for preservation and form the association which will dill with such conservation
- income generation
- Inclusion in postgraduate training
- concerted management, involving the policies to this methods and encourage farmers to conserve their breeds locally
- To organize awareness workshops to show the reality of erosion, show the need for conservation, show the importance of conservation. Also make publications (articles) on the situation of conservation in the country
- Encourage the practice of in situ conservation, Involvement of all relevant stakeholders, provide incentives to breeders who hold endogenous breeds, establishment of national gene bank, the local community should be encouraged and sensitized to promote in situ conservation and community base breeding pprogrammes
- Inclusion of threatened species in museums Support indigenous and local production systems and associated knowledge systems
- Branding and value addition, creation of market linkages for indigenous breeds. Dissemination of research-based information that will make economic sense to farmers for the purpose of promoting indigenous breeds.

- support local production system and breeds association
- Creation of niche market for products from local genetic resources
- encouraging both In-situ and ex-situ conservation, Development of appropriate breeding programs for indigenous AnGRs, Branding of products from indigenous breeds, Fostering and facilitating the formation of breeders' associations for indigenous breeds, Inclusion of threatened species in museums, Support indigenous and local production systems and associated knowledge systems
- implement restocking programs.
- Identification of animals and seed production and conservation and creation of computer applications for storage and management of zoo genetic resources
- First of all, it is necessary to train the researchers for the germpasm conservation technique. then to provide the necessary scientific equipment for the application of the technique and finally the mobilization of research funds to set up a national program for the genetic conservation of avians using the germplasm technique.
- In situ and ex situ invitro conservation

WHAT DO YOU THINK ABOUT REGIONAL BIOLOGICAL LIBRARIES AND DIGITAL FORMATS

- it is good initiative, a must establishing one to facilitate researchers
- Development of software for storage of information and which will be accessible to all members states
- very important to conserve and for best utilization of our biodiversity
- Well, I think that's where we should start before looking for what species can be resilient or adaptable and productive in our different regions.
- it is indispensable and practical
- Develop journals and develop protocols
- Is the way to go with adequate capacity development
- It is very important for the storage of data
- It has to be accessible and supplied by the different members
- A data base program will be form where all information will be fill and kept for future use
- Create the regional data base and bioinformatic platform
- They need to established in all 5 regions in the continent
- Should be prioritized
- Digitizing and creation of a repository platform that is accessible to all member states Developing a regional inventory/documentation software Capacity building on the use of digital platforms for data storage and management
- Highly recommended
- Capacity must be developed accompanied by the creation of a digital platform for REC to assist in digital information sharing.
- Strengthen the collaboration between members, collection of data and improve and train users of digital platform
- They have not been done on a larger scale and therefore their use must be improved
- It's good approach to storing genetic information
- Developing a regional inventory/documentation software, Capacity building on the use of digital platforms for data storage and management

- They should develop a regional inventory /documentation software
- I think they are important for present and future of research and development and utilisations of AnGR
- There is need to build capacity of scientists in the region to undertake data collection, management and repository; Creation of a repository platform that can be accessed by all member countries in the region.
- Some recent works related to conserve AnGR were done in the level of molecular genetics & published on NCBI
- There is need for collaboration and sharing of information in the region for the benefit of all member states and global.
- Essential for research and development

WHAT COULD BE YOUR BEST STRATEGY FOR FUNDING OF GENE BANKS, THEIR SUSTAINABILITY AND RELIABILITY

- Advocacy to convince governments on the importance of this. (Leaders need vusual vidences)
- Procedures for harmonising gene bank operations and rationalising collections
- Privatisation with utilisation will easily drive funds. Premium need placed on local germ plasm
- Close monitoring of the management of the gene bank, Proper policy guiding the gene bank.
- development of regional programs and legal texts
- involve the policy of the country and to tell the importance of the gene bank, for governments to take responsibility and help
- The AU must adopt a law to encourage each country to assign a budget in order to the management of the regional genebank
- Establish the genes banks as technical agencies of AU or centres of excellences for livestock development
- Regular fund call application for the country member states which should be honored, no country should be deprived of the opportunity.
- Member state contributions.
- Mobilize more resources from national and régional programs and promote PPP
- Commercialization of the products from the bank
- Developing proposal for funds at regional level
- services delivery (liquid nitrogen sales, support to PPP for breeding programmes, etc)
- open the bank to wildlife NGOS who could pay for services
- Incentives to the farmers involved in the conservation
- Develop a communication strategy that will enhance visibility to attract collaborations
- Securing research and development grants for the regional gene bank
- Diversification of services : Artificial insemination, commercialization of Liquid Nitrogen, training of scientist, Wildlife germplams conservation with NGOs inputs,
- Securing research and development grant for the regional gene bank
- Develop proposal and mobilize fund
- Encourage donations
- Public Private Partnership where individual farmers can bank their highly prized livestock in the gene bank
- Write regional project to be funded by international institution and donors

- Establishment of the regional benefit sharing fund to ensure the sustainability of the gene banks by the member states. This can be achieved by having a resource mobilization team for the Gene banks.
- The best financing strategy is to ask different regional research development agencies to fund the genbank budget each year, with support from the African Union.
- Sell genetic resources to requesting structures or countries
- By collaboration with another research centre's.
- Collaboration between ARC, NRC & some universities on MOET (buffaloes to solve difficulties in In Vitro fertilization).
- International funding research projects
- gene banks should be owned and funded by governments through annual budgets. AU should play the role of sensitization.
- I think the Gene Bank must be mandated to receive sustainable and fixed national funding, such as core funding. This does not preclude trying to bring international funds for research and development.
- To be funded by international organizations

CONCLUSION / RECOMMENDATIONS

From various perspectives, the workshop was said to be a success on which to building future livestock genetic actions for Africa, a special request came from northern Africa whishing to have more interaction and collaboration with ILRI for the livestock development programmes and capacity building.

POSSIBLE FOLLOW-UP

- Regional discussion forums (five regional gene bank WhatsApp groups) have already been establish and are operational, discussing the progress and way forwards for the effective operationalization of the gene banks, as well as the setting of the ABS mechanisms
- Regional targeted trainings on poultry and mammals cryobanking and ABS platform establishment should be implemented soonest to build on the assets

APPENDICES

a) Workshop programme

b) List of participants

c) Presentations

d) Any other relevant information