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A decade of collaboration on anti-tick vaccine research between SaBio-IREC-Spain and National Agricultural Research Organization-Uganda

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Abstract. These results are the outcome of ten years of collaboration between the Health and Biotechnology (SaBio) group at the Instituto de Investigación en Recursos Cinegéticos, IREC (CSIC-UCLM-JCCM), Spain, and the National Agricultural Research Organization (NARO), Uganda. The collaborative project evolved from initial controlled pen trials using a personalized vaccinology approach to develop an effective Subolesin-based vaccine against multiple cattle tick species, to field trials evaluating the vaccine's efficacy, effectiveness, and safety. Ultimately, the collaboration led to the successful transfer of vaccine production technology to Uganda. This partnership demonstrates how the challenge of limited access to biotechnological products in Sub-Saharan Africa can be addressed through sustained international cooperation.

Key words: Anti-tick vaccine, Cattle tick control, International collaboration, Sub-Saharan Africa, Technology transfer, Uganda

Precedents

Back in the nineties (1990s), Jose. de la Fuente then Director for R&D at the Center for Genetic Engineering, and Biotechnology (CIGB, Havana, Cuba) visited Uganda to establish a collaboration to evaluate the efficacy of the Bm86-based vaccine for the control of cattle tick infestations (Fig. 1). The collaboration was not established thus leaving the challenge of effective tick control unresolved. The need for innovative tick control solutions became even more pressing with the increasing resistance of ticks to conventional acaricides. Despite this challenge, scientific advances in vaccine development were limited in Uganda due to technological constraints, particularly in molecular biology, and biotechnological applications. This technological gap hindered the application of modern scientific tools in vaccinomics for the control of ticks, and tick-borne diseases.

Then, in 2015 an international collaboration on tick-borne pathogens in Uganda brought together researchers from Uganda, SaBio, IREC (Proboste *et al*., 2015). Building on this momentum, another strategic partnership emerged between IREC, SaBio, and NARO in Uganda (Fig. 2), resulting in the development of a Subolesin-based anti-tick vaccine, as reported by Kasaija *et al*. (2020) and Kabi *et al*. (2024). This collaboration was particularly impactful because it enabled Uganda scientists to gain

Figure 1. Cuban Scientist visiting EATRC, TORORO in Uganda, 1990s.

Figure 2. NARO Scientists visiting IREC, in Spain, 2018.

knowledge and advanced technological capacity required for vaccine development from Spanish partners. By leveraging Spanish partners' technological expertise, the collaboration bridged a critical gap, enabling the development of a novel solution to a pressing livestock health issue in Uganda.

Description of the collaboration

The effort to develop a Subolesin-based anti-tick vaccine brought together experts from Spain, and Uganda, each contributing unique skills to tackle the challenge of tick infestations affecting livestock in Uganda. The partnership combined advanced molecular research capabilities with local knowledge of tick species, and livestock systems thus creating a practical, and science-driven approach to vaccine development.

a) SaBio, IREC (Spain)
   SaBio (Health and Biotechnology) at the Institute for Game and Wildlife Research (IREC) contributed its expertise in animal health, particularly in host-pathogen interactions, and vacconomics to the design, and testing of the Subolesin-based vaccine. The team's strong background in molecular biology and immunology was key to the project. Principal investigators led different aspects of the research: José de la Fuente oversaw molecular, and immunological studies, leveraging his expertise in tick-host-pathogen interactions, and vaccine development; Marinela Contreras focused on vaccine design, formulation, and immunological analyses to assess effectiveness; and Christian Gortázar provided expertise in epidemiology with a focus on tick-borne diseases. The research team, including Marta Sánchez-Sánchez, Clara Muñoz-Hernández, Gabriela de la Fuente, Rubén Fernández-Melgar, Marta Rafael, Isabel G. Fernández de Mera, José F. Ruiz-Fons, and Isidro Sobrino, carried out laboratory-based molecular experiments, analyzed immunological responses, and coordinated research activities.

b) NARO (Uganda)
   The National Livestock Resources Research Institute (NaLIRRI), under Uganda's National Agricultural Research Organization (NARO), played a central role in evaluating the anti-tick vaccine by providing on-station, and field expertise, access to local tick populations, and knowledge of livestock management practices. Principal investigators led various aspects of the study: Fredrick Kabi managed field trials, assessed the vaccine's impact on livestock health and productivity, and oversaw data collection on tick infestations; Swidiq Mugerwa mobilized financial resources to enable implementation of the trials, supervised and coordinated vaccine trials, and contributed to report writing; Paul D. Kasaija led on-station vaccine studies; Jimmy Semakula led trial data collection, analysis and interpretation; and Justus Rutaisire integrated local insights into the study design, and helped organize research activities. The broader research team, including Halid Kirunda, Moses Matovu, Ivan Kyakuwa, Moses Dhikusooka, Godfrey Nsereko, Paul Boma, James Bugeza, Mwesigwa Moses, Nicholas Ssekabunga, and P. Emudong, supported fieldwork, data collection and analysis, animal management, and logistics. Their combined efforts ensured the vaccine was tested under real-world conditions.

c) Other Contributing Researchers (Independent Collaborators)
   Other researchers who supported the project with technical input and local perspectives: Agnes Namukasa, Okeny E. Adyero, Philip Obonyo, and A. Nanteza. Contributed to animal management, field data collection, stakeholder communication, and dissemination of findings.

Key achievements

The collaboration between SaBio, IREC, and NARO has made remarkable progress in developing sustainable solutions for the control of TTBDs for Uganda's livestock industry. This partnership combined advanced research expertise with local knowledge, leading to several key outcomes in scientific research, vaccine development, human capacity development, intellectual property, and international recognition. The achievements are elaborated on below.

a) Subolesin-based personalized anti-tick vaccine
   The Subolesin-based personalized vaccine was designed and evaluated in Ugandan field trials at different locations with safety and effectiveness higher than 95% against multiple tick species in cattle one year after administration of the first vaccine dose. This vaccine was regarded as safe, effective and efficacious against multiple tick species in Uganda and hence cleared for commercialization in Uganda by the National Biosafety Committee, under the Uganda National Council for Science, and Technology (Ref.: PROG 21/6), and has been registered as NAROVAC ATV-1 for control of cattle tick infestations in Uganda, and beyond.

b) Scientific publications and press communications
   The collaboration between SaBio-IREC and NARO resulted in a total of 34 publications, comprising 17 journal articles, and 17 press communication articles. These publications significantly advanced the scientific community's understanding of Subolesin-based anti-tick vaccines. The publications were featured in high-profile journals, and prominent media outlets, reinforcing the project's international recognition and influence.

   i) Scientific Journal Articles
      The collaboration produced 17 scientific journal publications, highlighting significant progress in vaccine research and implementation. These studies, published in leading biotechnology, and vaccine development journals, covered topics ranging from foundational research to large-scale field trials in Uganda. Key publications include Contreras *et al*. (2022, 2025), which explored innovative Subolesin-based vaccine platforms, and studies by Kasaija *et al*. (2020) and Kabi et al. (2024), which assessed vaccine efficacy under controlled and real-world conditions. A notable publication by de la Fuente *et al*. (2024) in *Nature Biotechnology* examined the challenges of vaccine development and deployment in Uganda, emphasizing the need for region-specific solutions. Nine of these articles appeared in top vaccine journals, including *Vaccine*, *Vaccines*, and *NPJ Vaccines*, recognized for their rigorous peer-review process, and high impact. The articles published in *Nature Biotechnology,* and *NPJ Vaccines* received widespread interest, further cementing the project's influence in the global scientific community.

   ii) Press Communications
      The collaboration between NARO and IREC has generated significant interest in the development of an anti-tick vaccine for livestock, especially in Uganda. Several media outlets have covered these developments, underscoring the breakthrough's potential impact on livestock production, and farmer livelihoods. For instance, *The Monitor* newspaper of Uganda published an article titled "Hope for tick disease victims: Research to develop vaccine" in December 2019, providing an overview of the ongoing efforts. In June 2023, *The Monitor* again highlighted the progress with "Ugandan scientists develop anti-tick vaccine". Additionally, the *New Vision* newspaper of Uganda reported about the vaccine's timely relief for farmers with an editorial titled "Anti-tick vaccine is a timely relief for farmers", reflecting the widespread excitement around the

breakthrough. Meanwhile, Spanish outlets such as *Lanza* also covered the success of the vaccine's development, including "Investigadores de SaBio del IREC y NARO desarrollan vacunas para el control de garrapatas en Uganda" and "El Irec y Uganda, más cerca de la producción y comercialización de una vacuna contra las garrapatas". Other Spanish outlets such as *La Tribuna de Ciudad Real* and *Noticias de Castilla-La Mancha* also covered similar developments, including experimental trials, and the prospects of mass production of the vaccine. Furthermore, José de la Fuente, the lead scientist, was featured in an exclusive interview on COPE.es, a renowned Spanish radio station. This interview not only showcased the project's success but also highlighted the significance of international collaborations in addressing global health challenges.

c) Human Capacity Development

Human capacity development was a fundamental component of the collaboration between SaBio-IREC, and NARO, aiming to bridge gaps in vaccine research and enhance local expertise in Uganda. The partnership focused on equipping Ugandan scientists with the skills needed for anti-tick vaccine development, evaluation, and data analysis. By building these competencies, the collaboration empowered local researchers to take lead in innovative livestock health research, ensuring long-term sustainability, and progress in vaccine development.

i) Advanced Short Training in Spain

A key aspect of the partnership was the short-term training program held at IREC in Spain, where six researchers from NARO participated in a comprehensive three-week training session (Fig. 3). This hands-on program covered essential topics related to subunit vaccine development, particularly focusing on Subolesin-based anti-tick vaccines. The training included modules on vaccine formulation, and production techniques, antigen identification and validation, and data analysis for vaccine trials. The participants including Mr. Ivan Kyakuwa, Miss. Rosette Nangoonzi, Dr. John Bosco Omony, Mr. Sam Mulondo, Dr. Moses Matovu, and Dr. Andrew Kiggundu gained

Figure 3. A team of NARO Scientists undergoing hands-on training at IREC in Spain, 2023.

practical experience and in-depth knowledge of advanced vaccine development and production techniques.

ii) Doctoral Research and Knowledge Transfer

The collaboration also promoted advanced academic development through training of a Ph.D. student: Dr. Kasaija Paul D. Kasaija from NARO. Paul's Ph.D. research which focused on "Vaccines for the Control of Cattle Ticks in Uganda," was conducted at IREC, University of Castilla La Mancha, Spain, under the supervision of Prof. José de la Fuente, and Dr. Marinela Contreras. This pioneering research provided valuable insights into the effectiveness of Subolesin-based vaccines in controlling cattle ticks, setting new research standards in Uganda, and contributing significantly to global tick control strategies. Kasaija's ground-breaking work earned international recognition, with coverage in major media outlets, including the *Monitor* (March 27, 2024), under the headline "Ugandan Scientist Develops Tick Vaccine," highlighting the transformative impact of the SaBio-IREC, and NARO partnership on both national, and global scientific communities.

iii) In-Country Training and Knowledge Exchange

Alongside the training in Spain, Prof. José de la Fuente, and his team from IREC facilitated four tailored training and skilling sessions at NARO during the field evaluation trials of the anti-tick vaccine in Uganda. These sessions focused on the practical aspects of field trial design, and implementation for vaccine efficacy studies, advanced data analysis techniques specific to tick vaccine research, and adaptive strategies for addressing challenges encountered during fieldwork. These in-country sessions were invaluable in enhancing the research capabilities of NARO scientists, fostering knowledge exchange, and encouraging collaborative problem-solving. They also promoted cross-institutional learning, contributing to a more resilient, and sustainable research network between SaBio-IREC, and NARO.

d) Intellectual property

The collaboration between the National Agricultural Research Organization (NARO), and IREC has strengthened efforts to protect innovations in tick control through secured intellectual property rights. A key outcome of this partnership is the development of an anti-tick vaccine, with key intellectual property protections detailed below.

i) Patent Application

One notable outcome is the patent application for a chimeric antigen designed for anti-tick vaccine formulation. The application, titled "Chimeric Antigen Q38-95 with Subolesin-BM95 Interactive Protein Domains," was filed by de la Fuente, J., Contreras, M., Kasaija, P., Rutaisire, J under UG/P/2024/000006 on April 24, 2024. This patent serves to protect the innovative antigen that is central to the vaccine, ensuring exclusive rights for its use in tick control and providing a basis for commercial exploitation.

ii) Utility Model

The vaccine, which uses recombinant Subolesin (SUB) tick antigens, was granted a utility model certificate by Uganda Registration Service Bureau on November 27, 2023. The utility model certificate recognized the practical application and role of the vaccine in offering a new functional solution to an existing problem.

iii) Trademark

To establish a distinct market presence, NARO has also registered NAROVAC as the official trademark for the anti-tick vaccine. The NAROVAC trademark was gazetted and published, awaiting the final certificate of grant. This ensures brand recognition, and legal protection for the vaccine in Uganda's livestock sector. The trademark will ensure that the vaccine is recognized under a unique brand, protecting its name, and distinguishing it from other products.

e) Awards

The collaboration between SaBio-IREC and NARO reached a major milestone by winning the 2024 V International Zendal Award in Animal Health for their project, *Vaccines for the Control of Tick Infestations in Sub-Saharan Africa.* This prestigious award, presented by the Zendal Group, recognizes groundbreaking innovations that advance human, and animal health. Winning the award brought global attention to the anti-tick vaccine project, highlighting its potential to transform livestock health in Sub-Saharan Africa, and positioning NARO as a leader in vaccine research. The recognition also attracted interest from international partners, and funders, emphasizing the need for investment in livestock health, and vaccine development in developing countries. Media coverage, including Zendal's press release (ZENDAL), *Portal Veterinaria* (Portal Veterinaria), and *La Voz de Galicia* (La Voz de Galicia), further underscored the project's significance. IREC also highlighted the achievement in its proclamation (IREC), reinforcing the collaboration's reputation, and opening doors for future funding, and partnerships.

Lessons learned and challenges

Over the course of their collaboration, SaBio-IREC, and NARO have gained valuable insights into the challenges, and opportunities of international partnerships in tackling livestock health issues. The following lessons highlight key takeaways from this ongoing collaboration:

a) Mutual benefit of international partnerships

One of the core lessons from this collaboration is the mutual benefit it has provided for both institutions. Uganda has gained access to advanced research expertise, and cutting-edge vaccine technology, while Spain has benefited from testing its innovations under diverse field conditions. This exchange of knowledge and technology has not only strengthened both institutions but also showcased the power of global scientific cooperation. By sharing resources, and expertise, both countries have advanced in their respective fields, proving that successful collaborations transcend borders.

b) Human capacity development

A significant aspect of the partnership has been its focus on human capacity development. The training of Ugandan scientists in vaccine research and biotechnology has enabled Uganda to take greater ownership of future vaccine development and production. This investment in human capital ensures that Uganda is not only a consumer of biotech products but also an active contributor to global veterinary vaccine innovation. The long-term benefits of this capacity-development effort are evident, as it empowers Uganda to independently tackle future challenges in livestock health and vaccine development.

c) Technology transfer and practical application
Another important lesson learned is the crucial role of technology transfer in bridging the gap between scientific discovery, and its practical application. While developing a vaccine is a significant achievement, ensuring its production, distribution, and adoption at scale requires robust regulatory support, institutional commitment, and investment in manufacturing infrastructure. The approval of NAROVAC ATV-1 by the National Biosafety Committee is a testament to how well-structured technology transfer mechanisms can lead to tangible, real-world outcomes, demonstrating the importance of turning research into actionable solutions that benefit local communities.

d) Sustainability beyond research funding
One of the major challenges facing many scientific projects is the transition from donor-dependent initiatives to self-sustaining enterprises. Ensuring the long-term sustainability of technology production, particularly vaccines, requires integration into national livestock health programs, strong government support, and private sector investment. The challenge lies in creating an ecosystem where technology continues to be produced and applied long after initial research funding has ended. This highlights the importance of building mechanisms for financial sustainability and broadening support for biotech innovations beyond research grants.

e) Time-intensive nature of technology development
Developing new technologies, particularly vaccines, is a time-intensive process that requires years of research, trials, and regulatory approvals. The lengthy timeline for these developments underscores the need for long-term, stable funding, and policy support. Without a sustained commitment to funding, and regulatory facilitation, innovations may falter before they reach full impact. The time-consuming nature of biotechnology development emphasizes the necessity of a robust, long-term vision, and sustained support to ensure success in the application of scientific innovations.

f) Strengthening regulatory and institutional frameworks
While progress has been made in Uganda's regulatory frameworks for biotech products, there are still gaps that need to be addressed, particularly in large-scale vaccine production. A more streamlined approval process, stronger quality control measures, and greater investment in biotech manufacturing are needed to facilitate the growth of the industry. Moreover, the relatively new field of recombinant technology is met with skepticism, which could delay adoption. Overcoming these regulatory challenges, and building public confidence in new technologies will be essential to the future success of agricultural biotechnology in Uganda, and beyond.

Bottom of Form

Policy implications

The success of this collaboration highlights the need to institutionalize veterinary vaccine research, and production as a national priority. Uganda should integrate biotech-driven livestock health solutions into its broader agricultural, and veterinary policies, ensuring sustained government support for research, development, and deployment. Sustainability will require diversifying funding sources. While international donors and government research grants have played a crucial role, Uganda must explore alternative financing models such as public-private partnerships, tax incentives for biotech firms, and

dedicated national research funds including presidential initiatives. These approaches will ensure that vaccine production continues beyond the lifespan of individual projects.

Additionally, regional collaboration presents another opportunity. By working with regional economic blocs with shared agricultural challenges like the East African Community (EAC), and the Common Market for Eastern, and Southern Africa (COMESA), Uganda can expand market access for locally produced agricultural technologies. A regional approach would not only make agricultural technology production more economically viable but also strengthen Africa's self-sufficiency in veterinary biotechnology.

Future research considerations

The collaboration between SaBio-IREC, and NARO continues with the development of novel antigens, and vaccine formulations for the control of tick infestations, and transmitted pathogens affecting human, and animal health such as Crimean-Congo Hemorrhagic Fever, East Coast Fever, and African Swine Fever. It includes innovative technologies such as quantum vaccinomics, and oral, and mRNA-lipid nanoparticles vaccine delivery platforms. New projects in other areas such as "Control of bovine mastitis", "development of auto vaccines", and "probiotic interventions for improving tilapia health, and growth" are under evaluation.

Conclusions

The results of the 10 years of collaboration between SaBio-IREC (Spain), and NARO (Uganda) allowed us to move with an innovative personalized vaccinology approach to develop a safe, efficacious and effective vaccine for sustainable control of cattle tick infestations in Uganda. The technology for vaccine production was transferred to Uganda thus providing access to biotech products in Sub-Saharan Africa, and moving science from bench to field. The collaboration increased the scientific and social impact of results for both Spanish and Ugandan institutions. These results also lead to possibilities for new collaborations to expand research on other interventions for the control of infectious diseases, and improving human, and animal health.

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