Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Animal Production & Health Newsletter

https://www.iaea.org/about/animal-production-and-health-section
https://www.fao.org/agriculture/fao-iaea-nuclear-techniques/en/

ISSN 1011-2529

No. 80, July 2024

Contents

To Our Readers

Beyond Deserts and Highlands – Global Celebration of the International Year of Camelids, Vienna, 10 June 2024 (IAEA, 2024)

Animal and zoonotic diseases outbreaks are increasing in frequency because of climate change, natural disasters, and wars. Coupled to this has been the observance of disease pathogens and associated outbreaks spreading into new and previously non-endemic zones and species affected. This has been the case with African Swine Fever (ASF) and Peste des Petits Ruminants (PPR) spreading into new and previously non-endemic regions and of Highly Pathogenic Avian Influenza (HPAI) that has been seen to affect new species including cattle.

During this first half of 2024, the Animal Production and Health Section (APH) of the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture continued with its efforts to increase (i) its own capacity in early and rapid

disease detection and surveillance through research and development and (ii) transferring this capacity to laboratories in Member States (MS) for them to be more capable and better prepared to tackle the challenges of emerging and reemerging diseases and the associated outbreaks. The laboratory has increased its knowledge and capacity to utilise nuclear and molecular technologies and their application in disease detection, characterisation, and surveillance. Multiparametric methods, next generation genome sequencing technologies are becoming routine technologies the APH are using to support MS in mitigating the effects of transboundary animal and zoonotic diseases. During the last six months the section assisted MS in managing diseases such as ASF and HPAI through providing support with detection methods and training of laboratories in MS.

Through the Veterinary Diagnostic Laboratory (VETLAB) Network, laboratories have been assisted in setting up next generation sequencing platforms and received training to update their diagnostic methods for HPAI outbreaks. The section, and through IAEA Technical Cooperation projects, trained participants on post flooding disease detection and control methods and strategies or other natural and man-made disasters as in the case of Ukraine. To support the PPR disease global eradication program (GEP) aimed at eradicating PPR by 2030, APH assisted MS with detection methods and training to build laboratory capacity and in R&D for vaccines. There are growing concerns over antimicrobial resistance (AMR) particularly in livestock production systems. Through the new coordinated research project and additional research in the laboratory, APH is conducting research and development to optimise sampling techniques and antimicrobial resistance profiling techniques that will facilitate comprehensive profiling of the extent of AMR in livestock production systems. Overall, the ongoing IAEA flagship ZODIAC initiative and VETLAB Network programme continue with their efforts to develop and disseminate tools for early and rapid detection, characterisation and surveillance of animal and zoonotic diseases, build networks amongst MS and support them to be better prepared to tackle disease outbreaks and pandemics.

APH continues with both R&D and technical capacity building in MS for animal nutrition, assisted reproductive technologies and animal breeding and genetics. Online bioinformatics courses were provided to MS to increase their capacity to use genomics and bioinformatics in the characterisation and improvement of indigenous and local genetic resources. In the laboratory and in collaboration with MS, APH is conducting research on cryopreservation techniques for semen, which will support the use of artificial insemination and other assisted reproductive technologies in livestock species such as llamas. Activities in animal breeding and genetics and assisted reproductive technologies will complement and support the implementation of the Global Action Plan on Animal Genetic Resources in FAO/IAEA MS.

APH together with the rest of the division undertook activities towards resource mobilisation and implementation of the Atoms4Food initiative. APH will, through this initiative, contribute to improved and sustainable food production through improved reproduction and breeding and control of animal and zoonotic diseases. R&D, support and capacity building for the application of nuclear and related technologies for sustainable animal production and improvement in MS will be used to achieve these goals.

The United Nations declared 2024 as the International Year of Camelids seeking to highlight the role of camelids in global food security, sustainable agriculture, and the preservation of cultural heritage. APH joined the global community and hosted a 1-day open event during which the academic and research community shared and discussed the status in respect to research and development in camelid production systems, diseases and health management and biodiversity and breeding. In addition, there were panel discussions on advances and gaps in advancing camelids to address challenges of climate change, food and nutrition security and as custodians of cultural heritage.

I would like to end by welcoming Ms Yuetong Ma who joined APH during this period and I acknowledge her valuable expertise and the additional capacity towards APH subprogrammes.

Farai Muchadeyi

Head, Animal Production and Health Section

Vienna Daughters' Day 2024

Bharani Settypalli, Taichiro Takemura, Bo Liu, Richard Kangethe

Now in its 15th year since inauguration, the IAEA opened its doors for the daughters of staff members on the 25 April 2024 with girls between the ages of 11 and 13 years directly interacting with APHL staff members in two different groups. The girls learnt about how APH uses nuclear techniques such as radiation hybrid mapping and progesterone radio immune assays for livestock breeding, stable isotope tracking of wild-bird droppings and feathers to identify zoonotic diseases such as Avian influenza and the development of irradiated vaccines as an alternative to traditional livestock vaccines. Demonstrations on how APH assists member states to respond to disease outbreaks using an emergency toolbox and how to protect clinical livestock workers in the field with PPE (personal protective equipment) were also carried out. The girls were able to ask various questions on issues ranging from animal testing to the impact of global warming on the spread of emerging zoonotic diseases. Overall, both sessions from the visiting groups were highly interactive, giving the staff members involved fresh insights into the impact of their work to general society.

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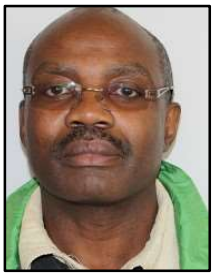
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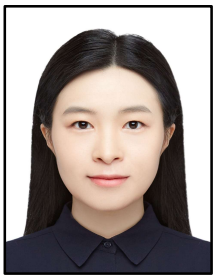
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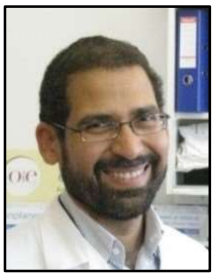
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VETLAB Network Bulletin

02/2024

VETLAB Highlights

VETLAB Assists Mozambique in Diagnosing First Avian Influenza Outbreaks

Mozambique, which experienced its first outbreak of avian influenza in October 2023, sought help from VETLAB to identify the virus responsible for the outbreak. VETLAB promptly supplied the necessary reagents, allowing the Central Veterinary Laboratory in Maputo to diagnose and characterize the H7N6 virus. This timely diagnosis enabled Mozambique to report the outbreak to the World Organisation for Animal Health (WOAH). Collaborating with the FAO regional office in Mozambique, the WOAH/EU, and the National Reference Laboratory for Avian Influenza & Newcastle Disease in Padova, Italy, VETLAB facilitated the full genome sequencing of the virus. The sequencing, conducted by the Animal Production and Health Laboratories (APHL), revealed that the Mozambican H7N6 virus closely resembled avian influenza viruses identified in the Republic of South Africa in May 2023, suggesting a common origin. This significant work has been published in the journal Emerging Microbes and Infections (https://doi.org/10.1080/22221751.2024.2321993).

Detection of Bovine Papular Stomatitis in Lumpy Skin Disease suspected outbreaks in Tanzania

Lumpy Skin Disease (LSD) and Pseudocowpox (PCP) are viral pox infections of cattle where similarities in their clinical presentation often lead to misdiagnosis in the field. Even though LSD exists in Tanzania, it has never been confirmed; while PCP has never been reported. In 2023, the Tanzania Veterinary Laboratory Agency (TVLA) and APHL investigated LSD outbreaks in Tanzanian cattle herds. They used a high-resolution multiplex melting assay to differentiate poxviruses, characterizing capripoxvirus (CaPV) and parapoxvirus (PPV). 91% of the samples were positive for LSDV and 9% PCPV positive. Phylogenetic analysis revealed that all targeted LSDV genes showed 100% similarity with commonly circulating LSDV field isolates. Furthermore, sequence analysis of the partial B2L gene of the Tanzanian Bovine Papular Stomatitis Virus (BPSV) showed the circulation of a different BPSV strain compared to publicly available sequences. The study confirms the presence of LSDV and establishment of BPSV in Tanzania, highlighting the importance of differential diagnosis of pox diseases.

National Training Workshop on Diagnosis of Contagious Bovine Pleuropneumonia (CBPP) at National Veterinary Reference Laboratories-Kabete (NVRL Kabete), Kenya

Recently, NVRL Kabete primarily relied on serological methods with limited diagnostic capacity to confirm CBPP outbreaks. To enhance the country's ability to effectively prevent and control the disease, strengthening the diagnostic capacity by training NVRL laboratory personnel and introducing modern techniques such as PCR tests was deemed crucial. From March 4th to 15th, 2024, the World Organisation for Animal Health (WOAH), in collaboration with the Botswana National Veterinary Laboratory, conducted a two-week training workshop. This workshop, aimed at enhancing the skills and knowledge of 25 laboratory personnel in diagnosing Contagious Bovine Pleuropneumonia (CBPP), covered sample collection, sample handling, and serological and molecular testing methods for CBPP.

Project for the Acceleration of Livestock Revolution in Thailand

The National Institute of Animal Health (NIAH) has been actively collaborating with the Japan International Cooperation Agency (JICA) on a project titled "The Project for the Acceleration of Livestock Revolution in Thailand, aiming to be the Kitchen of the World through the Development of Novel Technologies for Stable Livestock Production and Food Safety". This initiative has provided state-of-the-art equipment and expertise to NIAH and has strengthened laboratories across all nine regions of Thailand's Veterinary Research and Development Centre (VRDC) and the Regional Reference Laboratories for Southeast Asia (RRL-SEA). Comprehensive training on novel technologies, such as Nanopore sequencing and Pico gene analysis, has been conducted. This five-year project is expected to significantly enhance livestock production and food safety, positioning Thailand as a leading global player in the livestock industry.

Myanmar Detects and Characterizes African Swine Fever Virus in Recent Outbreak Samples (2022-2023)

VETLAB supported Myanmar in characterizing the circulating African Swine Fever (ASF) virus from 2022 to 2023 by providing standard operating procedures (SOPs), reagents, and genome analysis of field isolates, enabling the Yangon Veterinary Diagnostic Laboratory to detect and report the disease to local authorities. The subsequent characterization of the isolates, in collaboration with the Animal Production and Health Laboratories (APHL), revealed that the ASF virus isolates from Myanmar belong to genotype II, based on the analysis of the p72 and p54 genes, and serogroup 8, based on the CD2v gene analysis. This result confirms the persistence of ASFV genotype II in the country and the absence of recombinant ASFVs in the analyzed samples.

Successful Completion of the WOAH Rabies Twinning Project

The WOAH Rabies Twinning Project, a collaboration between the Agricultural Research Council (WOAH Rabies Reference Center, South Africa) and the Animal Health Institute (AHI, Ethiopia), was successfully completed in December 2023. The project culminated in a closing workshop and the launch of a new rabies laboratory, held from January 23-25, 2024, at AHI in Sebeta, Ethiopia. The establishment of this new rabies laboratory through the WOAH Twinning Project is expected to have a significantly positive impact, playing a crucial role in controlling and preventing the spread of rabies in Ethiopia.

To the Readers

The Veterinary Diagnostic Laboratory (VETLAB) Network remains committed to enhancing member states' laboratory capability to combat transboundary animal and zoonotic diseases. It offers advanced pathogen detection and monitoring techniques, which can be implemented in laboratories in various member states worldwide, especially in low- and middle-income nations. VETLAB Network stands out for its commitment to support ongoing research and development, which aims to ensure the long-term viability of laboratories by promoting the use of cutting-edge technologies. The publication of high-quality research in reputable journals demonstrates how member states might incorporate sophisticated technologies for pathogen identification. An example of this is the National Institute of Animal Health (NIAH) located in Bangkok, Thailand. These advanced laboratories can provide assistance to both the national network of diagnostic laboratories and other laboratories in the region. With the impact of climate change, pathogens are spreading to wider geographical areas. We also are concerned about pathogens infecting new types of hosts, e.g., recent cases of Highly Pathogenic Avian Influenza (HPAI) being detected in cattle. Given these circumstances, it is necessary to improve existing pathogen identification protocols or develop new, globally applicable ones. The VETLAB Network will guarantee the implementation of technological progress in this field and its dissemination among its members.

VETLAB
Network Bulletin

VETLAB CAPACITY BUILDING AND NETWORKING ACTIVITIES

VETLAB Network Laboratories Spotlight: National Institute of Animal Health (NIAH), Bangkok, Thailand

Technology Development for Pathogen Detection and Surveillance

The National Institute of Animal Health (NIAH) in Bangkok is at the forefront of technological advancement in pathogen detection and surveillance. With IAEA support, NIAH is integrating Next-Generation Sequencing (NGS) technologies, such as MiSeq and Oxford Nanopore, into its diagnostic workflows, aiming for more accurate identification and characterization of pathogens. These advanced technologies facilitate comprehensive genomic studies, improving the detection of emerging and transboundary animal diseases.

NIAH also leverages artificial intelligence (AI) in veterinary diagnostics. AI enhances literature reviews, generates innovative research ideas, and analyses experimental data, helping researchers to quickly access and synthesize relevant studies. This not only saves time but also uncovers emerging trends and knowledge gaps, inspiring new research initiatives.

Through international collaborations and training, NIAH is poised to become a leader in veterinary diagnostics, supporting animal health, the livestock industry, and food safety through innovation and excellence in veterinary science.

Support to National Laboratory Network and Neighbouring Countries

NIAH leads various training programs to enhance veterinary diagnostic capabilities.

In April 2024, NIAH organized a workshop on using Qubit 4 and E-gel electrophoresis for DNA sequencing with Illumina and Oxford Nanopore technologies, supported by the IAEA's ZODIAC project. This training aimed to enhance molecular research skills, particularly in NextGen sequencing for transboundary and zoonotic diseases.

In December 2023, NIAH hosted a practical training session on Bovine Spongiform Encephalopathy (BSE) diagnosis, teaching officials from Myanmar about diagnosing BSE using simple techniques. The National AMR Surveillance (NAS) Workshop in October 2023, supported by the European Union, focused on improving Thailand's capacity to monitor antibiotic resistance in livestock, involving various labs and sectors to create a roadmap for NAS in livestock for 2023–2027.

NIAH actively participates in international training programs to maintain and upgrade staff knowledge. These include workshops and training sessions on NGS and bioinformatics in Morocco, Austria, Bangladesh, and Kuwait, focusing on early diagnosis and pathogen characterization of transboundary diseases.

These initiatives underscore NIAH's commitment to advancing veterinary science and ensuring the health and stability of livestock populations through innovative research and technological development.

Vaccine Development

NIAH is actively developing vaccines to combat various animal diseases, including Foot-and-Mouth Disease (FMD) and Lumpy Skin Disease (LSD). Significant progress has been made in creating an intranasal vaccine for FMD, targeting serotypes O and A. This innovative vaccine stimulates both mucosal and systemic immune responses, providing enhanced protection through the generation of bovine-specific IgA and IgG antibodies.

For LSD, NIAH has developed an autogenous inactivated vaccine derived from the NIAH-991.2 strain, which shows robust immunogenicity and complete protection against virulent challenge strains. Additionally, NIAH is working on a live-attenuated LSD vaccine, focusing on understanding the virulence of recombinant strains and assessing vaccine efficacy through molecular and serological analyses.

Forthcoming Events

Coordination Meeting of the Veterinary Diagnostic Laboratory Network (VETLAB Network) with Directors of African and Asian Veterinary Laboratories, 19 to 23 August 2024, Vienna Austria

The event aims to update partners on the activities of the VETLAB Network and discuss the main challenges and gaps in diagnosing animal and zoonotic diseases

Training Course for Veterinary Diagnostic Laboratory (VETLAB) Network Partners on the Detection and Characterization of Pathogens Causing Major Transboundary Animal Diseases and Zoonoses, 16 to 27 September 2024, Seibersdorf, Austria

The course aims to enhance the capacity of partners in the VETLAB Network to utilize nuclear-derived/molecular assays to accurately detect and characterize pathogens associated with major transboundary and zoonotic animal diseases. The event will also focus on vaccine quality assessment and serological assays for disease control.

Training Course for Veterinary Diagnostic Laboratory (VETLAB) Network Partners on Next Generation Sequencing and Nanopore Sequencing Applications for the Detection and Characterization of Pathogens, 18 to 29 November 2024, Seibersdorf, Austria

The course aims to enhance the capacity of partners in the VETLAB Network to apply new sequencing technologies and relevant bioinformatics tools for the direct detection, characterization, and molecular surveillance of major pathogens causing transboundary animal diseases and zoonoses.

Impressum VetLab Network Bulletin No. 17 • Edited and designed by the Animal Production and Health Section, Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture • International Atomic Energy Agency • Vienna International Centre, PO Box 100, 1400 Vienna, Austria • Printed by the IAEA in Austria, July 2024.

The H5N1 subtype of highly pathogenic avian influenza continues to infect domestic poultry, wild birds, and various mammals worldwide, causing increased concern among veterinary and public health authorities. For up-to-date expert advice and information on avian influenza please visit the OFFLU network website at www.offlu.org

Forthcoming Events

Coordination Meeting of the Veterinary Diagnostic Laboratory Network (VETLAB Network) with Directors of African and Asian Veterinary Laboratories

Charles Lamien

The purpose of the event is to update partners on the activities of the VETLAB Network, and to discuss the main challenges and gaps in diagnosing animal and zoonotic diseases, will take place at the IAEA Headquarters in Vienna, Austria from 19 to 23 August 2024.

The meeting will be held in parallel with the third research coordination meeting of the VETLAB coordinated research project (CRP) D32036 to allow interactions between the laboratory directors and the CRP experts and their critical assessment of the CRP process.

Third Research Coordination Meeting on Application of Advanced Molecular Characterization Technologies Through the Veterinary Diagnostic Laboratory Network (VETLAB Network) (D32036)

Ivancho Naletoski

The meeting is scheduled to take place will take place at the IAEA Headquarters in Vienna, Austria from 19 to 23 August 2024. The purpose of the event is to review the achievements of the coordinated research project and define the work plan for the next year of the project.

The meeting will be held in parallel with the Coordination Meeting of the Veterinary Diagnostic Laboratory Network (VETLAB Network) with Directors of African and Asian Veterinary Laboratories to allow interactions between the laboratory directors and the CRP experts and their critical assessment of the CRP process.

Training Course for Veterinary Diagnostic Laboratory (VETLAB) Network Partners on the Detection and Characterization of Pathogens Causing Major Transboundary Animal Diseases and Zoonoses

Charles Lamien

The training course for VETLAB Network partners on the detection and characterization of pathogens causing major transboundary animal diseases and zoonoses will take place from 16 to 27 September at the APH Laboratories in Seibersdorf, Austria. The purpose of the event is to enhance the capacity of partners in the Veterinary Diagnostic Laboratory Network (VETLAB Network) to utilize nuclear-derived/molecular assays to accurately detect and characterize pathogens associated with major transboundary and zoonotic animal diseases. The event will also focus on vaccine quality assessment and serological assays for disease control.

Training Course for Veterinary Diagnostic Laboratory (VETLAB) Network Partners on Next Generation Sequencing and Nanopore Sequencing Applications for the Detection and Characterization of Pathogens

Charles Lamien

The training course for VETLAB Network partners on next generation sequencing and nanopore sequencing applications for the detection and characterization of pathogens will take place from 18 to 29 November 2024 at the Animal Production and Health Laboratories in Seibersdorf, Austria. The purpose of the event is to enhance the capacity of partners in the Veterinary Diagnostic Laboratory Network (VETLAB Network) to apply new sequencing technologies and relevant bioinformatics tools for the direct detection, characterization and molecular surveillance of major pathogens causing transboundary animal diseases and zoonoses.

Past Events

Triangular Cooperation Agreement between IAEA, Lao PDR, Cambodia and Viet Nam Meeting

Carla Bravo de Rueda

The meeting was held in Hanoi, Viet Nam from 13 to 14 November 2024 to discuss and explore future joint activities on animal health and new IAEA technical cooperation projects 2026-2027 in line with the Triangular Cooperation Agreement (TCA) between IAEA, Lao PDR, Cambodia and Viet Nam. The three countries gave an overview of their animal health laboratories, considering gaps and strengths. Followed by round table discussion for exploration of future joint activities on animal health in line with the TCA. Jointly, an action plan was written for possible collaborative activities to be implemented in future projects within the framework of the TCA. The technical officer (TO) visited the laboratories and gave further advice for improvements. Although very short, the visit exceeded expectations.

Lao PDR, Cambodia and Vietnam official veterinary laboartories agree to work together to strenghten their laboratories

For the first time the three neighbouring countries (deputy) directors of the animal health laboratories met to discuss alliances, joint activities and how to strengthen intra-regional capabilities in the diagnosis and control of animal and zoonotic diseases. Viet Nam animal health capabilities have shown a steady improvement during the past years which gave the TO a satisfactory outlook and opened perspectives for future collaborations with its neighbours. All countries involved showed support to Viet Nam to drive intra-regional developments. We hope for a continued support to Viet Nam specially on becoming a reference centre for Rabies and also a genomic and bioinformatic force in the near future.

Regional (AFRA) Training Course on Peste des Petits Ruminants (RAF5089)

Carla Bravo de Rueda

To support partners in their efforts to eradicate Peste des Petits Ruminants (PPR), the IAEA held a two-week regional training course entitled 'PPR (Peste des Petits Ruminants): Control Strategies, Epidemiology and Detection using Serology and Molecular Diagnostics' within the framework of IAEA project RAF5089 'Strengthening the Capacities of National Veterinary Laboratories for the Early Warning, Control and Prevention of Outbreaks of Animal and Zoonotic Diseases'.

The training took place in IAEA's Headquarter in Vienna, Austria from 19 February to 1 March 2024, and brought together animal health professionals from ten Member States; (Benin (4), Central African Republic (4), Eritrea (4), Eswantini (4), Libya (3), Malawi (2), Mauritania (4), Mauritius (4), Seychelles (4), Sierra Leone (2)), as well as, for the first week, representatives of the IAEA Zoonotic Diseases Integrated Action (ZODIAC) National Laboratories, international organisations, such as the African Union – Interafrican Bureau for Animal Resources (AU-IBAR), WOAH, FAO and the French Agricultural Research Centre for International Development (CIRAD), and research institutions to bolster the efforts towards the fight against PPR.

Participant from Malawi using serological tools for PPR diagnostics

The two-week training highlighted the latest theoretical and practical methodologies and strategies, emphasizing the crucial role they play in fulfilling the ambitious target of eradicating PPR by 2030. The training saw the participation of 36 animal health professionals including chief veterinarian officers, field veterinarians, epidemiologists, laboratory technicians and laboratory managers from Member States and international stakeholders. The first training week was dedicated to epidemiology and control strategies, where participants not only improved their knowledge in the PPR GEP strategies but also drafted surveillance protocols tailored to their countries' current

PPR status. During the second week, 17 laboratory technicians from the same countries were trained in the molecular and serological detection of the PPR virus in the Joint FAO/IAEA Animal Health and Production Laboratory in Seibersdorf, Austria.

Click here to read more

Open Event for Veterinary Diagnostic Laboratory (VETLAB) Network Partners on the Diagnosis of Peste des Petits Ruminants and Respiratory Diseases of Small Ruminants

William Dundon

In collaboration with the FAO PPR GEP Secretariat and the FAO regional Office for Africa (Nigeria), a training course was held at the National Veterinary Research Laboratory (NVRL), Vom, Plateau State, Nigeria from 29 April to 3 May 2024. The training course focused on the molecular and serological diagnosis of peste des petits ruminants virus (PPRV) and other respiratory diseases of small ruminants. Participants from Nigeria (2), Guinea (2), Liberia (1), Eswatini (2), Burundi (2), Rwanda (2), and Zimbabwe (2) attended the course.

Participants performing ELSIA during the training course

Theoretical sessions included and overview of the PPR GEP and PPR Secretariat activities, molecular epidemiology as an aid in PPR strain identification for Episystem establishment, basics of phylogenetic analysis and genome sequencing and vaccines and vaccination strategies. Laboratory based practical sessions covered serological detection of anti-PPRV antibodies by competitive ELISA, classical and quantitative RT-PCR for detection of PPRV, multiplex PCR for multiple pathogen detection and differential diagnosis and PPR antigen detection by rapid pen-side test. Each participant was provided with a handbook containing all SOPs used during training.

First Research Coordination Meeting On ZODIAC: Enhancing Laboratory Preparedness for the Detection and Control of Emerging and Re-Emerging Zoonotic Diseases - Asia (CRP D32039)

Charles Lamien

The International Atomic Energy Agency (IAEA) launched the Zoonotic Disease Integrated Action (ZODIAC) initiative in June 2020 to enhance global preparedness against zoonotic diseases, including COVID-19. ZODIAC is structured around five pillars emphasizing research, development, and innovation, particularly addressing key gaps in Pillar II. From this initiative, four coordinated research projects (CRPs) emerged, targeting regional disease surveillance and pathogen source identification to mitigate emerging and re-emerging zoonotic risks. One of these, CRP D32039, focuses on Asia and has received partial funding from the Republic of Korea. It involves three technical contracts within Korea and five research contracts across Indonesia, Thailand, Vietnam, Cambodia, and Mongolia, with additional future partnerships expected from Japan, China, and Italy.

The first research coordination meeting (RCM) for CRP D32039 took place in Daejeon, Republic of Korea, from 11 to 15 December 2023. The meeting aimed to review work plans of the CRP partners, align activities among research and technical contract holders, explore opportunities for expansion, discuss potential additional contributors, and establish a comprehensive research network to achieve CRP objectives.

The meeting began with welcoming addresses from Mr Ho Seong Seo (KAERI) and Mr Charles Lamien (IAEA Technical Officer). On the first day, Mr Charles Lamien outlined the objectives and expected outputs of CRP D32039, while Mr Ho Seong Seo presented an overview of Korea's technical contracts. Technical contract holders, Mr Dong Hun Lee (Konkuk University) and Mr Kyu-Ho Paul Park (Institute Pasteur Korea), discussed their research on avian influenza virus transmission and Hepatitis E virus (HEV) detection tools, respectively. Research contract holders, Mr Munkhduuren Shatar (Mongolia SCVL) and Mr Lerdchai Chintapitaksakul (Thailand NIAH), presented on zoonotic virus detection technologies and family-based nanopore sequencing.

On the second day, Mr Ho Seong Seo discussed their progresses in Luminex xMAP technology and nanopore sequencing using Cas9 nuclease. Ms Nguyen (Vietnam) highlighted the need for sequencing technologies for pig respiratory viruses. Ms Nurjanah (Indonesia) and Mr Karlsson (Cambodia) emphasized surveillance technologies for bat, pig, rodent, and avian influenza viruses. Mr Ki Bum Ahn presented on family-based nanopore sequencing and technology validation. Invited

experts, Mr Yoshihiro Kaku (Japan), Ms Liao Ying (China), and Mr Giovanni Cattoli (Italy), discussed pseudotyped viruses for BSL-3 pathogens, monitoring Avian Coronavirus, and environmental sample collection methods.

The third day focused on presentations by representatives from eight Asia-Pacific countries on zoonotic disease status and suitable detection technologies. A 'Research Aligning and Networking' session followed, where participants re-evaluated target pathogens, finalized sampling methods, and established sample exchange networks. Participants toured the Advanced Radiation Technology Institution at KAERI and IPK, discussing potential improvements and training venues.

The meeting concluded with revised work plans and defined collaboration strategies. Key recommendations included:

• For Research Contract Holders: Validate procedures under technical contracts, share samples with partners and collaborators.

• For Technical Contract Holders: Involve CRP participants in procedure validation, mentor data analysis, participate in comparative analysis.

• For Technical Partners (Experts/Observers): Liaise with CRP coordination and the Joint FAO/IAEA Centre for engagement, share SOPs, participate in tool transfer.

• For CRP Coordination and the Joint FAO/IAEA Centre: Promote interaction and material exchange among partners, ensure tool availability for comparative studies, support training.

The meeting successfully aligned all partners, setting the stage for effective CRP implementation to enhance regional preparedness against zoonotic diseases.

Regional Training Course on the Molecular Diagnostics and Nanopore Sequencing of the Infectious Pancreatic Necrosis Virus (RLA5086)

Carla Bravo de Rueda

This regional training course was hosted by the government of Peru through the Organismo Nacional de Sanidad Pesquera – SANIPES in Lima, Peru between 18 to 22 March 2024. Aquaculture is one of the fastest growing sectors and is expected to grow further in order to secure food for the growing human population. The culture of rainbow trout (*Oncorhynchus mykiss*) is one of the main aquaculture activities in the Latin American and the Caribbean (LAC) region, being the second largest producer in the world after Asia. Aquaculture is developed mostly by rural communities with low economic resources.

Consequently, many countries in the region lack adequate infrastructure; qualified personnel; epidemiological surveillance; and adequate sanitary controls. The region is experiencing increasing mortality rates in trout farming due to the entry of border pathogens in the absence of timely diagnosis. The purpose of the event was to provide hands on training on the molecular diagnostics and characterization of the Infectious Pancreatic Necrosis (IPN) virus, a fish disease of great concern in aquaculture.

Left: All materials ready prior to laboratory training in SANIPES Right: Participants from 8 Member States and experts from Canada and USA gather in SANIPES to participate in the aquaculture diagnostics training

The training involved the use of PCR and sequencing for the diagnosis and characterization of this disease, relevant aspects for obtaining accurate results and subsequent reporting, as well as the importance of common practices to avoid contaminations and achieve quality results. This workshop had three main objectives: i) to prepare participants to conduct molecular diagnostics of IPNV, ii) to train the participants in using the Nanopore platform for whole genome sequencing and iii) to help Member State participants to conduct molecular diagnostics and characterization under quality standards.

Regional Training Course on Maintenance and Calibration of Laboratory Equipment (RLA5085)

Carla Bravo de Rueda

This regional training course was hosted by The Government of Colombia through the Instituto Colombiano Agropecuario (ICA), Bogota, Colombia between 20 to 24 May 2024.

Participants at the training course

The purpose of this event was to train participants on the maintenance and calibration of laboratory equipment

according to international standards. IAEA project RLA5085 aims to strengthen the capacity of official laboratories in the response to animal and zoonotic diseases. This regional training course enabled project members to improve and to get familiar with current practices in the maintenance and calibration of laboratory equipment under international standards, which are required for the accreditation of diagnostic tests. The workshop had three main objectives: i) improve knowledge on common metrological parameters used in the laboratory environment such as: volume, mass, temperature, and humidity, ii) provide tools for the corrective maintenance of laboratory equipment and iii) teach participants about metrological assurance procedures (calibration). Regional experts were part of the workshop. During the last day, the invited participants discussed results and clarified doubts with technical experts. The participants were laboratory technicians, and technicians with an understanding of laboratory maintenance and calibration systems i.e. needs of calibration of laboratory equipment for example: pipettes, balances, etc; understanding of common terminology and linked methodologies to metrology and its concepts of mass/volume/temperature including units of measurements. Knowledge of institutional requirements for the accreditation of diagnostics tools and associated quality assurance procedures, were an asset for their acceptance.

National Training Course on Genetic Characterization of Livestock Breeds: Sequence Data Analysis (BKF5022)

Kathiravan Periasamy

Under the IAEA technical cooperation project "BKF5022: Improving Local Poultry and Local Goat Productivity through Health, Diet, Reproduction, Genetic Markers for Selection and Breeding Management", a national training course on "Genetic characterization of livestock breeds: Sequence data analysis" was organized from 25 to 28 March 2024 at Laboratoire de Biologie et santé animals, Institut de l'Environnement et de Recherches Agricoles (INERA-CREAF), Ouagadougou, Burkina Faso. The training was conducted in hybrid mode with participation of 17 researchers/students working at various research institutions in Burkina Faso and other countries (Niger, Mali and Madagascar).

The course included lectures and practical hands-on training on: (i) Introduction to mitochondrial sequence data and processing raw sequences (ii) Multiple alignment and assembly of sequence data (iii) Estimation of mitochondrial DNA diversity parameters (iv) Estimation of haplotype frequency and haplotype sharing among livestock populations (v) Identifying optimal nucleotide substitution model and constructing phylogeny of mitochondrial haplotypes and haplogroups (vi) Mismatch analysis and tests for demographic expansion (vii) Multidimensional scaling (MDS) analysis of mtDNA sequence data. The staff of Animal Production and Health Laboratory, Seibersdorf served as expert lecturers for the training course. The training is expected to help improve the national capacity on applying sequencing technologies for characterization of indigenous livestock breeds of Burkina Faso and other countries in the region. The training will also help strengthen human resource capacity for effective implementation of National Action Plan on Animal Genetic Resources in the country.

National training course on sequence data analysis for genetic characterization of livestock

Workshop on Manual Packaging and Freezing of Bovine Semen for Artificial Insemination (BKF5022)

Kathiravan Periasamy

Under the IAEA technical cooperation project "BKF5022: Improving Local Poultry and Local Goat Productivity through Health, Diet, Reproduction, Genetic Markers for Selection and Breeding Management", a technical workshop on "Manual packaging and freezing of bovine semen for artificial insemination" was organized on 29 March 2024 at Frozen Semen Centre, Loumbila, Burkina Faso.

Participants working on collection, packaging and freezing of crossbred bull semen

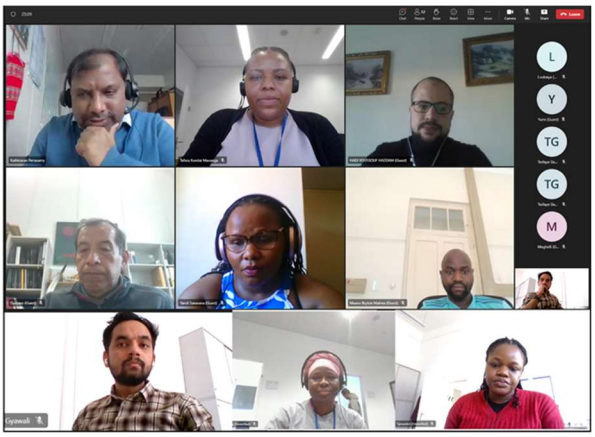
Five participants including staff working at Loumbila frozen semen center attended the workshop. The workshop

provided practical hands-on training to the participants on (i) Collection of semen from crossbred cattle (ii) Estimation of mass activity and sperm concentration (iii) Preparation of commercial and home-made extenders for dilution of semen (iii) Manual packaging of semen using French mini straws (iv) Pre-freeze evaluation of sperm motility (v) Cryopreservation of semen (vi) Post-thaw quality evaluation of spermatozoa. The staff of the Animal Production and Health Laboratory served as expert resource persons for the workshop. The workshop is expected to help improve the capacity of Loumbila centre to successfully cryopreserve bovine semen and provide better artificial insemination services for cattle breeding in Burkina Faso.

Virtual Training Course on Bioinformatics Analysis for Genomic Characterization of Livestock Biodiversity

Kathiravan Periasamy and Tafara Kundai Mavunga

A virtual group training course on "Bioinformatics analysis for Genomic Characterization of Livestock Biodiversity" was organized by APHL from 11 to 28 March 2024. 12 participants from five countries (Algeria, Benin, Morocco, Nepal and South Africa) attended the training course. The course included lectures and practical hands-on training on: (i) Principles of genome-wide typing using Affymetrix-GeneTitan microarray platform; (ii) Managing large sets of genotype data using command line platforms; (iii) Introduction to 'R' and working with 'R' Studio; (iv) Introduction to PLINK and Data Quality Control (pruning genome wide single nucleotide polymorphic data;



Virtual training course on bioinformatics analysis of genome wide data

(v) Estimating basic genomic diversity measures; (vi) Estimating effective population size using SNeP; (vii) Principal Components Analysis; (viii) Estimation of genetic distance and drawing NeighborNet tree; (ix) Estimation of global and pairwise genetic differentiation among breeds; (vi) Assessment of population structure and estimation of genetic admixture. Ms Tafara Kundai Mavunga served as lecturer for the training course. The training is expected to help improve the member state capacity on handling large livestock genome datasets and utilizing genome wide information for biodiversity assessment of local breeds.

First Research Coordination Meeting on Innovative Nuclear and Related Molecular Approaches for Detection and Characterization of Antimicrobial Resistance in Animal Production Environment (CRP D32043)

Kathiravan Periasamy

The first research coordination meeting (RCM) of the new coordinated research project (CRP D32043) on antimicrobial resistance (AMR) in animal production environment was held at IAEA headquarters from 15 to 19 April 2024. Eight research contract holders (Bangladesh, Burkina Faso, Kenya, Qatar, Serbia, Sri Lanka, Tunisia and Vietnam), four research agreement holders (Australia, Canada, Czech Republic and Denmark) and three technical contract holders (China, India and United Kingdom) attended the meeting. During the RCM, research contract holders shared information on the status of antimicrobial use and antimicrobial resistance in livestock production systems of their respective countries. The research agreement and technical contract holders shared the state-of-the-art technologies related to AMR surveillance, alternatives to antibiotic growth promoters and drug resistance among infections other than bacteria. The activities of IAEA and FAO to support member states combat AMR in livestock and agrifood systems were presented by the staff of the respective organizations.

Participants of the first research coordination meeting of the CRP D32043, VIC, Vienna, Austria

During the meeting, a brainstorming session was conducted to discuss and fine tune project objectives, methodologies and work plans of individual research and technical contracts of the project. The technical programme was finetuned/harmonized for each group of countries targeting; (i) Evaluation and optimization of farm-level sampling and analytical methods (culture dependent and culture independent methods) for detection and characterization of AMR in animal production environment (Bangladesh, China, Qatar, Serbia and Tunisia); (ii) Evaluation of the efficacy of alternatives to antibiotic growth promoters (AGPs) in ameliorating AMR in animal production settings (India, Kenya and Vietnam); (iii) Assessment of

phenotyping and genotyping methodologies related to drug resistance in animal infections other than bacteria (Burkina Faso, Sri Lanka). The needs for protocols and guidelines to produce an appropriate set of experimental data and challenges in implementing research activities of individual contracts were identified and discussed. The RCM recommended the CRP participants to utilize the knowledge products/resources on analytical methods related to detection and characterization of AMR available in the FAO AMR reference center portal. It also encouraged the research and technical contract holders to comply with national legislations related to ethical issues on animal experimentation and data privacy policies related to collection of information from farmers.

National Training Course on the Early Detection of Animal Diseases in Post Flooding Environment, with Emphasis on Water Borne and Vector Borne Diseases (UKR5001)

Ivancho Naletoski

Eight scientists from the central laboratory in Kyiv and the regional laboratories in Cherkasy, Mykolaiv and Zaporizhzhia attended the two-week training course at the IAEA laboratories in Seibersdorf from 20 to 31 May 2024. The course included theoretical classes and practical exercises on the techniques for detection and characterization of Clostridial infections / intoxications, Leptospirosis, West Nile fever and bluetongue. Additionally, the participants learned how to use iVetNet (integration of the diagnostic techniques under the umbrella of ISO 17025), the use of the Sanger sequencing service for characterization of the animal and zoonotic pathogens, as well as the basic principles of geo-visualization of the laboratory / testing results using the qGIS and Power BI software. The knowledge in the last learning module (geo-visualization) will be very relevant for the implementation of the ZODIAC Pillar 3, once the product is developed.

Participants at the national training course under the project UKR5001 during the practical exercises at the Animal Production and Health Laboratory in Seibersdorf

The course was supported by 4 international experts from the: i) University of California, Davis, School of Veterinary Medicine, Davis-CA, USA (Dr Francisco UZAL); ii) Academic Medical Center (AMC), Royal Tropical Institute (KIT) – Reference laboratory for Leptospirosis, Amsterdam, Netherlands (Dr Manon Koel); iii) Experimental Zoo-prophylactic Institute of Abruzzo and Molise G. Caporale, Teramo, Italy (Dr Alessio Lorusso) and the Central Veterinary Laboratory, Windhoek, Namibia (Dr Umberto Molini). The practical exercises were organized by the Animal Production and Health laboratory in Seibersdorf.

Second Research Coordination Meeting on Improving Efficiency of Animal Breeding Programmes Using Nuclear Related Genomic Information – Practical Applications in Developing Countries (D31030)

Kathiravan Periasamy and Victor Tsuma

The second research coordination meeting (RCM) of the coordinated research project (CRP) D31030 on "Improving efficiency of animal breeding programs using nuclear related genomic information – practical applications in developing countries was held at IAEA headquarters from 11 to 14 June 2024. Eleven research contract holders (Argentina, Bangladesh, Burkina Faso, China India, Kenya, Pakistan, Peru, South Africa and Sri Lanka), four research agreement holders (Austria, Italy, Kenya and Spain) and one technical contract holders (United Kingdom) attended the meeting. During the RCM, the progress of country projects was presented by research contract holders and the technical work plan was refined and revised to achieve the objectives of each project. The activities of Animal Production and Health Laboratory, Seibersdorf to support project partners in genomic analysis of livestock were presented by the staff of IAEA. The meeting allowed the identification of synergy across projects in different countries and promote collaboration for training and analysis of data to achieve the broader objectives of the CRP.

During the RCM, the participants agreed that projects targeting crossbreeding programs (Sri Lanka, Bangladesh, South Africa and Peru) for improved dairy productivity will focus on: (i) global admixture analysis to classify different genetic groups and association with production performance; (ii) local admixture analysis to ascertain adaptive introgression in crossbred cattle; (iii) genome wide association study for production and reproduction traits in crossbred cattle. Similarly, the projects targeting selective breeding of purebred cattle will focus on: (i) comparison of EBVs (and gEBVs) of purebred Holstein bulls across different production systems (pasture based, intensive and semi-intensive systems) in Argentina; (ii) estimation of

gEBVs of Peruvian Brown Swiss using the Italian prediction equations/methodology. The projects targeting water buffalo genomics (India, Pakistan and China) will focus on: (i) genomic characterization of native breeds/populations using whole genome sequence data; (ii) detection of selection signatures related to production and adaptation traits; (iii) establishing DNA bank of performance recorded buffaloes; and (iv) genome wide association studies for production and reproduction traits in river buffalo. The projects targeting camel genomics (India and Kenya) will focus on: (i) phenotypic characterization of local dromedary populations; (ii) genomic characterization of native breeds/populations using whole genome sequence or genome wide SNP data; (iii) detection of selection signatures related to production and adaptation traits; and (iv) genome wide association study for growth/milk traits in Indian dromedary populations.

Participants of the second research coordination meeting of the CRP D31030, VIC, Vienna, Austria

The CRP participants were encouraged to share the data generated to be available through public databases while following their respective institutional/organizational regulations. The RCM recognized the strong need for trainings on bioinformatics analysis of genome wide SNP and whole genome sequence data to improve the capacity of participating countries for interpretation and implementation of results. The meeting recommended the participants to share information on forthcoming virtual bioinformatics training courses in their respective institutions, wherever possible, the CRP partners from other countries may be encouraged to participate in such trainings.

Stories

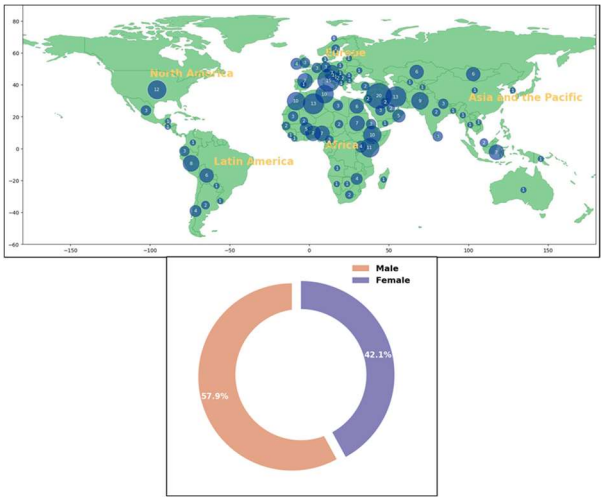
Beyond Deserts and Highlands – Global Celebration of the International Year of Camelids 2024

Kathiravan Periasamy, Farai Muchadeyi, Federico Verly, Yuetong Ma and Belinda Westmacott

Camelids, comprising one humped dromedary, double humped Bactrian, llamas, alpacas, vicugna and guanacos play an integral role in sustaining the livelihood of human societies across diverse geographical regions. From the arid deserts where camels have been indispensable companions for centuries to the high-altitude regions where alpacas and llamas have been integral to indigenous communities, camelids contribute significantly to socio-economy by providing milk, meat, fiber, draught, and recreation. The United Nations declared 2024 the International Year of Camelids seeking to highlight the role of camelids in global food security, sustainable agriculture, and the preservation of cultural heritage.

The International Event on “Beyond Deserts and Highlands – Global Celebration of the International Year of Camelids 2024”, organized on 10 June 2024 by the Animal Production and Health Section of the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture in cooperation with the Permanent Mission of Peru, served as a response to the growing global interest and the need for a collaborative platform that brings together experts, researchers, policymakers, and breeders to share knowledge, discuss challenges, and explore innovative solutions. The event aligned with the global agenda for promoting biodiversity conservation, given the unique ecological niches that camelids occupy. Recognizing the potential of camelids in sustainable agriculture, ecotourism, and poverty alleviation, the event fostered international collaboration and partnerships that will contribute to the well-being of both camelid-dependent communities and the broader global population.

The event comprised of a plenary session, three technical sessions, an open session and exhibition of camelid products. Throughout the 5 sessions, the event facilitated the exchange of cutting-edge research, technological advancements and best practices in camelid science, husbandry, and management. With more than 60 invitees attending in person and more than 300 registered participants online, the international event provided a platform for participants to network with fellow researchers, breeders and policymakers, sharing knowledge on various aspects of camelid husbandry, including genetics, nutrition, health and socio-economic impacts, while raising awareness about the significance of camelids in diverse fields and advocating for their sustainable integration into global agricultural and economic systems.



Geographic and gender distribution of participants of the international event on camelids

Among the relevant topics addressed during the event, the significance of camelids in addressing issues concerning adaptation to climate change was highlighted in both the plenary and open sessions. Mr Bernard Faye, Emeritus Scientist from The French Agricultural Research Centre for International Development (CIRAD), delivered the keynote speech, and in the open session "Camel Connections - Socio-economic and cultural dimensions of camel rearing", where Ms Ilse Kohler-Rollefson, Coordinator and Senior Advisor League for Pastoral Peoples, and Co-founder Camel Charisma, and Ms Ilona Gluecks, Head of Clinical Research Facilities and Clinical Research Officer from the International Livestock Research Institute, explored the topic. Mr Faye remarked "One of the consequences of climate change, that I have seen in the last 40 years, is the expansion of camel farming", due mainly to the increase in arid regions and the resilience of camels. The expansion, according to Mr. Faye, also relates to the "globalization of the world economy and the growing constraints on the resources linked to the camel demography, pushing some pastoralists to move closer to the urban areas". The increase in productivity and in the demand for camel products, however, should also consider the pastoralists' access to markets, lands, and the respect of cultural practice. Furthermore, a gendered approach is essential, as underlined by Ms Kohler-Rollefson: "Women are crucial as leaders in developing and marketing camel-based products".

The technical sessions emphasized the changes in camel production systems, as pointed out by Mr Ved Prakash, Senior Scientist from the Indian Council of Agricultural Research: "The camel production system is in a state of transition as well as diversification from traditional utility as a draught animal to dairy animal or multipurpose use". Mr Gutierrez Reynoso Gustavo, Head of the Animal Breeding and Research at Universidad Nacional Agraria La Molina, Peru and Ms Wilkister Nakami, Tutorial fellow at University of Nairobi showed the diversity of production environments in which camelids contribute to livelihood in arid regions and highlands across Africa and Latin America.

The genetic biodiversity of old (Dromedary, Domestic and Wild Bactrian) and new (alpaca, llama, vicugna and guanaco world camelids and their adaptive characteristics to extreme weather was highlighted by Ms Pamela Burger, Senior Researcher from Research Institute of Wildlife Ecology at University of Veterinary Medicine, Vienna. The need for advanced tools and resources for not only breeding and improvement of camelids but also to conserve the diversity was emphasized by Mr Kathiravan Periasamy, Livestock Geneticist/Breeder of the Joint FAO/IAEA Center. Ms Lulu Skidmore, Scientific Director, Camel Reproduction Centre, UAE provided information on reproductive biotechnological tools available for multiplying superior genetics in camel populations. Ms. Skidmore explained the challenges of artificial insemination in camelids but indicated embryo transfer and other advanced technologies like in vitro fertilization and cloning can also be promising approaches to improve reproductivity efficiency in these animals. The dynamic changes occurring in camel production also raise the issue of camel health and welfare and their potential impact on public health. Mr Norbert Nowotny, Professor at Institute of Virology, University of Veterinary Medicine, Vienna highlighted the significance of Middle East Respiratory Syndrome (MERS CoV) and Crimean-Congo Hemorrhagic Fever Virus (CCHFV). Mr William Dundon, consultant at the Joint FAO/IAEA Centre showcased the R&D advances in early and rapid diagnosis of diseases in camelids. Mr Habil. U. Wernery, Scientific Director, Central Veterinary Research Laboratory, UAE accentuated the challenges and way forward in the control of camel diseases.

Invited experts speaking at International Year of the Camelids event

Finally, the event highlighted that despite the great progress in camelids research, further studies are needed. The changes in camel production are generating new scientific questions that need to be addressed. More research is necessary in terms of validating the unique qualities of camel products, breeding for improved milk, meat and fibre production, detection of diseases, development of camel vaccines while, at the same time, the potential use of camelids nanobodies for drug development, diagnostic tools, and therapeutic applications. The Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture, with its unique expertise in the use of nuclear and nuclear derived technologies, is called to play a key role in future developments.

Supporting the Global Fight Against Peste des Petits Ruminants (PPR)

Peste des petits ruminants (PPR), one of the most economically important animal diseases in areas that rely on small ruminants, causes dramatic losses to local economies every year. In addition to occurring in extensive migratory populations, PPR can also appear in villages and urban settings affecting families who rely on sheep and goat farming. This highly infectious viral disease can infect up to 90 percent of a herd with a fatality rate as high as 70 percent. More than 70 countries, containing approximately 1.8 billion small ruminants, are at high risk. The disease is causing annual economic losses of up to USD 2.1 billion and endangers the livelihoods and food security of more than 300 million families.

In April 2015, the Food and Agriculture Organization of the United Nations (FAO) and the World Organisation for Animal Health (WOAH) launched the PPR Global Eradication Strategy aiming at global eradication of PPR by 2030. PPR would then be the second animal disease eradicated after Rinderpest, which was eradicated globally in 2011. A key component of the Rinderpest eradication programme was a strategic stakeholder partnership, a model that the PPR Global Eradication Programme (GEP) is following.

Nine Member States were trained in the molecular and serological detection of the PPR virus in the Joint FAO/IAEA Animal Health and Production Laboratory in Seibersdorf, Austria

Through the IAEA's Technical Cooperation programme, the VETLAB Network - a global network of national veterinary diagnostic laboratories- and several coordinated research projects (CRP), PPR detection protocols including reagents support and trainings have been implemented in many Member States across several regions, including a recent two-week training at IAEA's headquarters and the APHL in Vienna and Seibersdorf, Austria, respectively, from February to March 2024. By providing, among others, proficiency tests to Member States, the IAEA, with the expertise of the Joint FAO/IAEA Centre, plays a critical role in supporting Member States in their efforts to control PPR, therefore contributing to the objectives of the GEP.

"Based on the rinderpest eradication experience, the PPR eradication plan needs a tight inter-institutional collaboration where the IAEA, through the Joint FAO/IAEA Centre, is playing a major role on the PPR GEP Advisory Committee and the global research and expertise Network (PPR GREN) that was launched in Vienna in 2019," stated Felix Njeumi, Animal Health Officer for the FAO/WOAH PPR GEP Secretary.

"The comprehensive training programme organized by the IAEA on PPR had a remarkable impact on me as Chief Veterinary Officer of my country. By enhancing knowledge and skills in the fields of epidemiology, prevention, and control, as well as surveillance and laboratory testing, I have gained practical skills in conducting PPR outbreak investigations, learned how to trace the source of infection and assess the spread of the disease within and across small ruminant populations. These enhanced investigation skills contribute to more targeted control and prevention strategies." - Dr. Yonas Wouldu, CVO and WOAH Delegate of Eritrea

This training programme, along with the additional support offered by the IAEA to its Member States is one of the many crucial steps towards a PPR-free future. By equipping professionals with the latest knowledge and tools, similar collaborative efforts can empower communities and safeguard the livelihoods of millions of farmers who depend on small ruminants.

The power of scientific collaboration and the dedication shown by the participants of this training course are steps towards the ambitious goal set by the GEP, paving the way for a healthier future for animals and the communities that depend on them.

Click here to read more

Integrating Multi-Disciplinary Approaches to Combat Antimicrobial Resistance (AMR) in Agrifood Systems towards One Health

Maria Heiling, Jing Wang, Britt Maestroni, Christina Vlachou, Gerd Dercon, and Viskam Wijewardana

Antimicrobial agents, such as antibiotics, are essential in treating bacterial and other infections and diseases in both humans and animals. However, their widespread misuse and application of poor-quality antimicrobials, has led to antimicrobial resistance (AMR), which has been recognized as a critical threat to public health and requires joint efforts such as the quadripartite One Health Approach.

This major concern necessitates a coordinated approach involving various disciplines and sectors to assess and mitigate its negative impacts. To help control AMR, subprogrammes of the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture use nuclear and isotopic techniques in combination with biotechnology to study AMR in agricultural systems (Fig. 1 and 2 show examples of soil and pig farms). Their goal is to help

improve food safety and public health across these interconnected domains.

To tackle this multifaced issue, the Joint FAO/IAEA Centre has launched Coordinated Research Projects (CRPs) and specific training programmes, collaborating in a cohesive and interdisciplinary manner to help develop integrated approaches, spanning from plant, food safety, animal, and environmental health topics related to AMR.

Figure 1 (left): Using stable carbon isotope (13C) to study AMR in soil; Figure 2 (right): Collecting bioaerosol samples at a pig farm

Specifically, efforts are targeting: (i) AMR and antimicrobial resistance genes characterization and surveillance programmes; (ii) antimicrobial residue testing and monitoring programmes; (iii) the evaluation of novel alternatives to antimicrobial growth promoters in animal diets; (iv) the investigation of the fate and dynamics of antimicrobials in agricultural systems; and (v) the correlation between the presence of resistance and their genes.

The collaboration extends to developing rapid and accurate infection diagnostic technologies, detection methods for antimicrobial agents, effective vaccines, and good husbandry practices to reduce the need of antimicrobials.

Using a multidisciplinary collaborative approach, the Joint FAO/IAEA Centre continues to contribute to the development of sustainable and specific laboratory support for AMR control by providing targeted nuclear and isotopic techniques alongside biotechnology approaches. The centre is also helping to raise awareness among Member States of the importance of existing programmes on AMR implemented in collaboration with WHO, United Nations Environment Programme, and the World Organization for Animal Health (WOAH).

Figure 3: FAO/IAEA manuals of analytical methods and standard operating procedures available for the detection of antimicrobial residues

The work of the Joint FAO/IAEA Centre relevant to AMR started in 2009 focusing on the development and validation of analytical methods to detect, quantify, and confirm the presence of antimicrobial agents. Further work followed through CRPs on "Integrated Radiometric and Complementary Techniques for Mixed Contaminants and Residues in Foods" (CRP D52041, 2017-2023).

Dedicated laboratory manuals were prepared and are currently available in combination with a database of analytical methods, the Food Contaminant and Residue Information System (FCRIS) (see Fig. 3 and 4).

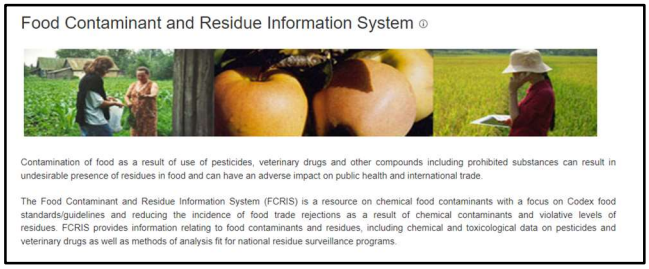


Figure 4: The Food Contaminant and Residue Information System (FCRIS) is hosted on the iaea.org web pages link

Current CRPs on or relevant to AMR include:

- D15022 "Isotopic Techniques to Assess the Fate of Antimicrobials and Implications for Antimicrobial Resistance in Agricultural Systems" (2021-2026);
- D32043 "Innovative Nuclear and Related Molecular Approaches for Detection and Characterization of Antimicrobial Resistance in Animal Production Environment" (2023-2028);
- D52043 "Depletion of Veterinary Pharmaceuticals and Radiometric Analysis of their Residues in Animal Matrices" (2021-2026);
- D52044 "Nuclear Techniques to Support Risk Assessment of Biotoxins and Pathogen Detection in Food and Related Matrices" (2022 – 2027).

Leveraging on these initiatives and diverse strengths within, the Joint FAO/IAEA Centre is taking steps to further align itself to multi-disciplinary One Health approaches in combating AMR in Members States.

This will require multisectoral collaboration and engagement addressing the health of humans, animals, plants, food and feed, as well as the environment. Through the expanded work on AMR, the Joint FAO/IAEA Centre is committed to initiating new and strengthening existing partnerships to contribute to the shared global vision of One Health.

The way forward will include, but not be limited to, expanding current CRPs on AMR and developing new CRPs to include cross-cutting research and capacity building through peaceful initiatives where, multiple stakeholders can play a significant role in the co-creation of knowledge and innovation. This work is also relevant to the Atoms4Food Initiative.

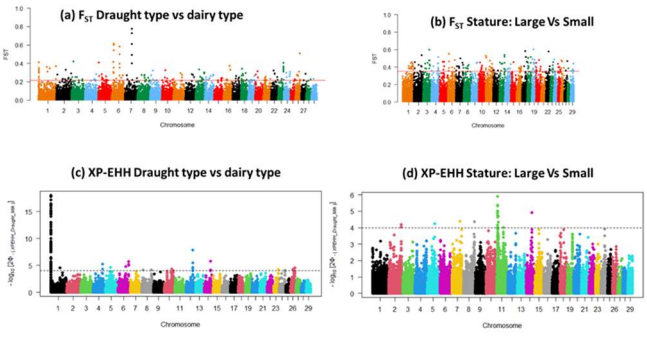
Research Activities of the Animal Production and Health Laboratory (APHL)

Animal Production

Improving Efficiency of Animal Breeding Programs Using Nuclear Related Genomic Information – Practical Applications in Developing Countries (CRP D31030)

(i) Genomic diversity and selection signatures in Asian Zebu cattle

Asian zebu cattle (*Bos indicus*), hold a high level of significance in various aspects ranging from agriculture to cultural heritage across Asia and beyond. These cattle are well-adapted to the harsh climates of tropical and subtropical regions, displaying resilience to high temperatures, parasites, and diseases that often afflict other cattle breeds. Their unique hump, floppy ears, and dewlap contribute not only to their distinctive appearance but also to their physiological adaptations that enhance heat dissipation and disease resistance. This makes them indispensable in regions where environmental conditions are challenging for livestock. Further, these cattle are highly valued for their versatility; they are used for milk, meat, and as draft animals, playing a crucial role in the livelihood of millions of smallholder farmers.



Detection of selection signatures related to production and stature traits in Asian Zebu cattle

During 2024, APHL conducted the global genomic diversity analysis of zebu cattle breeds from Asia. The objective of the initiative was to establish baseline information such as inbreeding levels, effective population size, basic diversity measures, gene flow, genetic admixture, and identification of selection footprints at the whole genome level. The study involved >1300 cattle from 29 zebu and seven taurine breeds located across six countries (Bangladesh, Cambodia, India, Myanmar, Pakistan, Sri Lanka). All the animals were genotyped on Axiom 60K Bovine Genotyping v3 array consisting of 63,655 SNPs (Single nucleotide polymorphisms).

The level of genetic diversity observed within the Zebu cattle populations was moderately high, while the average inbreeding coefficients ranged from 0.026 to 0.074 across different breeds. Candidate regions for signatures of selection (utility: draught vs dairy; body stature: large vs small) were revealed based on extended haplotype homozygosity (EHH) and fixation index (F_{ST}). Genes related to biological processes such as heat shock proteins (HSPP90AA1), homeostasis genes, fertility, reproduction (REC8, CLIC4, TSSK4) and immune response (RIPK3) were identified. Selection signatures pointed to enrichment of genes related to growth and physiology, immune response, and production traits in indicine breeds regardless of their use and stature. Most importantly, the interaction between pathways related to immune response, fertility, and reproduction also explained the superiority of Zebu cattle in terms of their ability to thrive in extreme hot temperatures and under sub-optimal nutrition.

(ii) Genome wide typing of Argentinian cattle to support association studies on production, reproduction, and health traits

Genome-wide association studies (GWAS) represent a cutting-edge approach to enhancing the genetic understanding and overall productivity of dairy cattle. By systematically scanning the genomes of a cattle breed/population, GWAS aim to identify specific genetic variants associated with economically significant traits such as milk production, reproductive efficiency, disease resistance, and overall health. Given the critical role of Holstein cattle in Argentina's dairy industry, such studies are pivotal for improving the efficiency and profitability of dairy farming. By pinpointing genetic markers linked to traits like high milk yield, improved fertility, robust disease resistance, and general health traits, geneticists/breeders can enable more precise and effective selective breeding programs. This will not only help in maximizing milk production and quality but also in enhancing the reproductive performance, health resilience, and longevity of the herd. Consequently, GWAS will contribute significantly to the sustainability and competitiveness of the Argentinian dairy sector by fostering the development of healthier, more productive, and more resilient cattle populations. APHL provided technical and laboratory support to Instituto de Genética Ewald A. Favret, Instituto Nacional de Tecnología Agropecuaria, Argentina to perform genome-wide typing of >750 Argentinian cattle using Axiom 60K Bovine Genotyping v3 array consisting of 63,655 SNPs. Genotypes were extracted using Axiom Analysis Suite and transferred to the member state to perform further downstream analysis for association with various production and health traits.

(iii) Genome wide typing of Sri Lankan cattle to improve efficiency of crossbreeding programme for enhanced productivity

Estimating genetic admixture in crossbred cattle of Sri Lanka is crucial for optimizing dairy cattle management and enhancing milk productivity in the country. Crossbred cattle (indigenous Sri Lankan zebu cattle X exotic commercial taurine) often exhibit hybrid vigour, combining desirable traits such as high milk yield with disease resistance and heat tolerance. By accurately estimating the genetic admixture, it is possible to identify the specific contributions of each breed to the crossbred population, allowing for targeted breeding strategies that amplify beneficial traits. This genetic insight helps in preserving the valuable characteristics of local breeds, such as their adaptability to the local climate and resistance to endemic diseases, while integrating superior traits from exotic breeds, like increased milk production and improved growth rates. Such information is critical to sustainable cattle development through informed decision making on breed selection and mating strategies that enhance overall herd performance. APHL provided technical and laboratory support to the Department of Animal Sciences, University of Peradeniya, Sri Lanka to perform genome-wide typing of >950 Sri Lankan cattle using Axiom 60K Bovine Genotyping v3 array. This included reference populations of exotic (such as Jersey and Holstein) and indigenous zebu (such as Batu, White cattle, Northern Local, and Thawalam). The reference genotype database will be utilized to estimate zebu-taurine admixture levels in crossbred cattle. Genotypes were extracted using Axiom Analysis Suite and further downstream analysis on data pruning and estimation of genetic admixture is currently in progress.

Implementation of Global Action Plan on Animal Genetic Resources

In continuation of Joint FAO/IAEA efforts towards implementing the Global Plan of Action on animal genetic resources (AnGR), APHL supported genetic characterization of 16 livestock breeds including one sheep from Mozambique, eight cattle from Benin, four chickens, and three sheep from Burkina Faso.

(i) Genomic diversity and characterization of Benin cattle

The native cattle of Benin play a critical role in the country's livestock production, offering unique advantages due to their adaptation to local conditions. The native taurine cattle, such as the Lagune breed, are known for their resilience to diseases, particularly trypanosomiasis, which is prevalent in the region. These cattle are well-suited to the humid and tsetse-infested areas of southern Benin, making them invaluable for sustainable livestock farming in these challenging environments. On the other hand, zebu cattle, including breeds like Goudali, are prized for their hardiness and ability to thrive in the arid and semi-arid zones of northern Benin. Zebus are recognized for their superior heat tolerance, drought resistance, and capacity to cover long distances in search of water and forage. The genetic diversity and complementary traits of these cattle breeds enhance the overall productivity and resilience of the livestock sector in Benin. By integrating the strengths of both taurine and zebu cattle, farmers can optimize meat and milk production and ensure sustainable agricultural practices, thereby supporting the livelihoods of many rural communities in Benin.

APHL supported the genomic characterization of native cattle breeds of Benin. A total of 379 cattle from eight breeds of native cattle were sampled and analysed. This included taurine (Lagune, Pabli and Somba), three Zebu (Goudali, Zebu Peuhl, and Yakana), and two crossbred (Bourgou, Bourgou X Zebu) cattle. All the cattle were genotyped using the Axiom 60K Bovine Genotyping v3 array on Affymetrix GeneTitan platform. Extraction of genotype data was completed and further downstream pruning and analysis to estimate genomic diversity, inbreeding, effective population size, population structure, genetic admixture and gene flow is currently in progress.

(ii) Genetic characterization of Mozambique sheep

Sheep farming is a vital source of income, food security, and livelihood for many rural communities in Mozambique. The Landim sheep breed of Mozambique, also known as the "Indigenous Mozambican Sheep", is renowned for its adaptability and resilience in the harsh environmental conditions of the region. These sheep are characterized by their hardy nature, thriving in arid and semi-arid climates with minimal resources. One of the most notable characteristics of Landim sheep is their remarkable resistance to local diseases and parasites, which significantly reduces the need for veterinary interventions. Additionally, these sheep are well-adapted to grazing on the sparse and variable forage available in Mozambique, making them a sustainable option for smallholder farmers. The Landim breed also exhibits good reproductive performance and mothering abilities, ensuring the survival and growth of lambs even in challenging conditions. By improving the genetic quality of sheep through targeted breeding programs informed by genetic characterization, farmers can achieve higher productivity, better meat and wool quality, and increased disease resistance.

APHL supported the Directorate of Animal Science, Agriculture Research Institute of Mozambique to conduct the genetic characterization of Mozambique sheep. A fellow from Mozambique was trained on molecular techniques to perform the characterization using DNA markers. The study also involved assessing the relationship of Mozambique sheep with native sheep breeds of East Africa, West Africa, and West Asia. A total of 139 samples (48 Landim sheep from Mozambique, 30 Mossi sheep from Burkina Faso, 30 Sahelian sheep from Burkina Faso, and 31 Menz sheep from Ethiopia) were genotyped and sequenced. Additionally, genotypes on >380 sheep (belonging to

Djallonke, Sudanese and West Asian breeds) available at APHL database were utilized. All the samples were sequenced for the mtDNA control region to assess the extra nuclear variations and evolutionary relationships among the studied populations. Further analysis of data is currently in progress, while the Agricultural Institute of Mozambique will collect additional samples from unrelated Landim sheep located in different regions to expand the study for a comprehensive assessment.

Fellows from Mozambique (left) and Burkina Faso (right) processing samples at APHL for genetic characterization of local livestock and poultry

(iii) Genetic characterization of native chicken ecotypes of Burkina Faso

The native chicken ecotypes of Burkina Faso are integral to the country's poultry sector, contributing significantly to rural livelihoods and food security. These indigenous chickens are highly valued for their adaptability to local environmental conditions, including high temperatures and low-input farming systems. Characterization studies of these ecotypes have revealed a range of phenotypic traits that make them well-suited to the diverse agro-ecological zones of Burkina Faso. These traits include varied plumage colours, body sizes, and comb types, which are not only important for local breeding preferences but also for their roles in heat dissipation and disease resistance. APHL supported Laboratoire de Biologie et santé animals, Institut de l'Environnement et de Recherches Agricoles (INERA-CREAF) to conduct the genetic characterization of native chicken ecotypes of Burkina Faso. More than 100 chicken samples from Sahel, Pulpuli, Naked Neck, and Kolontoodjé ecotypes were genotyped using FAO recommended short tandem repeat markers. A fellow from INERA-CREAF were trained on laboratory procedures related to molecular characterization techniques.

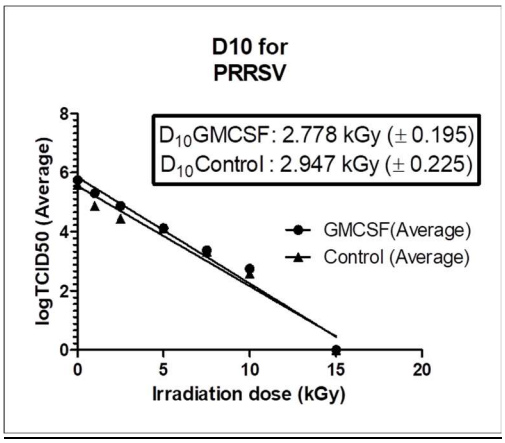
Animal Health

Inactivation of Porcine Reproductive and Respiratory Syndrome Virus Through Irradiation for Developing Vaccines

Porcine Reproductive and Respiratory Syndrome (PRRS) presents a significant challenge to the swine industry, causing considerable economic losses annually. The disease is triggered by the Porcine Reproductive and Respiratory Syndrome Virus (PRRSV), which leads to reproductive complications in pregnant sows during the latter part of gestation. These complications often manifest as preterm labour, abortions, or stillbirths. Additionally, PRRSV is known to cause respiratory issues in newborn piglets.

In our project focused on developing an irradiated PRRSV vaccine, a strain of PRRSV isolated in China was grown in both swine GM-CSF transfected Marc-145 cell lines and regular Marc-145 cell lines. The transfected cell lines demonstrated enhanced virus proliferation. We studied the viral growth curves in both MACR-145 and SG-MARC-145 cell lines, with viral titers peaking at 54 hours post-infection.

Building on previous research, we continued to determine the optimal dose of gamma irradiation for deactivating PRRSV while preserving its immunogenic properties. Viral stocks obtained from both GM-CSF-transfected and non-transfected cell lines were treated with trehalose to a final concentration of 0.25 M. The virus was then subjected to gamma radiation at incremental doses of 1.0 kGy, 2.5 kGy, 5.0 kGy, 7.5 kGy, 10 kGy, and 15 kGy to determine the D10 value. Each dose was applied in duplicate across all virus samples.



Graph shows reduction of virus load against each irradiation dose. This allows to calculate the D10 value (the irradiation dose needed to reduce the pathogen concentration by one log

Our findings revealed that the D10 values for PRRSV cultured in GM-CSF transfected cell lines and in standard Marc-145 cells were 2.788 kGy and 2.947 kGy, respectively. Moving forward, we plan to utilize these results to irradiate viral stocks further and evaluate their immunogenicity *in vitro*.

Characterisation of Lumpy Skin Disease Attenuation for Vaccine Development

Lumpy skin disease (LSD) poses a significant threat to domestic cattle due to its highly contagious nature, substantial economic impact, and recent geographical expansion that now includes the Middle East, Europe, and Asia. Many LSD vaccines have been developed through serial passages of virulent strains, and understanding the immune responses elicited by these vaccines is crucial to preventing the spread of the disease. Previous studies at APHL developed an *in vitro* assay that could identify innate immunological markers of attenuation by incubating early (wild type) and late (attenuated) viral passages of the Massalamia LSD strain isolated from Sudan. Briefly, Bovine peripheral blood mononuclear cells (PBMC) were obtained by density gradient centrifugation before the depletion of CD14+ monocytes using magnetic beads conjugated to an anti-bovine CD14 monoclonal antibody. Whole PBMC and remaining CD14 negative cell fractions were incubated with wild-type, and attenuated passages of Massalamia for qPCR (48 h) and flow cytometry (72 h). The results from both flow cytometry and qPCR were able to identify significant differences in the expression of interferon-gamma (IFN-γ) along with other interleukins with the attenuated virus inducing an increase in the expression of IFN-γ thus confirming a distinctive divergent innate immune response in bovine cells incubated with either wild-type or attenuated virus. To further characterise viral attenuation, wild-type and attenuated virus samples were also used for whole genome sequencing to identify molecular changes that occur during attenuation. The information derived from sequencing has been analysed to identify the genes responsible for the divergent innate responses previously observed in bovine cells. RNA isolated from bovine cell samples for qPCR was also used to measure replicating virus to confirm the differences observed (Fig 1). The results from this study will be useful when investigating irradiated vaccine candidates for their fitness *in vitro* before attempting animal studies.

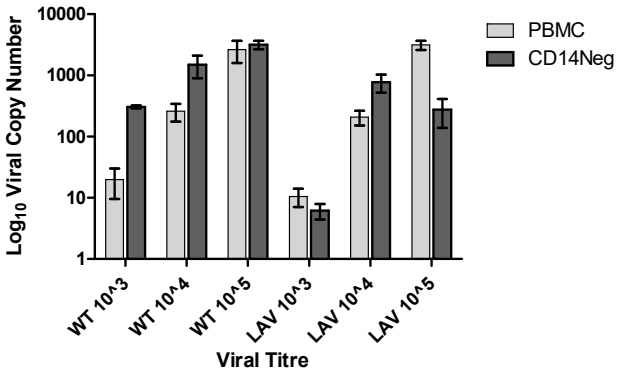


Figure 1. Viral replication in PBMC and CD14 negative cells. DNAse-treated RNA was used as a template for the absolute quantification of the RPO30 gene from LSD in cultures incubated with either wild-type (WT) or live attenuated virus (LAV) at different viral titers and PBMC or CD14 negative PBMC bovine cells. The viral copy number was calculated as a mean ± standard error (n=3)

Characterizing Lumpy Skin Disease Virus in Asia

The APHL has continued its support in characterizing the Lumpy Skin Disease Virus (LSDV) from outbreaks in various Asian countries. Originally endemic to Africa, LSD has spread to the Middle East, Europe, and Asia over the past decade, starting in 2019. Vaccination of cattle with live-attenuated LSDV vaccines is the most effective control strategy. However, the emergence of two distinct groups of LSDV strains in Asia—one closely related to ancient Kenyan LSDV isolates and another consisting of recombinant viruses with a Neethling-vaccine and field isolates backbone—highlights the need for constant molecular surveillance.

Recently, in collaboration with scientists from the Research Center for Veterinary Science in Indonesia, APHL published a report on the first LSD outbreak in Indonesia, which occurred in 2022. Molecular characterization of the Indonesian isolate, using selected LSDV-marker genes (RPO30, GPCR, EEV glycoprotein gene, and B22R) and whole genome analysis, identified the isolate as a recombinant of LSDV_Neethling_vaccine_LW_1959 and LSDV_NI-2490. The analysis grouped the Indonesian LSDV with previously reported recombinants circulating in East and Southeast Asia, distinguishing it from recombinant viruses in Russia and field isolates in South Asia.

Additionally, this study demonstrated alternative methods for accurate whole genome analysis and clustering of LSDV isolates, including recombinants, beyond traditional whole-genome phylogenetic tree analysis. These findings enhance our understanding of the pathogen's origin, spread, and inform suitable control measures.

Molecular Characterisation of ASFV

African swine fever (ASF) is a highly lethal, incurable disease affecting domestic pigs and wild boars caused by the ASF virus (ASFV). ASF has significant economic impacts on pork production, food security, and international trade. First documented in 1921 in Kenya, ASF has since spread to various African countries, Europe, and recently to several Asian countries, including China, the world's largest pork producer, in 2018. Ongoing surveillance and control measures are critical to managing ASF's global impact, including the introduction of new genotypes (genotype II in West Africa in 2020) and the emergence of recombinant genotypes I and II in China in 2023.

APHL has continuously supported affected countries through training, supplying reagents and controls, and assisting with diagnostic confirmation and molecular characterization. Recent examples include support for the genetic characterization of ASFVs in Angola, Mali, and Vietnam. Partial and whole genome sequencing revealed the co-circulation of genotype II ASFVs with recombinant genotype I/II ASFVs in Vietnam. In Mali, both genotype I

and II ASFVs were present, while in Angola, only genotype I ASFVs were found. These results underscore the need for continuous monitoring of ASFVs during outbreaks, especially given the rollout of ASFV vaccines in some countries.

Evaluating the Cross-Neutralization Efficacy of Sera Against Capripoxviruses

Sheeppox virus (SPPV), goatpox virus (GTPV), and lumpy skin disease virus (LSDV) are the three members of the genus Capripoxvirus within the Poxviridae family. These viruses are the etiologic agents of sheeppox (SPP), goatpox (GTP), and lumpy skin disease (LSD), respectively. Endemic in Africa and Asia, these diseases cause severe outbreaks and significant economic losses in livestock. Recently, incursions of SPP and LSD have also been reported in Europe.

To control these diseases, vaccination with live attenuated homologous and heterologous viruses is commonly used. APHL scientists conducted a study using the gold standard virus neutralization test (VNT) to evaluate the ability of homologous and heterologous sera to neutralize SPPV and LSDV.

The study revealed that sera from animals infected by LSDV and SPPV effectively neutralize their respective homologous viruses. Additionally, sera from GTPV-infected animals could neutralize SPPV. However, while LSD sera effectively neutralize SPPV, sera from animals infected with SPPV and GTPV do not effectively neutralize LSDV.

These findings highlight the complexities of cross-protection among Capripoxvirus vaccines and have significant implications for VNT methodology and heterologous vaccine efficacy. A manuscript detailing these results and their implications has been prepared for dissemination.

Understanding the neutralization capabilities of different sera is crucial for developing more effective vaccination strategies. This research aids in refining disease management protocols and ensuring better protection for livestock against these economically impactful diseases.

Innovative Nuclear and Related Molecular Approaches for Detection and Characterization of Antimicrobial Resistance in Animal Production Environment (CRP D32043)

(i) Antimicrobial resistance in animal production environments: preliminary analysis of bioaerosol, faeces, and wastewater

Antimicrobial resistance (AMR) in livestock and humans has been extensively investigated for a long time, leading to a wealth of scientific knowledge in these areas. However, there is significantly less information available about AMR in the environment. While recent years have seen an increase in reports on AMR in wastewater and soil, bioaerosols remain an underexplored area. The methods for collecting and analyzing bioaerosol samples for AMR are still lacking, posing a challenge for comprehensive environmental surveillance.

To address these challenges, the Animal Production and Health Laboratory (APHL) is dedicated to advancing the study of AMR in bioaerosols in animal production environments. APHL is actively working on developing innovative techniques and protocols for the collection and analysis of bioaerosols to better understand their role in the spread of antimicrobial resistance. This aims to contribute to a more comprehensive understanding of AMR in the environment, ultimately aiding in the global effort to combat antimicrobial resistance.

To test the performance of selected air samplers, APHL utilized two types of bioaerosol samplers: a filter-based sampler and an impactor sampler. Impactor samplers are low-cost, simple to use, and effectively capture particles within a specific size range. They are also compatible with various detection methods. However, they exhibit low collection efficiency and may desiccate microorganisms during sampling. Conversely, filter-based samplers provide volumetric data in one test and can detect low concentrations of bacteria and resistance genes using specific targeted methods. Their drawbacks include the need for advanced laboratory skills for DNA extraction and sequencing and the risk of missing information if using the metagenomic method.

Bioaerosol samples were collected from two farms using both a filter-based and an impactor sampler. With the impactor, 3-6 colonies were selected per genus of importance to veterinary medicine and public health from both gram-positive and gram-negative bacteria. Metagenomic shotgun sequencing was performed for the filter sampler. For Sample One, the filter sampler detected aminoglycosides, penicillins, macrolides, lincosamides, and tetracyclines. However, the impactor also identified cephalosporins, carbapenems, fluoroquinolones, and sulfonamides—antibiotic classes not detected by the filter sampler. For Sample Two, both samplers detected aminoglycosides, penicillins, macrolides, and tetracyclines; the impactor additionally detected cephalosporins and lincosamides. These results indicate that while the filter sampler provides useful AMR predictions, the impactor captures a broader spectrum of resistant phenotypes, highlighting the need for multiple sampling methods for comprehensive AMR surveillance.

Capacity Building

Building Research Capacity to Improve Cryopreservation Techniques for Llama Semen in Argentina

Kathiravan Periasamy and Rudolf Pichler

Llamas play a pivotal role in the highland agriculture of South America, where they have been integral to the livelihoods of Andean communities for thousands of years. These versatile animals are not only valued for their high-quality wool, but also for their utility as pack animals capable of navigating the rugged mountainous terrain. Additionally, their relatively low impact on the environment, due to their soft-padded feet and efficient grazing habits, helps to preserve the fragile highland ecosystems. In the face of climate change and economic challenges, the multifunctional role of llamas in highland agriculture underscores their importance as a sustainable resource for food security, economic stability, and cultural heritage in the region.

Researcher from CONICET, Argentina receiving hands on training on semen packaging at APHL

Breeding programs for Llamas aim to enhance desirable traits such as fiber quality, disease resistance, and reproductive efficiency through selective breeding and advanced reproductive technologies like artificial insemination and embryo transfer. Cryopreservation of llama semen is an emerging field with significant potential for advancing genetic conservation and breeding programs. Currently, research focuses on optimizing cryopreservation techniques to ensure high post-thaw sperm viability and functionality. Key challenges include the unique structural characteristics of llama sperm, which require specific cryoprotectants and freezing protocols.

Recent studies have made progress in identifying optimal cooling rates, cryoprotectant concentrations, and thawing procedures, resulting in improved post-thaw motility and fertility rates. Despite these advancements, further research is needed to fully understand the impact of cryopreservation on llama sperm and to develop standardized protocols that can be widely adopted. The Faculty of Agronomy, Animal Husbandry and Veterinary Medicine, National Council for Scientific and Technical Research (CONICET), Tucumán, Argentina is working to improve the cryopreservation techniques for llama semen through proteomic approaches. APHL provided technical and equipment support to CONICET for packaging of llama semen and improving the process of freezing. Prof. Silvana A Apichela, researcher, CONICET visited APHL and was provided training along with required transfer of equipment, reagents and laboratory supplies.

Building Research Capacity to Improve Farm Environment Sampling Techniques for Detection and Characterization of AMR

Kathiravan Periasamy and Jing Wang

Bioaerosol sampling for the detection of antimicrobial resistance (AMR) in animal farms is one of the methods for monitoring the spread of resistant bacteria and genes in agricultural environments. This process involves collecting air samples from farm facilities where animals are housed and raised, as these environments can harbor high concentrations of airborne microorganisms, including bacteria that have developed resistance to antibiotics. The collected samples are then analyzed using microbiological and molecular techniques to identify and quantify the presence of AMR genes and resistant bacterial strains. This method provides valuable data on the dissemination of AMR within animal farming operations, helping to inform strategies for mitigating the spread of resistance from animals to humans and the broader environment. However, bioaerosol samples for AMR surveillance in animal farms presents several technical challenges.

The heterogeneous and dynamic nature of bioaerosols complicates the collection process, as particle size, concentration, and composition can vary significantly with changes in animal activity, ventilation, and environmental conditions. Efficiently capturing a representative sample of airborne microbes requires specialized sampling equipment and techniques, such as impingers, impactors, and filter-based systems, each with its own limitations in efficiency and specificity. Further, the subsequent analysis of bioaerosol samples is technically demanding, requiring sophisticated molecular techniques like quantitative PCR, amplicon sequencing and metagenomics to accurately identify and quantify AMR genes and resistant bacteria. These methods must be sensitive enough to detect low concentrations of resistance markers amidst a complex background of non-resistant microbes and environmental contaminants. Moreover, differentiating between viable and non-viable organisms in the samples adds another layer of complexity, as it is crucial for understanding the potential for AMR transmission. Ensuring the reliability and reproducibility of results under these varying conditions

requires rigorous standardization of sampling and analytical protocols.

Impactor bioaerosol samplers for detection and characterization of AMR in animal farms

To address these existing capacity and knowledge gaps in optimally utilizing bioaerosol samplers in farm animal settings, APHL provided technical and equipment support (impactor bioaerosol samplers) to three countries (China, Tunisia, and Pakistan) for strengthening research capacities on environmental sampling techniques to detect and characterize AMR. This support aims to strengthen research infrastructure and foster collaboration among international research communities. The three research groups, based in China (School of Environmental Science and Engineering, Tianjin University, Tianjin), Tunisia (Institut de la Recherche Vétérinaire de Tunisie, Tunis), and Pakistan (Institute of Biochemistry & Biotechnology, University of Veterinary & Animal Sciences, Lahore) will conduct a coordinated research programme in partnership with APHL. This collaboration will focus on validating bioaerosol sampling methods and developing analytical protocols applicable to both high and low input animal production settings. The ultimate goal is to transfer this knowledge to other animal and public health professionals and researchers in the Members States, thereby enhancing global capabilities in addressing the threat of AMR.

Updates on Selective Culling in ASF Control

In the ongoing battle against African Swine Fever (ASF), a strategic method known as "selective culling," or the "tooth extraction" approach, has become increasingly applied. This method entails removing only the sick and suspect animals from the herd, thereby preserving as many healthy animals as possible. This strategy is especially crucial in regions with valuable breeding sows, aiming to minimize economic losses. However, the absence of a standardized protocol based on scientific considerations has led to inconsistent implementations across affected farms. Our recent analysis focused on a large sow farm in Vietnam, which houses approximately 1,200 sows and has endured two major ASF outbreaks with significant impacts. The initial outbreak necessitated extensive culling based solely on clinical signs—a practice that unfortunately allowed the virus to persist on the farm longer than necessary. Our findings underscore the necessity for early diagnosis and consistent removal of infected pigs. In response to these challenges, a significant adjustment was made during the ongoing second wave; the strategic housing pattern was altered so that sows are spaced with empty stalls in between, substantially reducing transmission risks.

Field Visit Findings: During a recent farm visit, three lethargic sows were found to be positive for ASF when tested via qPCR and ELISA.

Recommendations for Optimized Control

1. Early and Accurate Diagnosis: Implementing regular and reliable diagnostic testing is essential to confirm ASF at early stages.

2. Strategic Animal Removal: Infected animals should be promptly removed from the population to prevent further spread.

3. Enhanced Biosecurity Measures: Robust biosecurity protocols are vital to prevent inter-farm spread and new infections.

Onsite DNA extraction and amplification for the detection of ASF disease on a Vietnamese sow farm

Conclusion: Selective culling presents a resource-saving alternative to total herd eradication. However, its success heavily relies on precise and quick actions based on robust diagnostics and stringent biosecurity measures. As ASF continues to pose a significant threat to the pig farming industry, refining these strategies is crucial for effectively managing the disease and sustaining the livelihoods dependent on pig farming.

Fellows, Interns, Consultants

Ms Yuetong Ma, from China, joined the Joint FAO/IAEA Centre, as an intern in February 2024 to support the ZODIAC initiative, primarily focusing on Pillar 3. Yuetong's main role involves developing Animal Health Monitoring Systems to streamline workflows for effective monitoring and disease control. Her key tasks include data management and processing, integrating multi-tier spatial and temporal data into interactive tools, and designing a user-friendly platform for GIS-based data visualization and analysis, ensuring accessibility and efficiency in decision-making processes.

Mr Wend-Benedo Geoffroy Kinda from Laboratoire de Biologie et santé animals, Institut de l'Environnement et de Recherches Agricoles (INERA-CREAF), Ouagadougou, Burkina Faso was trained at APHL, Seibersdorf on "Genotyping local chicken ecotypes of Burkina Faso for genetic characterization" for two months (29 January to 29 March 2024) under the IAEA fellowship (FS-BKF5022-2207333).

Ms Hiracema de Jesus Inacio from Agricultural Research Institute of Mozambique, Directorate of Animal Science, Maputo, Mozambique was trained at APHL, Seibersdorf on "Genetic characterization of indigenous Mozambique sheep" for three months (12 February to 10 May 2024) under the IAEA fellowship (FS-MOZ5011-2302326-001).

Ms Loukaiya Zorobouragiu from Benin is undergoing her internship training at APHL, Seibersdorf on "Genomic diversity, population structure and genetic admixture in Benin cattle" for six months from 15 January to 12 July 2024.

Ms Tafara Kundai Mavunga from Zimbabwe is undergoing her internship training at APHL, Seibersdorf on "Genomic characterization of indigenous livestock breeds" for one year from 3 July 2023 to 28 June 2024.

Mr Saidu Kanu from University of Makeni, Makeni, Sierra Leone visited APHL, Seibersdorf as a scientific visitor on "Antimicrobial Resistance in Livestock Systems" for one week (3 to 7 June 2024) under the IAEA project SIL5023 (SV-SIL5023-2400847).

Ms Juliana Nabuco Pereira Otaka from the Federal Agricultural Defense Laboratory (LFDA-SP) of the Ministry of Agriculture and Livestock (MAPA), Brazil was trained at APHL on the next generation sequencing (Ion S5 Platform), third generation sequencing (Nanopore and PacBio), bioinformatics and phylogenetic from 5 March to 31 May 2024.

Mr Christian Steffe Domingues from the Federal Agricultural Defense Laboratory (LFDA-SP) of the Ministry of Agriculture and Livestock (MAPA), Brazil was trained at APHL on the next generation sequencing (Ion S5 Platform), third generation sequencing (Nanopore and PacBio), bioinformatics and phylogenetic from 5 March to 31 May 2024.

Coordinated Research Projects (CRPs)

Project Number	Title	Project Officers
D31030	Improving Efficiency of Animal Breeding Programs Using Nuclear Related Genomic Information – Practical Applications in Developing Countries	V. Tsuma K. Periasamy
D31031	Nuclear and Related Techniques to Measure the Impact of Type of Feeding and Production System on Greenhouse Gas (GHG) Emissions and Livestock Productivity	V. Tsuma
D32034	Use of Stable Isotopes to Trace Bird Migrations and Molecular Nuclear Techniques to Investigate the Epidemiology and Ecology of the Highly Pathogenic Avian Influenza - Phase II	I. Naletoski
D32035	Improvement of Diagnostic and Vaccine Tools for Emerging and Re-emerging Animal Health Threats	C. Bravo de Rueda V. Wijewardana
D32036	Application of Advanced Molecular Characterization Technologies Through the Veterinary Diagnostic Laboratory Network (VETLAB Network)	I. Naletoski
D32037	Novel Test Approaches to Determine Efficacy and Potency of Irradiated and Other Vaccines	V. Wijewardana C. Bravo de Rueda
D32038	Enhancing laboratory preparedness for the detection and control of emerging and re-emerging zoonotic diseases – ZODIAC in the Americas and the Caribbean	C. Lamien
D32039	Enhancing laboratory preparedness for the detection and control of emerging and re-emerging zoonotic diseases – ZODIAC in Asia and the Pacific	C. Lamien
D32040	Enhancing laboratory preparedness for the detection and control of emerging and re-emerging zoonotic diseases – ZODIAC in Europe and Central Asia	C. Lamien
D32041	Enhancing laboratory preparedness for the detection and control of emerging and re-emerging zoonotic diseases – ZODIAC in Africa	C. Lamien
D32043	Innovative Nuclear and Related Molecular Approaches for Detection and Characterization of Antimicrobial Resistance in Animal Production Environment	K. Periasamy

Submission of Proposals

Research contract proposal forms can be obtained from IAEA, the National Atomic Energy Commissions, UNDP offices or by contacting a Project Officer. The form can also be downloaded from http://cra.iaea.org/cra/index.html

Improving Efficiency of Animal Breeding Programs Using Nuclear Related Genomic Information – Practical Applications in Developing Countries (D31030)

Victor Tsuma and Kathiravan Periasamy

The Coordinated Research Project (CRP) aims to enable use of nuclear and related genomic technologies in Member States to enhance the efficiency of national breeding programmes for increased milk productivity and dairy animal adaptability to the production environment. Specifically, the CRP aims to a) develop nuclear and related genomic tools/resources such as radiation hybrid maps and DNA microarrays for tropical dairy species, and b) identify genomic regions of importance for milk and adaptability traits in local dairy animal populations, c) establish strategies to incorporate genomic information for selection and breeding of dairy animals, and d) develop and validate radiolabelled biomarker assays for early pregnancy diagnosis in cattle. Three major dairy animal species viz. cattle, buffalo and camel have been targeted. Eleven

research contracts awarded to institutes in 10 developing countries from Africa, Asia and Latin America. Year two project activities have successfully been implemented and sample and data analysis are ongoing.

Nuclear and Related Techniques to Measure the Impact of Type of Feeding and Production System on Greenhouse Emissions and Livestock Productivity (D31031)

Victor Tsuma

This Coordinated Research Project (CRP) aims to enable the Member States (MS) of the IAEA, particularly in developing countries, to use nuclear and related technologies and resources to optimize livestock feeding practices that reduce greenhouse gas (GHG) emissions and help mitigate climate change. Specifically, the CRP aims to a) evaluate nitrogen and energy supplementation strategies in cattle feeding to mitigate enteric and manure GHG emission, b) to develop and/or validate nuclear and related tools/resources for nutrition related GHG mitigation in cattle production, and c) to provide MS with tools and mechanisms to monitor livestock GHG emissions. Targeted are dairy cattle production systems. The 10 research contracts awarded to institutes in 10 developing countries from Africa, Asia and Latin America have successfully implemented year two project activities and sample, data analysis and dissemination of research findings are progressing well. Studies from Brazil and Indonesia have demonstrated benefits of some non-conventional fodder species and Green Medicated Supplement, respectively, in livestock feeding strategies for reduction of animal production related GHG emissions.

Use of Stable Isotopes to Trace Bird Migrations and Molecular Nuclear Techniques to Investigate the Epidemiology and Ecology of the Highly Pathogenic Avian Influenza Phase II (D32034)

Ivancho Naletoski

The aim of this Coordinated Research Project (CRP) is to evaluate the origin of wild birds that carry Avian Influenza (AI) and other potentially dangerous pathogens at their stopover places and match the obtained results with the knowledge obtained through conventional migration monitoring approaches.

Stable isotopes (SI) are promising huge potential when the origin (migration) of individual wild birds is required, because the probability of capturing a labelled bird with specific characteristics (disease carrier) using conventional methods is negligible.

Knowledge and experience obtained through the previous project (D32030 - Use of Stable Isotopes to Trace Bird Migrations and Molecular Nuclear Techniques to Investigate the Epidemiology and Ecology of the Highly Pathogenic Avian Influenza) will be of great value for the success of this project.

The use of SI in migration studies of wild animals, including wild birds, primarily in environmental protection studies and conservation activities, has attracted the attention of the scientific community; however, this technique can also be used in epidemiological studies that target long-range transmission of animal pathogens.

The development and maintenance of the IAEA Global Network of Isotopes in Precipitation (GNIP) became a significant facilitator of these studies, as it offered geo-spatial reference values for correlation of the SI ratios in the animal tissues (especially metabolically inert tissues like beaks, claws and feathers) and the SI ratios in the environment (especially open waters).

During the first phase of this CRP, several important steps in the linking of SI ratios of feather samples (bird migrations) with the epidemiology of AI were established. Achievements of project D32030 have shown not only that the isotope assignment works, but also have delivered a full package of techniques that will strengthen and supplement (SI component) the official wild bird monitoring programmes of Member States.

In the current project, the partners will focus on two critical issues:

a) detecting birds that carry avian influenza viruses and eventually other dangerous pathogens, and

b) evaluating stable isotope ratios in feathers of these birds (only the pathogen carriers) to understand their origins and migration pathways.

During the last reporting period (2021-2023) the counterparts have detected 213 wild birds positive with influenza A virus and performed characterization of the pathogens (84 from the Russian Federation, 45 from Republic of Korea, 18 from Iran, 14 from Nigeria and 52 from Romania). Feathers from these birds were thermically and chemically treated and sent to the laboratory of the technical partner at the “Environment and Climate Change Canada and Dept. Biology, University of Western Ontario, Canada” for determination of the origins using the stable isotope ratios.

Improvement of Diagnostic and Vaccine Tools for Emerging and Re-emerging Animal Health Threats (D32035)

Carla Bravo de Rueda and Viskam Wijewardana

Vaccination has proven to be the best preventive measure against infectious diseases. Despite significant successes, there are several limitations to the currently practiced approaches. In veterinary medicine, the application of vaccines by injection frequently limits their use for small ruminants and poultry. This practice requires well-trained staff taking care to practice the utmost hygiene and maintain vaccine cold chain. Further, also in poultry rearing it is not easy to inject individual birds. In addition to that, injected vaccines rarely induce production of specific mucosal antibodies (IgA) covering the mucosal tissues in the nose, mouth and lungs, which are the primary site of multiplication for bacteria or viruses before they provoke a systemic infection. Such IgA antibodies can efficiently be induced by 'mucosal' vaccines, i.e. formulations that are applied to the nose, mouth or eyes. These mucosal vaccines, especially eye drop vaccines, have the big advantage in requiring small volumes as the vaccine dose. Therefore, the application can be done by village vaccinators and the cold chain will be relatively easy to maintain.

Recent experiments on formulating such mucosal vaccines have presented a number of challenges: a) low viscosity leading to spills; b) unsuitable components for freeze drying; and c) the process of formulating the components appropriately. Among the latest development of this Coordinated Research Project is the research on Fowl cholera (FC) caused by Pasteurella multocida conducted in Ethiopia. When the irradiated FC vaccine was administered to chickens through intranasal and intraocular routes, a 100% protection was observed, as compared to a much lower rate with intramuscular injection. This work is now published in the major research journal "Frontiers in Immunology". Pakistan has improved their viral vaccine production titres significantly using a Celcradle system and have also shown efficacy of their ocular vaccines by improving its immune response. This work has been published in the 13th International Conference on Goats and the Animal Production and Health symposium. Indonesia has shown progress on the irradiation of the bacteria with maintenance of metabolic activity; in addition, they have further characterized chitosan as a vaccine carrier and immune modulator. Kenya has shown progress on pathogens detection by PCR and has initiated students' programmes; they will soon be starting to test the developed vaccines against New Caste and Gumboro in poultry. Cameroon has also made some advances on the area and is now studying the different routes of vaccines administration against PPR. The next research coordination meeting will be in 2025.

Application of Advanced Molecular Characterization Technologies Through the Veterinary Diagnostic Laboratory Network (VETLAB Network) (D32036)

Ivancho Naletoski and Charles Lamien

The Animal Production and Health Section (APH) of the Joint FAO/IAEA Centre has established a free-of-charge Sanger sequencing service for all counterparts of the subprogramme. So far, over 4000 samples have been submitted for Sanger sequencing by 30 counterpart laboratories (mainly partners in the VETLAB Network) and the results were published in 27 articles in peer reviewed journals.

The APH intends to upgrade this service with additional workflows which should enable counterparts' access to service-based Whole Genome Sequencing (WGS) including the possibility for metagenomic analysis.

Such workflows need to be validated, primarily for biological inactivation of the field samples prior to submission, as well as regarding the quality of the DNA / RNA extracted from the field samples. Additionally, standardized bio-informatic package for processing of the raw data and further phylogenetic analysis needs to be validated and verified for use by the counterpart community. In order to perform these activities, a new Coordinated Research Project (CRP) was developed and approved by the management of IAEA. Priority targets for this CRP will be the established users of the Sanger sequencing service of APH. However, the final objective of the CRP is to further disseminate the validated workflows to the wider counterparts' community.

Novel Test Approaches to Determine Efficacy and Potency of Irradiated and Other Vaccines (D32037)

Viskam Wijewardana and Carla Bravo de Rueda

The objective of this Coordinated Research Project (CRP) is to enhance the assessment efforts of irradiation and other new vaccines, along with the use of cutting-edge techniques, in order to ascertain the immune response and develop immunological instruments for the purposes of quality control and effectiveness.

In order to comprehend the immune response elicited by the particular vaccination and the fundamental techniques used to assess it, this CRP needs input from each participant. These new processes are anticipated to enhance the ability of vaccine production laboratories to conduct more effective quality control of their products in the future. The use of a

more technical approach will enhance the reliability of the outcomes, leading to increased trust. A total of six research contracts have been granted under this CRP, namely in Cameroon, Ethiopia, Indonesia, Iran, Sri Lanka, and Tunisia. Additionally, there have been five agreements made with Ethiopia, the United Kingdom, China, Germany and the Republic of Korea. Furthermore, one technical contract has been issued in Italy. Five research contract holders have identified the vaccine candidate strains, have optimized the protocols for in-vitro expansion and conducted the preliminary irradiation experiments to identify the inactivation dose.

Enhancing Laboratory Preparedness for the Detection and Control of Emerging and Re-emerging Zoonotic Diseases (D32038, D32039, D32040 & D32041)

Multiple zoonotic diseases have impacted public health, peoples' livelihoods, and the global economy in the last few decades. The COVID-19 pandemic is the most recent severe threat, which will have a long-term and far-reaching influence on the population and economy worldwide.

Surveillance and early detection tools and technologies are the critical links in the chain of disease control. They enable the rapid discovery of source and movement of pathogens as well as analysis, planning, and decision-making through the design and implementation of preventive or control measures.

Nuclear, nuclear-derived and -related techniques are reliable tools that can help scientists to investigate, prevent, detect, and contain outbreaks of zoonotic diseases. In addition, the IAEA has considerable experience in assisting the Member States in building their capacity to detect and characterize pathogens early and diagnose diseases rapidly and accurately. Moreover, the IAEA has developed or contributed to developing early detection and characterization tools, nowadays recognized as international testing standards.

Over the last few decades, technological development has enabled miniaturization and multiplexing of diagnostic assays, thus opening new windows in understanding the ecology and evolution of zoonotic pathogens. Next-generation sequencing, nanopore sequencing, and metagenomics-based approaches will enable novel pathogen characterization and discovery and will help to find potential reservoirs, vectors and additional susceptible hosts for known zoonotic pathogens.

ZODIAC in the Americas and the Caribbean (D32038)

Charles Lamien

The ZODIAC CRP for the Americas and the Caribbean aims to develop and validate immunological and molecular tools under Pillar 2 of the ZODIAC project. In this way empowering national and regional disease surveillance programmes in the Americas and the Caribbean to identify potential sources of pathogen spill over to humans and identify emerging- and/or re-emerging pathogens with zoonotic risk.

ZODIAC in Asia and the Pacific (D32039)

Charles Lamien

The ZODIAC CRP for Asia and the Pacific aims to develop and validate immunological and molecular tools under Pillar 2 of the ZODIAC project. In this way empowering national and regional disease surveillance programmes in Asia and the Pacific to identify potential sources of pathogen spill over to humans and identify emerging- and/or re-emerging pathogens with zoonotic risk.

ZODIAC in Europe and Central Asia (D32040)

Charles Lamien

The ZODIAC CRP for Europe and Central Asia aims to develop and validate immunological and molecular tools under Pillar 2 of the ZODIAC project. On this way empowering national and regional disease surveillance programmes in Europe and Central Asia to identify potential sources of pathogen spill over to humans and identify emerging and/or re-emerging pathogens with zoonotic risk.

ZODIAC in Africa (D32041)

Charles Lamien

The ZODIAC CRP for Africa aims to develop and validate immunological and molecular tools under Pillar 2 of the ZODIAC project. In this way empowering national and regional disease surveillance programmes in Africa to identify potential sources of pathogen spill over to humans and identify emerging- and/or re-emerging pathogens with zoonotic risk.

Innovative Nuclear and Related Molecular Approaches for Detection and Characterization of Antimicrobial Resistance in Animal Production Environment (D32043)

Kathiravan Periasamy

Antimicrobial resistance is an important global health concern and is considered to be a pandemic in silence causing more than one million deaths annually. Antimicrobial drugs are used in animals for therapeutic, prophylactic and growth promotion purposes. Emergence and transmission of AMR in animal production systems is a major issue, considering the fact that more than two-thirds of antibiotics sold globally are used on animals. A bulk of this is used as growth promoters for improving production efficiency. Hence, identifying effective alternatives will be an important approach to reduce antimicrobial usage in animal production settings. Further, national AMR surveillance programmes have mostly focused on the detection of AMR in human health and in animals for food safety purposes, but not in animal production facilities. AMR surveillance in animal production settings is constrained by lack of (i) guidelines and harmonized sampling methodologies (ii) cost-effective technologies for AMR detection (iii) effective alternatives to antibiotic growth promoters and (iv) appropriate biosecurity measures to improve herd health and reduce the use of antimicrobials in farm animals. This project aims to enable developing member states (MSs) use innovative nuclear and related approaches for enhancing the efficiency and effectiveness of national AMR surveillance programmes and promoting good husbandry practices to mitigate AMR in animal production settings. Specifically, it aims to (i) develop, evaluate and validate farm-level sampling methods for detection of AMR in high and low-input animal production environments (ii) establish AMR distribution characteristics in high and low input animal production environments using nuclear, molecular and microbiological techniques (iii) assess the efficacy of alternatives to antibiotic growth promoters (AGPs) as feed additives in animal production settings (iv) establish scientific evidence on development and transmission of AMR at animal-human-environment interface (v) evaluate and optimize phenotyping and genotyping methodologies related to drug resistance in animal infections other than bacteria (vi) pilot and recommend good husbandry practices or antimicrobial stewardship that aim to reduce the risk of emergence and occurrence of AMR in farm animal settings. Three major animal production systems viz. pig, chicken and cattle will be targeted. Nuclear techniques like Raman spectroscopy based stable isotope probing (SIP) and stable isotope linked amino acids (SILAC) will be used to develop novel phenotyping and genotyping methods for AMR characterization. Isotopic methods involving 60Cobalt will be used to produce metabolically active but non-replicative bacteria as candidate para probiotic and potential alternative to antibiotic growth promoters. The project will run for five years and will involve 8 Research Contract (RC) holders from developing countries, three Technical Contract (TC) holders and three Research Agreement (RA) holders from laboratories engaged in high level research on AMR and One Health.

Technical Cooperation Projects

Country TC Number	Description	Technical Officer(s)
Algeria ALG5032	Strengthening the Capacity of the Central Veterinary Laboratory, Regional Laboratories and the Early Warning Laboratories in the Detection, Confirmation of Diagnosis and Surveillance of Animal and Zoonotic Diseases	I. Naletoski
Angola ANG5016	Recovering the Vaccine Production Unit and Monitoring Active Animal Immunity	V. Wijewardana C. Bravo de Rueda
Angola ANG5017	Optimizing Pasture Utilization for Improved Livestock Productivity	V. Tsuma
Belize BZE5013	Strengthening national capacities for the early detection and rapid response on shrimp diseases	I. Naletoski C. Bravo de Rueda
Benin BEN5014	Improving Sheep and Pig Productivity and Livestock Traceability	V. Tsuma
Botswana BOT5026	Reducing the Impact of Transboundary Diseases and Strengthening Livestock Breeding Programme	F. Muchadeyi C. Lamien

Country TC Number	Description	Technical Officer(s)
Burkina Faso BKF5022	Improving Local Poultry and Local Goat Productivity through Health, Diet, Reproduction, Genetic Markers for Selection and Breeding Management	V. Tsuma
Burundi BDI5002	Improving Animal Production Through Enhanced Application of Nuclear and Related Techniques	C. Bravo de Rueda I. Naletoski V. Tsuma
Burundi BDI5006	Improving Milk and Livestock Production	V. Wijewardana V. Tsuma
Cambodia KAM5009	Improving Livestock Productivity and Control of Transboundary Animal Diseases	V. Tsuma
Cambodia KAM5010	Strengthening National Capability for Antimicrobial Resistance Surveillance	K. Periasamy
Cameroon CMR5024	Improving Goat and Sheep Productivity in Rural Areas Using Nuclear-Derived Techniques for Genetic Marker Identification, Reproduction Harnessing and Feed Analysis	V. Tsuma
Cameroon CMR5027	Controlling Foot and Mouth Disease and Contagious Bovine Pleuropneumonia	C. Lamien V. Wijewardana
Central African Republic CAF5010	Building National Capacities for the Diagnosis and Control of Animal Diseases and for Increasing Animal Production	C. Bravo de Rueda
Chad CHD5008	Improving Bovine Productivity Using Artificial Insemination	V. Tsuma
Chad CHD5010	Eradicating Pests in Small Ruminants Using Nuclear Technology	C. Bravo de Rueda
Chad CHD5013	Improving Livestock Feed Using Nuclear Techniques	V. Tsuma
Chile CHI0022	Building Capacity for Nuclear Science and Technology Applications	C. Bravo de Rueda
China CPR5029	Improving Feeding Low Protein Diets in Dairy Cows Using Stable Isotope Labelled Techniques	V. Tsuma
Congo PRC6002	Contributing to the Epidemiological Surveillance of Neglected Tropical Diseases	C. Bravo de Rueda
Côte d'Ivoire IVC5043	Applying Nuclear and DNA-Based Techniques to Improve Productivity of Local Livestock	V. Tsuma
Côte d'Ivoire IVC5044	Applying Nuclear and Molecular (DNA) Techniques to Improve Local Cattle Productivity	V. Tsuma K. Periasamy
Cuba CUB5026	Improving the Rapid Detection and Early Warning System of Diseases that Affect Animals of Economic and Social Importance	C. Bravo de Rueda
Dominican Republic DOM0006	Building and Strengthening the National Capacities and Providing General Support in Nuclear Science and Technology	C. Bravo de Rueda
El Salvador ELS5014	Strengthening National Capacities for the Control of Brucellosis	I. Naletoski
Eritrea ERI5015	Enhancing Laboratory Diagnostic Testing Capacity for Brucellosis, Sheep Pox and Leishmaniosis at the National Animal and Plant Health Laboratory	C. Bravo de Rueda
Grenada GRN0001	Building National Capacity through the Applications of Nuclear Technology	V. Tsuma

Country TC Number	Description	Technical Officer(s)
INT5157	Supporting National and Regional Capacity in Integrated Action for Control of Zoonotic Diseases	I. Naletoski
Kenya KEN5039	Using Nuclear and Nuclear Related Technologies for Sustainable Livestock Productivity	V. Tsuma
Kingdom of Eswatini SWA5001	Reducing the Incidence and Impact of Transboundary Animal and Zoonotic Diseases	C. Bravo de Rueda
Kyrgyzstan KIG5001	Establishing Effective Testing and Systematic Monitoring of Residues and Food Contaminants and of Transboundary Animal Diseases	I. Naletoski
Lao P.D.R. LAO5007	Strengthening National Animal Health Laboratory Network	C. Bravo de Rueda
Lesotho LES5013	Improving Animal Health and Production Using Nuclear Related Techniques	F. Muchadeyi
Madagascar MAG5029	Achieving Food Security and Improved Nutrition through Sustainable Livestock Breeding	V. Tsuma
Madagascar MAG5027	Improving Livestock Production through Artificial Insemination and Disease Control	V. Tsuma
Malawi MLW5004	Strengthening Capacity for the Diagnosis and Control of Mastitis in Dairy Cattle	C. Bravo de Rueda
Malaysia MAL5034	Strengthening National Capacity and Capability in Nuclear and Molecular Techniques in Supporting Transboundary Animal and Zoonotic Diseases of Veterinary Public Health Significance	C. Bravo de Rueda
Mauritania MAU5010	Enhancing National Capabilities for the Control of the Incidence and Impact of Viral Diseases	C. Bravo de Rueda
Mexico MEX5033	Sustainable Production of Sheep and Goats in Mexico using Nuclear and Nuclear Related Techniques	V. Tsuma
Mongolia MON5026	Improving the Diagnosis and Treatment of Transboundary Animal Diseases with Potential Pandemic Patterns	C. Bravo de Rueda
Montenegro MNE5005	Enhancing Capacity of the National Veterinary Laboratory for Detection of Highly Contagious Animal Diseases	I. Naletoski
Morocco MOR5040	Improving the Productivity of Livestock and Crops	I. Naletoski
Mozambique MOZ5011	Using Nuclear and Nuclear Related Techniques to Improve Animal Health and Breeding	C. Lamien
Mozambique MOZ5014	Strengthening Animal Health Through the Use of Nuclear and Nuclear Related Techniques to Improve Quality Vaccines Production and Early Disease Diagnostics	V. Wijewardana W. Dundon
Myanmar MYA5030	Advancing National Capacities to Detect and Respond to Transboundary Animal Diseases	C. Bravo de Rueda
Myanmar MYA5032	Advancing National Laboratory Capacities to Detect and Respond to Transboundary Animal Diseases and Zoonoses — Phase II	I. Naletoski
Nepal NEP5008	Reducing the Incidence of Brucellosis in Animals and Humans through Surveillance and Control	I. Naletoski
Nepal NEP5010	Enhancing Animal Productivity through Integrated Management of Nutrition, Reproduction, and Health using Nuclear and Molecular Techniques	I. Naletoski V. Tsuma

Country TC Number	Description	Technical Officer(s)
Nigeria NIR5041	Improving Livestock Productivity through Enhanced Nutrition and Reproduction Using Nuclear and Molecular Techniques	V. Tsuma
North Macedonia MAK5011	Improving National Capacities for Early Detection and Characterization of Emerging and Re-emerging Animal Diseases with Strong Economic Consequences and Upgrade of the Bio Risk Management at the National Laboratory	I. Naletoski
Oman OMA6009	Building and Strengthening Technical Capacity to Prevent and Respond to Outbreaks of Viral Diseases	C. Bravo de Rueda
Pakistan PAK5052	Improving Livestock Productivity Using Nuclear and Related Techniques by Exploiting Indigenous Feed Resources while Reducing Enteric Greenhouse Gas Emissions	C. Bravo de Rueda
Pakistan PAK5053	Strengthening and Enhancing National Capabilities for the Development of Climate Smart Crops, Improvement in Animal Productivity and Management of Soil, Water, and Nutrient Resources Using Nuclear and Related Techniques	V. Tsuma C. Bravo de Rueda
Palau PLW5004	Establishing Technical Capability in Animal Production and Disease Control	C. Bravo de Rueda
Papua New Guinea PAP5004	Improving Reporting of the Incidence and Prevalence of Animal Health and Diseases Using Nuclear Derived Techniques	I. Naletoski
Papua New Guinea PAP5006	Improving Reporting of the Incidence and Prevalence of Animal Health and Diseases using Nuclear Derived Techniques — Phase II	I. Naletoski
Qatar QAT5010	Supporting the Serological, Molecular, and Virological Study of Peste des Petits Ruminants	I. Naletoski
RAF5082	Enhancing Veterinary Diagnostic Laboratory Biosafety and Biosecurity Capacities to Address Threats from Zoonotic and Transboundary Animal Diseases (AFRA)	I. Naletoski
RAF5089	Strengthening the Capacities of National Veterinary Laboratories for the Early Warning, Control and Prevention of Outbreaks of Animal and Zoonotic Diseases (AFRA)	C. Bravo de Rueda
RAF5090	Supporting Climate Change Adaptation for Communities Through Integrated Soil–Cropping–Livestock Production Systems (AFRA)	V. Tsuma
RAF5092	Enhancing Agricultural Productivity for Improved Food Security in Africa (AFRA)	F. Muchadeyi C. Lamien
RAS5085	Using Nuclear Derived Techniques in the Early and Rapid Detection of Priority Animal and Zoonotic Diseases with Focus on Avian Influenza	C. Bravo de Rueda I. Naletoski
RAS5100	Strengthening Regional and National Surveillance Capacity and Capability Through Nuclear and Molecular Techniques for Priority Animal and Zoonotic Diseases and Potential Vector-Borne Diseases	C. Bravo de Rueda
RER5027	Enhancing Preparedness Capacities of the Veterinary Sector to Confront with Emerging and Re-emerging Diseases of Livestock and Wildlife	I. Naletoski
RLA5084	Developing Human Resources and Building Capacity of Member States in the Application of Nuclear Technology to Agriculture	C. Bravo de Rueda
RLA5085	Strengthening the Capacity of Official Laboratories for Monitoring and Response to an Outbreak of Priority Animal and Zoonotic Diseases (ARCAL CLXXIV)	C. Bravo de Rueda I. Naletoski
RLA5086	Decreasing the Mortality Rate of Rainbow Trout Associated with Infectious Pancreatic Necrosis Virus and Emerging Diseases Using Molecular and OMIC Techniques (ARCAL CLXXV)	C. Bravo de Rueda

Country TC Number	Description	Technical Officer(s)
Senegal SEN5042	Using Nuclear and Related Techniques in Improving the Productivity of Domestic Ruminants	V. Tsuma
Serbia SRB5005	Upgrading and Strengthening the Capacities of National Reference Laboratories for Early Detection, Surveillance, and Control of Transboundary Animal Diseases in Outbreak Situations	I. Naletoski
Sierra Leone SIL5022	Enhancing Livestock Production and Artificial Insemination Programme to Increase Milk and Meat Production in Cattle	V. Tsuma
Sierra Leone SIL5023	Controlling Antimicrobial Resistance Parasites in Humans and Animals Using Nuclear Related Techniques	C. Bravo de Rueda K. Periasamy
Sri Lanka SRL5049	Supporting Control of Stomach Worm Infection in Goats	C. Bravo de Rueda V. Wijewardana
Sri Lanka SRL5053	Improving Buffalo Productivity using Assisted Reproductive Technologies, Genetic, Molecular, and Nutritional Analysis, and Forage Conservation Integrated with Nuclear Derived Techniques	K. Periasamy V. Tsuma
Tajikistan TAD5006	Applying Nuclear and Molecular Techniques for Diagnosis and Control of Transboundary Animal Diseases	I. Naletoski
Togo TOG5005	Enhancing Animal Production Using Artificial Insemination	V. Tsuma
Tunisia TUN5030	Enhancing Feed and Food Safety by Appropriate Management of Livestock Feed Resources for Safer Products	V. Tsuma
Tunisia TUN5032	Establishing a National Certified Pipeline to Produce Aquaculture Vaccines by Irradiation	V. Wijewardana R. Kangethe
Ukraine UKR5001	Building Laboratory Capacity for Diagnostics, Surveillance and Prevention of Emerging Animal Diseases	I. Naletoski
U.R. of Tanzania URT5036	Enhancing Artificial Insemination Services and Application of Radioimmunoassay Techniques to Improve Dairy Cattle Productivity	V. Tsuma
Uruguay URU5030	Introducing Genetic Traceability Technology for Improved Food Safety	V. Tsuma
Vanuatu NHE5003	Enhancing Livestock Production and Health	V. Tsuma C. Bravo de Rueda
Viet Nam VIE5024	Strengthening Diagnosis, Surveillance, and Control of Emerging Transboundary Animal and Zoonotic Diseases with Emphasis on African Swine Fever and Severe Acute Respiratory Syndrome Coronavirus 2	C. Bravo de Rueda
Viet Nam VIE5025	Applying Nuclear Related Technology for Selecting Climate Adapted Indigenous Swine and Chicken Breeds	V. Tsuma
Yemen YEM5017	Enhancing National Food Security through the Development of Climate Smart Crops and the Improvement of Livestock Productivity Using Nuclear Techniques	F. Muchadeyi V. Tsuma
Zimbabwe ZIM5024	Establishing an Artificial Insemination Center to Enhance the Rebuilding of the National Herd	V. Tsuma
Zimbabwe ZIM5025	Producing Theileriaparva and Other Tick Borne Disease Vaccines	C. Bravo de Rueda

Publications

Publications in Scientific Journals

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Impressum

Animal Production and Health Newsletter No. 80, July 2024

The APH Newsletter is prepared twice per year by the Animal Production and Health Section, Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture.

International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Printed by the IAEA in Austria, January 2024

24-02529