STAR IDAZ | International Research Consortium on Animal Health

STAR IDAZ IRC Capripoxvirus Gap Analysis Workshop Report

21-23 July 2026

Kuta, Bali, Indonesia



STAR IDAZ IRC is the 'Global Strategic Alliances for the Coordination of Research on the Major Infectious Diseases of Animals and Zoonoses - International Research Consortium'. It is a global consortium that brings together funders and programme owners for research on animal health to maximise funding for coordinated animal health research. To achieve its aim, STAR IDAZ IRC facilitates networking among funders, researchers, industry experts, policymakers and other stakeholders to collaborate on research and innovation in the field of infectious animal diseases. This document was produced by SIRCAH, the Scientific Secretariat of the STAR IDAZ IRC.

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More information on STAR IDAZ IRC can be found at www.star-idaz.net

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Introduction

STAR IDAZ International Research Consortium (IRC) is a global initiative to address the coordination of research programmes at international level in the area of animal health and in particular infectious animal diseases including zoonoses (STAR IDAZ – Global Strategic Alliances for the Coordination of Research on the Major Infectious Diseases of Animals and Zoonoses).

As a global network of research funders and programme owners, STAR IDAZ IRC works to align research priorities and coordinate investment, helping to reduce unnecessary duplication and ensure that animal health research is targeted towards areas of greatest global need and potential impact.

Capripoxviruses have been identified as a high-priority research topic by the STAR IDAZ IRC. By identifying and prioritising critical research gaps, the Consortium aims to accelerate the development of improved diagnostics, vaccines and integrated disease-control strategies.

The geographic range of capripoxviruses has historically been largely confined to Africa, Asia and the Middle East. However, recent incursions into Europe, together with changes in vector distribution associated with climate change, are increasing the risk of further global spread. Capripoxviruses cause clinically and economically significant transboundary diseases in cattle, sheep and goats. Recognising both their growing international threat and the need for a more coordinated research response, STAR IDAZ IRC activated its Poxvirus Working Group to assess the current evidence, identify important gaps in knowledge and help establish priorities for future research investment.

To inform the activities of the Poxvirus Working Group, STAR IDAZ IRC commissioned the Capripoxvirus Research Review 2015–2026. The Review summarises key research on capripoxviruses published between January 2015 and June 2026. It covers advances in diagnosis and field differentiation; pathogenesis and the determinants of virulence; immune responses to infection and viral immune-evasion strategies; epidemiology; and approaches to disease control, including vaccines, antimicrobial treatments and policy interventions.

Importantly, the Review also identifies areas in which evidence and knowledge remain limited. These findings provided an evidence base for the Capripoxvirus Gap Analysis Workshop and informed the research gaps considered by participants.

Co-organised by STAR IDAZ IRC and the National Research and Innovation Agency of Indonesia (BRIN), the Capripoxvirus Gap Analysis Workshop brought together researchers, funders and other experts to review and refine the identified gaps and translate them into clear, actionable research priorities.

Objectives of the workshop:

- Convene the international capripoxvirus research community to share the current global situation and foster international collaborations
- Carry out gap analyses for the development of candidate vaccines, diagnostic tests, and integrated control strategies for capripoxviruses to develop STAR IDAZ IRC research roadmaps on these topics.

Report of the workshop

Twenty-one international experts attended the capripoxvirus gap analysis workshop, which was held in Kuta, Indonesia on 21-23 July 2026.

In preparation for the workshop, participants and additional invited experts were provided with the Capripoxvirus Research Review 2015–2026, the DISCONTOOLS Sheep and Goat Pox Virus Chapter (April 2021), the DISCONTOOLS Lumpy Skin Disease Report (in progress), and the STAR IDAZ IRC publication '*Construction of generic roadmaps for the strategic coordination of global research into infectious diseases of animals and zoonoses*'[1]. Participants were asked to review these documents and complete a pre-workshop online consultation to identify priority research needs and knowledge gaps for the control of capripoxviruses (lumpy skin disease virus (LSDV), sheeppox virus (SPPV), and goatpox virus (GTPV)).

The workshop utilised a World Café methodology to support structured discussions across three key themes: diagnostics, vaccinology and integrated control strategies. During each thematic discussion, participants were divided into three groups and presented a set of pre-defined questions by a table moderator to prompt discussion about knowledge or research gaps in relation to the session theme. The findings from each group were subsequently presented by the table moderators, enabling cross-group discussion, validation of the identified gaps, and the development of consensus among participants.

Across all three themes, participants in the breakout groups identified a need to strengthen the evidence base underpinning capripoxvirus prevention, detection, and control. Full discussion available in the 'Identified research priorities' section.

The vaccines session highlighted the need to optimise live-attenuated vaccines through improved understanding of the mechanism(s) of attenuation, protective immunity, safety, and duration of protection. Development of DIVA-compatible vaccines, multivalent vaccine platforms, standardised challenge models, and robust quality control systems were also noted as important research priorities, as well as improving vaccine availability more generally.

The diagnostics session highlighted the need for affordable and accessible diagnostic tools suitable for use in both laboratory and field-based settings, including point-of-care assays. Participants also identified important gaps related to DIVA-compatible diagnostics, correlates of protection, whole genome sequencing capacity, environmental surveillance, and standardisation of validation methods and reference materials.

The integrated control strategies session highlighted the need for evidence- and risk-based approaches that combine surveillance, diagnostics, vaccination, biosecurity, movement management, and sector control. Key knowledge gaps identified by participants included transmission dynamics, including the role of arthropod vectors and wildlife; socioeconomic drivers of disease spread; governance and implementation challenges; and economic evaluation of different interventions.

Research needs and scientific knowledge gaps were prioritised using an interactive, multi-round ranking activity, followed by a plenary discussion to reach consensus on the most urgent and most impactful research and knowledge gaps. Promoting a 'global capripoxvirus research alliance' was identified as the most urgent and most impactful need by participants. A need to conduct socioeconomic studies to understand barriers to vaccination uptake; develop and evaluate differentiating-infected-from-vaccinated animals (DIVA)-compatible vaccines and companion diagnostics; develop field-deployable rapid diagnostics for early

[1] Entrican G, Charlier J, Dalton L, Messori S, Sharma S, Taylor R, Morrow A. Construction of generic roadmaps for the strategic coordination of global research into infectious diseases of animals and zoonoses. Transbound Emerg Dis. 2021 May;68(3):1513-1520. doi: 10.1111/tbed.13821. Epub 2020 Sep 19. PMID: 32896967.

detection and outbreak control; and, development of evidence-based decision frameworks to support implementation of control measures in different epidemiological and socioeconomic settings were also noted as high-impact, urgent research gaps to be addressed by future research.

The complete list of research needs identified across the workshop will be reported in the research roadmaps, following validation by the STAR IDAZ Scientific Committee, and published on the STAR IDAZ IRC website.

The outputs of the prioritisation activity will also be reported in an executive summary and disseminated to STAR IDAZ IRC Partners, research funders, and other key stakeholders to support future research coordination and investment.

Methodology

Workshop participants

The Capripoxvirus Gap Analysis Workshop brought together 21 international experts from 15 countries across Africa and the Middle East, Asia and the Pacific, Europe, and the Americas, representing academia, government, research institutes, and international organisations. Participants included specialists in epidemiology, virology, vaccinology, immunology, disease control, diagnostics, One Health, and policy. The workshop was designed to capture diverse scientific perspectives in order to identify the key research and knowledge gaps pertinent to the prevention, detection, and control of LSDV, SPPV, and GTPV. A copy of the agenda can be found in Annex 1.

Pre-workshop consultation

To inform the workshop discussions, a pre-workshop consultation was conducted to gather expert perspectives on current knowledge gaps and research needs relating to capripoxviruses. The online consultation was launched on 29 June 2026 and remained open until 8 July 2026. A total of 26 individuals responded from a range of regions and institutions, providing a diverse and globally balanced set of perspectives. The consultation included a series of structured and open-ended questions designed to identify research priorities relating to diagnostics, vaccines and integrated control strategies. A copy of the online consultation questions can be found in Annex 2. Raw data are available on request.

Prior to each thematic workshop session, expert presentations summarised the current state of scientific knowledge and evidence relating to capripoxviruses and drew on findings from the Capripoxvirus Research Review 2015-2026, the results of the pre-workshop consultation, and other relevant reference materials provided to participants in advance of the workshop (DISCONTOOLS Sheep and Goat Poxvirus Chapter and the *draft* DISCONTOOLS Lumpy Skin Disease Report). The presentations provided an overview of current knowledge, recent scientific advances and perceived knowledge gaps and were intended to establish a common evidence base for discussion and ensure that subsequent discussions were informed by both current research and stakeholder perspectives.

World Café methodology

A World Café methodology was used to facilitate structured discussion and identification of research gaps relating to diagnostics, vaccines, and integrated control strategies for capripoxviruses. For each thematic session, participants were randomly divided into three breakout groups and asked to discuss a set of pre-

defined questions relating to specific research challenges and evidence gaps. A full description of the World Café methodology can be found in Annex 3.

Prioritisation activity

Participants were presented with a consolidated list of research needs generated during the World Café activity and invited to assess each item according to urgency and potential impact using a multi-round, sticker-based voting system. Full details of the prioritisation activity can be found in Annex 4.

Identified research priorities

Vaccine development

The Vaccine development breakout groups considered the questions:

- What the strengths and weaknesses of currently available LAVs? – Table 1
- How can we build on the strengths or mitigate the weaknesses of the current LAVs? – Table 1
- What research is needed in order to optimise these vaccines? – Table 1
- What are the desired characteristics of a capripoxvirus vaccine? – Table 2
- Do you consider that we have DIVA at the moment? Do we need it? How should we go about developing it? – Table 3
- What challenge models do we use at the moment, which work, how could they be better? – Table 3

There were a number of research needs identified by the three tables and these have been combined and are presented below.

Research and knowledge gaps for vaccine development

The three discussion tables identified research priorities to improve the safety, effectiveness, quality and availability of capripoxvirus vaccines and support the development of next-generation vaccines and companion diagnostics. Common themes included understanding vaccine-induced protection, strengthening vaccine evaluation, harmonising quality standards and generating evidence to guide vaccine selection and deployment in different settings.

Understanding attenuation and vaccine-induced protection

Research is needed to establish the biological basis of vaccine-induced protection, including the viral antigens and humoral and cell-mediated immune responses associated with protection. Validated assays should be developed to measure these responses and identify reliable immunological correlates or biomarkers that can predict vaccine efficacy.

The genetic determinants and mechanisms of attenuation in live attenuated vaccines (LAVs) also require investigation, including the contribution of non-coding regions. Studies should establish how attenuation influences residual virulence, the risk of reversion to virulence and the potential for recombination. The degree of attenuation needed to balance safety and protective efficacy should be defined and validated for different vaccine strains, host species and breeds.

Further research should investigate the mechanisms underlying the host restriction of sheeppox and goatpox viruses and their implications for vaccine safety, host specificity and cross-protection. The

feasibility of using a single antigen or vaccine type to protect susceptible livestock species against different capripoxviruses should also be explored.

Onset, duration and consistency of protection

The onset and duration of vaccine-induced protection should be determined under experimental and field conditions. Studies should establish whether annual revaccination is necessary or whether longer intervals can provide adequate protection. Research should also identify the optimum vaccine dose and titre needed to achieve consistent protection while minimising adverse reactions.

Vaccine performance should be evaluated across livestock populations, breeds, production systems and epidemiological settings, including against emerging capripoxvirus strains. The influence of host genetics, immune status and population susceptibility on vaccine responses requires further investigation.

Studies should determine how long maternally derived antibodies persist in young animals born to vaccinated dams and how these antibodies affect vaccine responses. This evidence is needed to establish the most appropriate age and timing for vaccination.

Greater attention should be given to sheeppox and goatpox vaccines, including their safety, duration of immunity, field effectiveness and cross-protection. This would help address the current imbalance in the evidence base, which is weighted towards lumpy skin disease vaccines.

Vaccine safety, shedding and environmental persistence

Comprehensive safety data are needed to establish the causes, frequency and risk factors associated with adverse post-vaccination reactions. These include the “Neethling response”, fever, reduced milk production, reproductive losses and skin lesions. Strengthened pharmacovigilance should assess whether these reactions are associated with vaccine strain, product quality, host characteristics or vaccination conditions.

Research should characterise vaccine-virus shedding, transmission and clearance following vaccination, together with environmental persistence and the potential for recombination. These studies should clarify the implications for animal health and vaccine safety and provide evidence for regulatory assessments and risk-based decisions about vaccine use.

Standardised vaccine evaluation and challenge models

Standardised vaccination–challenge studies are needed to compare vaccine performance and establish appropriate criteria for safety and efficacy. Challenge models for sheeppox, goatpox and lumpy skin disease should be refined and harmonised, with particular attention to the selection of challenge-virus strains, doses and routes of infection for lumpy skin disease.

Agreed clinical scoring systems, sampling schedules, outcome measures and criteria for defining protection should be developed. The reproducibility of challenge models should be assessed across laboratories and geographical settings to improve the comparability of results and strengthen the evidence supporting vaccine evaluation, regulation and quality control.

In parallel, research should identify and validate correlates or biomarkers of protection that can complement challenge studies and reduce the number of animals required. Where scientifically justified, these assays could replace some animal challenge experiments.

Large-scale field studies will also be essential to establish vaccine effectiveness and safety under practical conditions and inform context-specific vaccination policies.

Vaccine quality, delivery and availability

Harmonised quality-control requirements and independent batch evaluation should be developed to ensure vaccine potency, safety and consistency. These standards should support reliable comparisons between products and manufacturers.

Research should improve vaccine thermostability and resilience to cold-chain disruption, particularly in remote and resource-limited settings. Alternative delivery methods that could make vaccination more accessible and practical should also be evaluated.

Demand aggregation and versatile vaccine banks should be assessed as approaches to improving vaccine availability. Economic tools are needed to demonstrate the cost-effectiveness of vaccination, alongside evaluation of communication strategies to strengthen vaccine confidence and uptake among farmers, industry and policymakers.

Comparing vaccine platforms and developing multivalent vaccines

Live attenuated, inactivated and next-generation vaccine platforms should be compared systematically. Evaluations should consider protective efficacy, onset and duration of protection, safety, vaccine-virus shedding, DIVA capability, thermostability, dosing frequency and total cost of use.

The potential of capripoxviruses as vaccine vectors should be investigated further, including the development of recombinant, bivalent and multivalent vaccines. These could target multiple capripoxviruses or combine capripoxvirus protection with protection against other co-circulating pathogens.

Research should establish the safety and field effectiveness of these combinations, including antigen compatibility, possible immune interference or competition, adverse reactions and any risk of recombination.

DIVA vaccines and companion diagnostics

DIVA approaches, which differentiate infected from vaccinated animals, were identified as a priority for strengthening surveillance and supporting vaccination where disease-free status, trade and market access are important considerations.

An initial priority is to validate existing candidate DIVA ELISAs using large, well-characterised serum panels from naturally infected and vaccinated animals. These panels should represent different host species, vaccine strains, virus isolates and epidemiological settings. Studies should establish diagnostic sensitivity, specificity and reproducibility, including the ability to distinguish infection from vaccination under field conditions.

Internationally coordinated comparisons should use agreed protocols, reference materials and performance criteria. These evaluations should determine whether candidate assays are suitable for surveillance, outbreak response, vaccination monitoring and the maintenance or recovery of disease-free status.

Proteomic and other comparative approaches should identify reliable differences between vaccine strains and wild-type capripoxviruses that could provide diagnostic targets and support marker-vaccine

development. The potential to differentiate infection from vaccination through cell-mediated immune responses should also be investigated.

Once suitable diagnostic targets have been identified, corresponding marker vaccines could be developed by deleting genes encoding selected proteins from existing live vaccines or using next-generation platforms based on protective antigens. This work will depend on a stronger understanding of the antigens and immune responses required for protection.

The economic value, operational feasibility and necessity of DIVA vaccination should be assessed in different epidemiological, regulatory and trade contexts. This would identify where investment in DIVA vaccines and companion diagnostics would provide the greatest benefit and how these tools could be incorporated into national and regional control strategies.

Diagnostics

During the diagnostics breakout groups, participants considered the diagnostic tools and capabilities required for accurate and timely detection of capripoxviruses, the scientific knowledge needed to support their development and implementation, and the practical challenges associated with diagnosis in low- and middle-income countries. Discussions highlighted priorities spanning pathogen-based and immune-based diagnostics, surveillance and epidemiology, diagnostic validation, and the infrastructure and partnerships required to improve accessibility and deployment.

The diagnostics breakout groups considered the following questions:

- What pathogen-based detection diagnostic tools and capabilities do we need for accurate and timely capripoxvirus detection? - Table 1
- What knowledge do we need to make those diagnostic tools a reality? - Table 1
- What immune-response based detection diagnostic tools and capabilities do we need for accurate and timely capripoxvirus detection? - Table 2
- What knowledge do we need to make those diagnostic tools a reality? - Table 2
- How can capripoxvirus diagnosis be carried out safely, rapidly and cheaply in low-and-middle income countries? - Table 3
- What options are there for multiplex diagnoses, and which differential diagnoses should be considered for a “one test fits all” option? - Table 3

Research and knowledge gaps for diagnostics

Pathogen-based diagnostic tools and capabilities

Clinical recognition remains an important and cost-effective means of diagnosing capripoxvirus diseases, particularly in resource-constrained settings. However, a broader range of diagnostic tools is needed to support accurate and timely detection across diverse epidemiological contexts.

Molecular diagnostic methods that can be deployed outside centralised laboratory settings, including point-of-care PCR platforms, loop-mediated isothermal amplification (LAMP) assays and lateral flow devices, may improve access to testing and support earlier detection of infection. Multiplex diagnostic platforms, including multiplex LAMP assays and high-resolution melting technologies, may further enhance diagnostic efficiency by enabling simultaneous detection of multiple pathogens within a single testing workflow.

Diagnostic decision-support tools may support more consistent and efficient deployment of available testing methods. Participants discussed the potential application of photographic evidence, drone technologies, artificial intelligence (AI) and large language model-based decision-support systems to support case detection and clinical diagnosis. Participants also highlighted the value of practical diagnostic pathway decision-support frameworks to assist veterinary services in selecting the most appropriate testing approaches under different epidemiological, logistical and economic circumstances.

Syndromic diagnostic approaches may also support differential diagnosis of diseases presenting with similar clinical signs in cattle, sheep and goats. Evidence-based frameworks are needed to guide diagnostic test selection based on species, clinical presentation, epidemiological context and vaccination status.

Whole genome sequencing (WGS) was recognised as an important tool for outbreak investigation, strain characterisation and epidemiological tracing. Its application can support understanding of disease transmission pathways and improve epidemiological investigations, although substantial disparities remain in access to sequencing technologies and associated analytical capacity. Mechanisms to facilitate access to sequencing services through regional reference laboratories were considered important, particularly in countries where national sequencing capacity remains limited.

Knowledge gaps underpinning pathogen-based diagnostics

Important knowledge gaps remain regarding the performance, application and optimisation of pathogen-based diagnostic approaches.

Further research is required to determine the diagnostic accuracy of clinical diagnosis under different field conditions and to assess how reliably clinical signs distinguish capripoxvirus infections across livestock species, breeds, geographical regions and epidemiological settings. Additional evidence is also needed to evaluate the performance of image-based diagnostic approaches and AI-assisted decision-support tools under operational conditions.

Evidence is lacking on the sensitivity, specificity and cost-effectiveness of different testing strategies, including pooled-sample approaches. Further research is required to determine whether sample pooling can reduce testing costs while maintaining acceptable diagnostic performance, and to identify the circumstances in which such approaches may be most effective.

Evidence remains limited regarding the diagnostic performance and operational utility of field-deployable diagnostic technologies. Further validation studies are required to assess the sensitivity, specificity, reliability and cost-effectiveness of point-of-care PCR platforms, LAMP assays, lateral flow devices and other portable molecular tools under diverse field conditions, particularly in low-resource settings, and in comparison with laboratory reference methods.

Important epidemiological uncertainties remain regarding the proportion of infected animals that develop clinical disease compared with subclinical infection. While some evidence exists for lumpy skin disease, information for sheeppox and goatpox remains limited. Further research is needed to improve understanding of host, pathogen and environmental factors associated with susceptibility, resistance and disease severity, and how these factors influence disease detection and surveillance effectiveness.

The incubation period of capripoxvirus infections under diverse field conditions also requires further investigation. Studies are needed to determine which diagnostic tools can reliably detect infection during the

pre-clinical phase, before the appearance of overt clinical signs, thereby supporting earlier disease detection and outbreak response.

Research is also needed to improve understanding of risk factors associated with capripoxvirus outbreaks across different ecological and production settings. A systematic review and meta-analysis of existing evidence may help reconcile conflicting findings and identify the most important drivers of disease emergence and spread.

Further work is required to determine the persistence of capripoxvirus genetic material in different environmental matrices and under varying environmental conditions. Such evidence is necessary to assess the utility of environmental surveillance approaches and their potential role in outbreak investigations and disease monitoring. Studies are also needed to validate the use of environmental samples, including soil, faeces, and water, in pan-capripoxvirus PCR and related molecular assays.

Diagnostic methods require further validation for use in wildlife species, alongside the development of highly sensitive assays capable of detecting low-level and subclinical infections. Improvements in these areas would strengthen surveillance systems and contribute to a better understanding of disease transmission dynamics.

Although WGS is increasingly used to support epidemiological investigations, additional work is needed to improve access to sequencing capacity, strengthen regional laboratory networks and facilitate timely sharing of genomic data.

Immune-based diagnostic tools and capabilities

Immune-based diagnostic approaches have an important role in surveillance, outbreak investigation and disease control, particularly in settings where vaccination is used. Discussions focused primarily on serological assays, diagnostics capable of differentiating infected from vaccinated animals (DIVA), and approaches for measuring cell-mediated immune responses.

Further development of serological diagnostics is needed to improve the sensitivity, specificity and reliability of assays used to detect antibodies following infection or vaccination. DIVA-compatible diagnostic tools were widely recognised as a major priority for supporting surveillance and disease control programmes where vaccination forms part of disease control policy. A key challenge will be the development and validation of assays capable of reliably distinguishing infected from vaccinated animals across different vaccine platforms, capripoxvirus species and epidemiological settings.

The availability of additional, commercially-produced diagnostic assays may improve diagnostic resilience, reduce dependence on individual suppliers and provide opportunities for independent confirmation and verification of serological findings.

Practical tools for measuring cell-mediated immunity remain limited, and further work is required to optimise and validate approaches such as interferon-gamma release assays, and other methods capable of assessing immune responses that may not be adequately captured through antibody testing alone.

Neutralisation assays remain valuable tools for assessing immune responses. Further evaluation of quantitative plaque-forming or focus-forming assays and pseudovirus-based systems may help improve assay performance while reducing dependence on high-containment laboratory facilities.

Knowledge gaps underpinning immune-based diagnostics

Significant knowledge gaps remain regarding the immune mechanisms associated with protection against capripoxvirus infection and disease.

Further research is required to define correlates of protection and improve understanding of both humoral and cell-mediated immune responses following infection and vaccination. Addressing these uncertainties would support the development, interpretation and validation of immune-based diagnostic tools and improve understanding of protective immunity.

Additional work is needed to identify and characterise the most appropriate viral antigens and peptide targets for diagnostic assay development. Improved understanding of antigen selection may enhance assay sensitivity, specificity and applicability across different capripoxvirus species, strains, and vaccination scenarios.

Further evidence is also required to evaluate diagnostic performance across different host species, capripoxvirus species, viral strains and vaccination scenarios. Such studies are necessary to ensure assays remain robust and broadly applicable across the diverse epidemiological contexts in which capripoxvirus diseases occur.

The limited availability of well-characterised biological samples remains a significant constraint to diagnostic development and validation. Longitudinal animal studies are needed to generate reference sera, blood samples and other biological materials from infected and vaccinated animals. Such resources are essential for assay optimisation, validation and comparative performance assessments, including evaluation of strain-specific variation and diagnostic performance under different epidemiological conditions.

Cross-cutting implementation and capacity-building considerations

Diagnostic tools must be accessible, affordable and operationally feasible if they are to have maximal impact in endemic and at-risk countries. Further research is needed to understand user acceptability, training requirements and the factors influencing uptake of novel diagnostic technologies, including AI-assisted decision-support tools, point-of-care diagnostics and field-deployable assays, by farmers, field veterinarians and frontline animal health workers.

Development of field-deployable antigen-detection assays will also require improved access to well-characterised monoclonal antibodies and a better understanding of appropriate antigenic targets. Addressing these constraints will be important for the optimisation and validation of technologies such as lateral flow devices.

The effectiveness of training approaches, materials and delivery methods also requires further evaluation. Evidence is needed to determine which approaches most effectively improve disease recognition, reporting, and diagnostic decision-making across different settings and user groups.

Across all diagnostic modalities, participants emphasised that development of new technologies alone will be insufficient. Rigorous validation under diverse field, epidemiological and resource settings remains a major outstanding requirement. Validation studies should assess diagnostic accuracy, operational performance, cost-effectiveness and applicability across livestock species, production systems and geographical regions to support wider adoption and implementation.

Participants emphasised the value of stronger international collaboration to support diagnostic development and implementation. Collaborative networks of reference laboratories could facilitate sample collection, characterisation, validation and sharing, while also supporting harmonised validation approaches, access to specialist diagnostic capabilities and assessment of strain-specific variation. Mechanisms to facilitate access to specialist services, including sequencing through regional reference laboratories, may be particularly valuable in countries with limited in-country capacity.

Participants also highlighted the importance of partnerships between endemic countries, reference laboratories, academic institutions and commercial developers. Such collaborations are likely to be important for supporting diagnostic innovation, optimisation and validation, and for improving the availability and accessibility of high-quality diagnostic tools for capripoxvirus surveillance and control.

Integrated control strategies

The integrated control strategies breakout groups considered the questions:

- What control methods are currently used, and which are most effective? – Table 1
- If you were Chief Vet Officer of Australia, what would you spend your capripoxvirus research budget on? – Table 2
- If you were Chief Vet Officer of an endemic, low-resource country, what would you spend your capripoxvirus research budget on? – Table 2
- What lessons have been learned from capripoxvirus disease outbreaks in recent years? – Table 3

Research and knowledge gaps for integrated control strategies

Developing context-specific integrated control frameworks

A major research gap is the limited evidence on how control measures should be combined, prioritised and implemented under different local conditions. Capripoxvirus transmission and the effectiveness of control are shaped by interconnected epidemiological, ecological, economic, social and institutional factors. These include livestock production systems, farming practices, animal movements, markets, arthropod vectors, surveillance capacity and human behaviour.

Research should support the development of integrated, risk-based and evidence-driven control frameworks that combine vaccination, diagnostics, surveillance, vector control, animal movement management, biosecurity and community engagement. These frameworks should draw on epidemiological and genomic data, vector ecology, economic analysis and stakeholder perspectives to identify strategies that are both effective and practically feasible, particularly in low- and middle-income countries.

Priorities should reflect the local disease situation. Disease-free countries require approaches focused on preventing introduction, early detection, preparedness and rapid response. Endemic countries need to understand why transmission persists despite existing interventions and how to achieve sustainable control. Although lumpy skin disease has received greater international attention, including through its emergence in previously unaffected countries, the substantial burden of sheeppox and goatpox in low- and middle-income countries must also be addressed.

Cross-cutting implementation and capacity-building considerations

Further research is needed to establish the drivers of introduction, persistence and spread of lumpy skin disease, sheeppox and goatpox. This should examine production-system risk factors, animal husbandry practices and other activities that increase exposure or facilitate transmission.

The contribution of legal and illegal animal movements, animal products, livestock markets, trade networks and slaughter systems should be assessed. Research should examine animal prices, movements between regions and interactions among stakeholders to understand how commercial and behavioural factors influence transmission.

Movement-network mapping and modelling should identify high-risk locations and practices and support targeted vaccination, movement controls and other interventions. Integrating epidemiological, genomic, movement and vector data would help identify outbreak sources, clarify transmission pathways and improve predictions of disease spread.

For disease-free countries, country-specific evidence is needed on potential introduction routes, vector competence and virus survival in the environment and relevant animal products. These data should strengthen risk models and guide prevention and preparedness.

Vector ecology and control

Uncertainties remain about the contribution of arthropod vectors to capripoxvirus transmission under different environmental and production conditions. Research should identify the most important vector species, establish their competence and determine their epidemiological significance in different geographical settings.

Field studies should compare targeted and broad-spectrum vector-control approaches, including biological, chemical and locally adapted measures. Evaluations should establish their effectiveness, feasibility and cost-effectiveness and determine how they can best contribute to integrated control programmes.

Wildlife and other potential maintenance hosts

The role of wildlife and non-target domestic species in capripoxvirus persistence and transmission requires further investigation. Research should determine whether these species maintain infection, transmit viruses between livestock populations or contribute to disease re-emergence following control campaigns.

This evidence is needed to establish whether wildlife surveillance or other targeted measures should be included in control programmes and to clarify the contribution of these hosts to persistent circulation in endemic areas.

Surveillance, diagnostics and early detection

Research should identify gaps in surveillance and reporting and develop sustainable systems suited to local veterinary capacity, livestock production systems and reporting structures. Priorities include active surveillance, stronger epidemiological data, genomic surveillance and timely, transparent access to disease information.

Rapid, accurate and field-deployable diagnostics, including point-of-care tests, should be evaluated and linked to reporting and laboratory-confirmation pathways. Newer surveillance approaches, such as drones and thermal imaging, should also be investigated to establish their practical value for early detection.

Veterinarians, farmers and others working with livestock need to recognise suspected cases and understand when and how to report them. Research should assess how surveillance design and diagnostic access can shorten the interval between suspicion, confirmation and response. In endemic settings, surveillance should also help explain continuing transmission and assess the impact of control programmes.

Vaccination strategies, delivery and monitoring

Vaccine effectiveness should be evaluated under endemic, epidemic and disease-free conditions, using systematically collected field and outbreak data. Research should examine vaccine failures, duration of protection, achieved coverage and the coverage required for effective control.

Studies should determine the most appropriate timing of campaigns, booster requirements, use and size of buffer zones, opportunities for risk-based vaccination and criteria for ending vaccination programmes. Post-vaccination monitoring should assess whether campaigns achieve the intended protection and help explain why outbreaks continue despite vaccination.

Operational research should address vaccine access and delivery, difficulties restraining animals and other practical barriers to participation. These findings should inform vaccination approaches that are feasible within local livestock systems.

Further work is needed on vaccine quality, safety and genetic stability, including risks associated with recombinant or vaccine-derived strains. Clear evidence and regulatory requirements should support the evaluation, authorisation and deployment of novel vaccines.

The potential roles of DIVA vaccines and companion diagnostics, and the availability of inactivated vaccines, should be assessed, particularly for emergency use in disease-free countries. Research should establish where these options offer meaningful epidemiological, operational or trade benefits.

Biosecurity, sanitation and movement management

Research should evaluate the effectiveness and cost-effectiveness of biosecurity measures, sanitation and disinfection protocols, and animal movement controls as components of integrated programmes.

Particular attention should be given to wet markets, informal livestock and slaughter sectors, and other settings where conventional measures may be difficult to apply. Evaluations should establish whether interventions can be adopted, maintained and scaled under local conditions, as well as whether they reduce transmission.

Evidence is also needed to determine the appropriate targeting and intensity of movement restrictions, taking account of transmission risks, trade networks, production systems and practical implementation constraints.

Outbreak preparedness, culling and control objectives

Disease-free countries need evidence to support practical outbreak-response plans, including emergency vaccination and the capacity to implement measures rapidly. Preparedness research should assess how surveillance, diagnostics, vaccination, movement restrictions and other interventions can be coordinated when an incursion occurs.

Further studies should determine whether, and under which epidemiological and production conditions, culling contributes to disease elimination. The discussion highlighted limited evidence that culling is

universally necessary for eradication; its contribution should therefore be evaluated in relation to other interventions and local circumstances.

Research should also establish where eradication is feasible and where sustained control is a more realistic objective. In the latter settings, studies should identify combinations of measures capable of reducing disease impact over the longer term.

Farmer behaviour, communication and community participation

Research should examine how risk perception, cultural practices, social circumstances and economic pressures influence disease reporting and compliance with vaccination, movement restrictions and biosecurity measures. Under-reporting and non-compliance should be understood within their local context, including the practical and financial constraints faced by farmers.

Studies should assess incentives that encourage reporting and cooperation, alongside barriers that prevent participation. Communication approaches should be compared to determine which most effectively improve awareness, reporting and vaccine uptake. These could include mobile applications, photographs and other visual materials, locally appropriate languages, farmer education and engagement through community leaders.

Gender roles and the involvement of foreign, seasonal and migrant workers should be considered when assessing access to information and participation. The potential contribution of women and other community members to vaccination, surveillance and sample collection should also be explored.

Farmers and affected communities should participate in designing and evaluating interventions so that programmes reflect local needs and are more likely to secure sustained support.

Disease burden, production losses and trade impacts

Better evidence is needed on the true burden of capripoxvirus disease, including potentially underestimated mortality following new incursions. Particular attention should be given to sheeppox and goatpox and their effects on growth, milk production, reproduction, hides and wool.

Research should quantify impacts on livelihoods, livestock industries and trade, alongside direct animal-health losses. In livestock-exporting countries, studies should assess the consequences of lumpy skin disease outbreaks for international trade, the appropriate duration of trade restrictions and the circumstances in which DIVA vaccination could help address trade-related concerns.

These data would support more informed decisions about the priority given to capripoxvirus control and the allocation of limited resources.

Economic evaluation and decision support

Robust cost–benefit and cost-effectiveness analyses are needed for individual interventions and integrated programmes across different production systems and resource settings. Evaluations should use reliable field data and realistic assumptions, addressing weaknesses in models that insufficiently reflect practical conditions.

Analyses should capture the full economic and social consequences of disease and control, including mortality, production losses, trade disruption, movement restrictions, vaccination expenditure and wider

effects on livelihoods, communities and public services. They should account for externalities and examine how costs and benefits are distributed among farmers, governments and other stakeholders.

Decision-support frameworks should bring this evidence together with epidemiological, ecological and operational information. They should help authorities compare alternative strategies, understand trade-offs and prioritise limited resources.

Governance, implementation and institutional capacity

Research should assess how government leadership, compensation mechanisms, veterinary services and coordination among stakeholders influence surveillance, outbreak response and sustained control. The roles of veterinary paraprofessionals and community-based animal health workers should also be evaluated.

Implementation research should establish how integrated strategies can be adapted, delivered, scaled and sustained under different institutional, socioeconomic and resource conditions. Farmers, veterinarians, policymakers, market participants and other affected groups should inform programme design, prioritisation and evaluation.

Collaboration, programme comparison and sustainability

Regional and international collaboration should support early warning, coordinated preparedness and the sharing of disease information, sequence data and practical experience. Communication with neighbouring countries and stronger research networks are important in both endemic and disease-free settings.

Integrated programmes should be compared across geographical regions, production systems and high- and low-resource settings. Evaluations should assess epidemiological effectiveness, feasibility, scalability and long-term sustainability, identifying which components can be transferred between settings and which require local adaptation.

Collaboration among national stakeholders, international organisations, researchers, veterinary services and communities will be essential to translate this evidence into policy and practice.

Comparison of the vaccines, diagnostics and integrated control strategies sessions

The three sessions were strongly interconnected, as shown in Table 1. Recurring priorities included field validation, standardisation, surveillance and early detection, understanding transmission and immunity, context-specific implementation, economic evaluation, stakeholder participation and international collaboration.

Table 1. Comparison of the vaccines, diagnostics and integrated control strategies sessions

Common theme	Vaccines	Diagnostics	Integrated control strategies	Cross-cutting research need
Performance under field conditions	Establish vaccine effectiveness, duration of protection, optimal dose, coverage requirements, causes of vaccine failure and adverse reactions across species, breeds and epidemiological settings. (V1, V2)	Establish the sensitivity, specificity and operational performance of clinical, laboratory and field-based tests across species, strains, vaccination scenarios and settings. (D1–D3)	Evaluate vaccination, surveillance, movement controls, vector control, biosecurity and culling—individually and in combination—under real outbreak conditions. (C1–C3)	Conduct coordinated, large-scale field studies using standardised data collection to determine what works, for whom and under which conditions.
Standardisation, validation and quality assurance	Harmonise vaccine quality-control requirements, vaccination–challenge protocols, clinical scoring, outcome measures and criteria for protection. (V1–V3)	Harmonise validation protocols, reference materials and performance criteria for molecular, serological, DIVA, point-of-care and multiplex tests. (D1–D3)	Develop consistent approaches for evaluating integrated programmes, including epidemiological effectiveness, feasibility, scalability and sustainability. (C1, C3)	Establish internationally agreed standards and comparable evaluation frameworks for vaccines, diagnostics and control programmes.
Protective immunity and correlates of protection	Define humoral and cell-mediated mechanisms of protection and identify biomarkers that can reduce dependence on challenge studies. (V1–V3)	Develop and validate assays for protective humoral and cell-mediated responses, including interferon-gamma release and neutralisation assays. (D2)	Use knowledge of immunity to guide vaccination schedules, booster requirements, coverage targets and post-vaccination monitoring. (C1, C2)	Link immunological research, diagnostic development and vaccine evaluation to establish measurable indicators of protection.
DIVA vaccines and companion diagnostics	Develop marker vaccines and evaluate their safety, efficacy, trade value and suitability for disease-free and endemic settings. (V1–V3)	Validate candidate DIVA ELISAs and identify antigenic or cell-mediated targets capable of distinguishing infected from vaccinated animals. (D2, D3)	Determine when DIVA strategies are economically and operationally justified, particularly for emergency vaccination, surveillance and disease-free status. (C2, C3)	Develop and evaluate DIVA vaccines and companion diagnostics as an integrated system, supported by epidemiological, regulatory and economic evidence.
Reference materials, samples and shared resources	Generate well-characterised samples from vaccinated and challenged animals for vaccine assessment, immunological studies and DIVA development. (V2, V3)	Establish longitudinal sample collections and internationally accessible reference panels from infected and vaccinated animals. (D2)	Systematically collect samples and epidemiological information during outbreaks and control campaigns. (C2, C3)	Develop shared biobanks, reference materials and linked clinical, epidemiological, immunological and genomic datasets.

Common theme	Vaccines	Diagnostics	Integrated control strategies	Cross-cutting research need
Surveillance and early detection	Strengthen post-vaccination monitoring, pharmacovigilance and surveillance capable of differentiating vaccination from infection. (V1, V3)	Improve pre-clinical and subclinical detection, clinical recognition, point-of-care testing, environmental surveillance, sample pooling and wildlife diagnostics. (D1–D3)	Develop sustainable surveillance linked to rapid reporting, laboratory confirmation, early warning and proportionate response. (C1–C3)	Design integrated surveillance systems combining clinical, laboratory, genomic, environmental, wildlife and vaccination data.
Epidemiology and transmission	Investigate vaccine-virus shedding, clearance, environmental persistence, recombination and the influence of host susceptibility on protection. (V1, V2)	Determine incubation periods, clinical and subclinical infection frequency, environmental persistence and factors affecting detectability. (D1, D3)	Quantify the roles of animal movements, trade, markets, husbandry, vectors, wildlife, environment and production systems in disease spread. (C1–C3)	Integrate epidemiological, genomic, diagnostic, movement, vector and environmental data to identify transmission pathways and improve risk models.
Genomic research and data sharing	Use genomic information to understand attenuation, genetic stability, recombination and effectiveness against emerging strains. (V1, V2)	Expand access to whole-genome sequencing for strain characterisation, outbreak investigation and epidemiological tracing. (D1)	Combine genomic surveillance with epidemiological, movement and vector data to identify outbreak sources and guide interventions. (C1, C2)	Strengthen sequencing capacity, shared analytical methods and timely international exchange of sequence data and metadata.
Species, strain and host differences	Evaluate safety, immune responses, cross-protection and duration across cattle, sheep, goats, breeds and vaccine strains; strengthen evidence for sheeppox and goatpox. (V1, V2)	Validate tests across virus species, strains, livestock species and wildlife hosts, including detection of low-level infection. (D1–D3)	Clarify the roles of livestock and wildlife hosts and ensure policies address sheeppox and goatpox as well as lumpy skin disease. (C1–C3)	Generate comparable evidence across viruses, host species, breeds and regions rather than extrapolating mainly from lumpy skin disease in cattle.
Tools for low-resource and remote settings	Improve thermostability, tolerance of cold-chain disruption, affordability, availability and alternative delivery methods. (V1, V2)	Develop rapid, affordable and easy-to-use tools such as lateral flow devices, LAMP assays, pooled testing and image-based support. (D1, D3)	Identify feasible combinations of vaccination, surveillance, diagnostics, movement management, biosecurity and vector control. (C1, C2)	Make affordability, robustness, usability and infrastructure requirements central criteria throughout development and evaluation.

Common theme	Vaccines	Diagnostics	Integrated control strategies	Cross-cutting research need
New technologies and innovation	Compare live attenuated, inactivated, recombinant, multivalent and other next-generation platforms, including capripoxviruses as vaccine vectors. (V1, V2)	Evaluate artificial intelligence, drones, thermal imaging, pseudovirus systems, multiplex technologies and environmental testing. (D1–D3)	Assess how new tools can be incorporated into surveillance, preparedness, vaccination and outbreak-response systems. (C1, C2)	Evaluate innovations as components of practical disease-control pathways rather than as isolated technologies.
Socioeconomic, behavioural and gender considerations	Investigate vaccine confidence, accessibility, acceptance and behavioural and logistical factors affecting uptake. (V1)	Assess user acceptability, training needs and adoption by farmers, veterinarians and frontline animal-health workers. (D1, D3)	Examine under-reporting, compliance, risk perception, incentives, gender roles, livelihoods and barriers to participation. (C1–C3)	Include social science and participatory research in the design, delivery and evaluation of vaccines, diagnostics and control programmes.
Communication, training and decision support	Develop communication tools demonstrating vaccine safety, benefits and cost-effectiveness to farmers, industry and policymakers. (V1)	Evaluate training and decision-support tools for clinical recognition, reporting, sampling and selection of diagnostic pathways. (D1, D3)	Identify effective, locally appropriate communication methods and decision-support frameworks for selecting control measures. (C1, C3)	Co-design training, communication and decision-support resources with intended users and evaluate their effects on behaviour and outcomes.
Economic evaluation and prioritisation	Assess total cost and cost-effectiveness of vaccine platforms, vaccination strategies, vaccine banks and DIVA approaches. (V1–V3)	Determine the cost-effectiveness and operational value of pooled, multiplex, point-of-care and DIVA testing strategies. (D1–D3)	Quantify disease burden and compare the costs, benefits, trade-offs and distributional effects of individual and combined interventions. (C1–C3)	Undertake linked epidemiological and economic evaluations using reliable field data to guide investment and allocation of limited resources.
Context-specific strategies	Determine which vaccines, schedules and delivery approaches suit different species, production systems and disease situations. (V1, V2)	Select diagnostic pathways and differential panels according to species, presentation, vaccination history, resources and epidemiological context. (D1, D3)	Tailor strategies to endemic, epidemic and disease-free settings, with priorities for sustainable control, prevention, preparedness or eradication. (C1–C3)	Develop risk-based frameworks that adapt technologies and interventions to local epidemiological, ecological, socioeconomic and institutional conditions.
Collaboration, capacity and data sharing	Coordinate vaccine trials, DIVA evaluations, reference materials and regulatory assessments internationally. (V1–V3)	Establish networks connecting endemic countries, reference laboratories and commercial developers for validation, sample sharing and technology transfer. (D1–D3)	Strengthen regional early warning, research networks, institutional coordination and collaboration among authorities, researchers and communities. (C1–C3)	Create sustained international and regional mechanisms for shared research, laboratory capacity, data exchange and coordinated preparedness.

Common theme	Vaccines	Diagnostics	Integrated control strategies	Cross-cutting research need
Translation into policy and implementation	Generate evidence to support vaccine selection, authorisation, deployment and monitoring policies. (V1–V3)	Ensure diagnostic results are rapidly communicated and linked to surveillance and outbreak decisions. (D1, D3)	Investigate how integrated programmes can be implemented, scaled, governed and sustained within different veterinary systems. (C1–C3)	Strengthen implementation research so findings are translated into workable regulations, policies and locally sustainable programmes.

Key: V = Vaccines; D = Diagnostics; C = Integrated control strategies. Numbers indicate the relevant breakout table or tables.

Research prioritisation

The final session of the workshop focused on identifying the research gaps considered by participants to be the most urgent and which were most likely to have a significant impact on capripoxvirus prevention, detection, and control. Using outputs from the World Café breakout sessions, participants undertook a multi-round prioritisation exercise, followed by plenary discussions, to review the results, refine priorities, and build consensus.

Across all workshop themes, participants identified a number of priorities that were considered both urgent and high impact. These priorities reflect the need to strengthen international collaboration, improve vaccine and diagnostic capacity and capability, and develop evidence-based approaches to disease prevention and control.

High impact research priorities

Several research needs were identified as being likely to have substantial long-term, positive impacts on the control of capripoxvirus disease. The highest-ranked high impact research priorities were as follows, based on votes recevied and subsequent discussions to reach consensus:

- Promote a global capripox research alliance for collaborative research and information sharing
- Conduct socioeconomic studies to understand barriers to vaccination uptake
- Investigate the role of wildlife and other potential reservoir hosts in capripoxvirus maintenance and transmission
- Develop and evaluate DIVA-compatible vaccines and companion diagnostics
- Develop and validate rapid, field-deployable diagnostic tools
- Identify correlates of protection following vaccination

These results indicate consensus among participants that the greatest long-term gains in capripoxvirus disease prevention and control is likely to arise from stronger international collaboration, improved understanding of disease transmission and vaccine uptake, and the development of more effective, more accessible vaccines, diagnostics, and surveillance tools and technologies. Collectively, these priorities, if

addressed, could deliver substantial and sustained benefits across endemic, epidemic, and disease-free settings.

Urgent research priorities

The most urgent research priorities were selected by participants based on the perception that addressing such a knowledge gap would address immediate barriers to disease prevention and control.

The highest ranked urgent research priorities were as follows:

- Determine optimal vaccination strategies for different epidemiological settings
- Promote a global capripox research alliance for collaborative research and information sharing
- Develop and validate active surveillance approaches that are feasible and sustainable in low-resource settings
- Develop and evaluate DIVA-compatible vaccines and companion diagnostic tests
- Validate DIVA diagnostic assays using large panels of serum samples
- Develop and validate rapid, field-deployable diagnostic tools

These priorities suggest that participants viewed improvements in vaccination strategies, surveillance capacity, diagnostic capability, and international coordination as the most pressing research needs requiring immediate attention. Addressing these gaps will support timely decision-making, strengthen preparedness, and improve the effectiveness of current disease-control programmes.

Conclusion

The prioritisation exercise demonstrated broad consensus that future capripoxvirus research should focus, not only on the development of improved vaccines and diagnostics, but also on strengthening international collaboration, understanding barriers to implementation and improving evidence-based disease-control decision making. The highest-ranked priorities highlight the importance of translating scientific advances into practical tools, technologies, and strategies that can be applied across a range of epidemiological, socioeconomic, and field-based settings. These findings will inform the development of STAR IDAZ IRC research roadmaps and support future coordination of international research investment directed towards lumpy skin disease, sheeppox and goatpox.

Forward look

The Capripoxvirus Gap Analysis Workshop represents an important step in strengthening the international coordination of research activities aimed at preventing, detecting and controlling lumpy skin disease, sheeppox and goatpox. Through a structured process of evidence review, expert consultation, knowledge gap identification and research prioritisation, participants identified a series of high-priority research needs spanning vaccines, diagnostics, surveillance, epidemiology and integrated disease-control strategies.

The research priorities identified during the workshop will be consolidated into thematic STAR IDAZ IRC research roadmaps covering vaccine development, diagnostic development, and integrated control strategies. The draft roadmaps will be reviewed and validated by the STAR IDAZ Scientific Committee. Once

approved, the roadmaps will be published on the STAR IDAZ IRC website and disseminated to IRC Partners, research funding organisations, policy makers, and other key stakeholders involved in animal health research and disease control. These roadmaps will provide a strategic framework for the coordination of international research efforts, promote collaboration, and support effective investment decisions by research funders and programme owners.

Acknowledgement

The STAR IDAZ IRC Capripoxvirus Gap Analysis Workshop was made possible through close collaboration with the National Research and Innovation Agency (BRIN), Indonesia, as well as the invaluable contributions of our dedicated scientific committee, session chairs, presenters, table moderators, and engaged participants. We extend our deepest appreciation to the following experts for their valuable contribution and leadership:

Scientific Committee and Organising Committee: Pip Beard, Jeremy Salt, Harimurti Nuradji, Fitrine Ekawasti, Khaliim Jati Kusala, Dimas Novianto, Diana Nurjanah, Desy Sugiani, Georgina Grell, Maddy Newman, Katie Gordon

Session Chairs: Harimurti Nuradji, Pip Beard, Baratang Alison Lubisi, Camilla Benfield, Eyal Klement, Jeremy Salt

Presenters: Antoinette van Schalkwyk, Adeyinka Adedeyi, Manjunatha Reddy, Henry Munyanduki, Jeremy Salt, Tim Bowden, Maddy Newman, Baratang Alison Lubisi, Camilla Benfield, Shawn Babiuk, Eyal Klement, Christiana Hebel, Pip Beard.

Table Moderators: Pip Beard, Tim Bowden, Baratang Alison Lubisi, Henry Munyanduki, Adeyinka Adedeji, Shawn Babiuk, Indrawati Sendow, Christiana Hebel, Eyal Klement

Document reviewers and participants: We are also grateful to the 26 experts who participated in the pre-workshop global consultation and the numerous experts from diverse institutions and background (see List of participants), whose active engagement and contributions enriched our discussions during the workshop.

Together, our efforts are helping to advance capripoxvirus research by fostering collaboration, identifying key research priorities and driving innovative solutions to enhance capripoxvirus disease control worldwide.

List of participants

Adedeji, Adeyinka National Veterinary Research Institute, NVRI Vom Nigeria	**Lubisi, Baratang Alison** Onderstepoort Veterinary Institute South Africa
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Klement, Eyal Koret School of Veterinary Medicine Israel	

Annex 1: Workshop agenda

Day 1: Tuesday 21 July 2026		
Session 1. Scientific Symposium | Chair: Dr Harimurti Nuradji Indonesian Research Center for Veterinary Sciences, BRIN, Indonesia		
08:30-08:35	Housekeeping	Katie Gordon, STAR IDAZ Secretariat
08:35-08:50	Opening Remarks from BRIN	Prof. Ni Luh Putu Indi Dharmayanti, M.Si., Chair of the Research Organization for Health, BRIN
08:50-09:10	Overview of STAR IDAZ International Research Consortium for Animal Health	Maddy Newman, STAR IDAZ Secretariat Lead
09:10-09:35	Capripoxviruses - Setting the Scene and Highlighting Key Challenges	Dr Pip Beard, Keele University, UK
09:35-10:00	Capripoxviruses in Focus: Global Dynamics and WOAH's Strategic Initiatives	Dr Waroonsiri Charoenlarp, World Organisation of Animal Health
10:00-10:30	**Morning break**	
10:30-11:45	Scientific Presentations	
	1. Phylogenetic epidemiology of Lumpy skin disease virus: Insights from whole-genome sequencing compared with selected open reading frames	Dr Antoinette van Schalkwyk, Agricultural Research Council, South Africa
	2. Five Decades of Capripoxvirus infections in Nigeria: Endemic, severe impact, but underreported	Dr Adeyinka Adedeji, National Veterinary Research Institute, Vom, Nigeria
	3. Current situation of Capripoxvirus diseases in India, an epidemic example	Dr Manjunatha Reddy, ICAR-National Institute of Veterinary Epidemiology & Disease Informatics (NIVEDI), India
	4. From Vector Capacity to Preparedness: Informing Surveillance and Readiness for Lumpy Skin Disease in Australia	Dr Henry Munyanduki, Australian Centre for Disease Preparedness, CSRIO, Australia
11:45-12:00	Symposium Closing Remarks	Dr Harimurti Nuradji, BRIN
12:00-13:00	**Lunch and Symposium Photo**	

Session 2. Gap Analysis Introduction | Chair: Dr Pip Beard Keele University, UK		
13:00-13:10	Introduction to Gap Analysis Workshop	Katie Gordon, STAR IDAZ Secretariat
13:10-13:40	Overview of STAR IDAZ IRC Research Roadmaps	Dr Jeremy Salt, The Vaccine Group, UK
Session 3. Diagnostic Research Needs | Chair: Dr Baratang Alison Lubisi Agricultural Research Council, South Africa		
13:40-13:55	State-of-the-Art in Diagnostics	Dr Tim Bowden, ACDP, CSRIO, Australia
13:55-14:10	Overview of Survey Results - Diagnostic Research Needs	Dr Baratang Alison Lubisi, ARC, South Africa
14:10-14:15	Instructions for Breakout Groups	Katie Gordon, STAR IDAZ Secretariat
14:15-14:45	**Afternoon break**	
14:45-16:45	Breakout Group Activity	
16:45-17:25	Diagnostics Plenary Discussion	Group Moderators
17:25-17:30	Forward look to Day 2	Dr Baratang Alison Lubisi, ARC, South Africa
17:30 End of Day 1		

Day 2: Wednesday 22 July 2026		
Session 4. Vaccinology Research Needs | Chair: Dr Camilla Benfield GALVmed		
08:30-08:35	Welcome and Introduction to Day 2	Dr Camilla Benfield, GALVmed
08:35-08:50	State-of-the-Art in Vaccines	Dr Shawn Babiuk, Canadian Food Inspection Agency, Canada
08:50-09:05	Overview of Survey Results - Vaccine Research Needs	Dr Camilla Benfield, GALVmed
09:05-09:15	Instructions for Breakout Groups	Maddy Newman, STAR IDAZ Secretariat
09:15-10:00	Breakout Group Activity	
10:00-10:30	**Morning break**	
10:30-12:00	Breakout Group Activity [Continued]	

12:00-13:00 Lunch		
13:00-14:00	Vaccinology Plenary Discussion	Group Moderators

Session 5. Integrated Control Strategies Research Needs | Chair: Dr Eyal Klement Koret School of Veterinary Medicine, Israel		
14:00-14:20	State-of-the-Art in Integrated Control	Dr Eyal Klement, Koret School of Veterinary Medicine, Israel
14:20-14:35	Overview of Survey Results – Integrated Control	Dr Christiana Hebel, Central Veterinary Research Laboratory, UAE
14:35-14:40	Instructions for Breakout Groups	Katie Gordon, STAR IDAZ Secretariat
14:40-15:30	Breakout Group Activity	
15:30-16:00	**Afternoon Break**	
16:00-17:30	Breakout Group Activity [Continued]	
17:30-18:00	Integrated Control Plenary Discussion	Group Moderators
18:00 End of Day		

Day 3: Thursday 23 July 2026		
Session 6. Prioritisation, Next Steps and Closing | Chair: Dr Jeremy Salt The Vaccine Group, UK		
09:00-09:05	Welcome and Introduction to Day 3	Dr Jeremy Salt, The Vaccine Group, UK
09:05-09:30	Integrated Control Plenary Discussion	
09:30-09:40	Instructions for Prioritisation Activity	Maddy Newman, STAR IDAZ Secretariat
09:40-10:15	Research Needs Prioritisation Activity: First Round	
10:15-10:45	**Morning break**	
10:45-11:05	Prioritisation Plenary Discussion	
11:05-11:25	Research Needs Prioritisation Activity: Second Round	
11:25-11:40	Gap Analysis Outputs: 1. Research Review 2. Workshop Report 3. Research Roadmaps Development 4. Executive Summary 5. Peer-reviewed Publication	Dr Pip Beard, Keele University, UK

11:40-11:50	Next Steps	Dr Jeremy Salt, The Vaccine Group, UK
11:50-12:00	Closing Remarks	BRIN Representative
12:00-12:45	**End of Workshop & Lunch**	

Annex 2: Capripoxvirus Research Gap Expert Consultation

Scope: Lumpy skin disease virus (LSDV), goatpox virus (GTPV) and sheeppox virus (SPPV)

1. I consent to participate in this expert consultation
   Yes, I consent
   No, I do not consent
2. I consent for my name and affiliation to be included in the list of acknowledged experts
   Yes, I consent
   No, I do not consent
3. Name of Respondent *[free text]*
4. Email address *[free text]*
5. Organisation and role *[free text]*
6. Area(s) of expertise *[free text]*

Research needs relating to epidemiology and integrated control

7. Please outline gaps in knowledge relating to global burden of disease/ cost of disease and benefits of control options *[free text]*
8. Please outline gaps in knowledge relating to additional research needs
9. Please detail specific research and knowledge priorities relating to **epidemiology and control** into the table below, including research category (STA, short term applied; LTA, long term applied; BR, basic research) and justification. *Enter up to 8 priorities, one per line. Use the following format: Research Topic / Research Category (STA, LTA, BR) / Justification*

Research needs relating to diagnosis

10. Please outline gaps in knowledge relating to limitations of current diagnosis *[free text]*
11. Please outline gaps in knowledge relating to research needed to improve current diagnostics *[free text]*
12. Please outline gaps in knowledge relating to research needed to deliver novel diagnostics *[free text]*
13. Please outline gaps in knowledge relating to additional research needs *[free text]*
14. Please detail specific research and knowledge priorities relating to **diagnostics** into the table below, including research category (STA, short term applied; LTA, long term applied; BR, basic research) and justification. *Enter up to 8 priorities, one per line. Use the following format: Research Topic / Research Category (STA, LTA, BR) / Justification*

Research needs relating to immunology

15. Please outline gaps in knowledge relating to better understanding of innate immune response to pathobiology *[free text]*

16. Please outline gaps in knowledge relating to understanding the contributions of humoral, cellular and innate arms of immunity to protective responses / resistance *[free text]*
17. Please outline gaps in knowledge relating to additional research needs *[free text]*
18. Please detail specific research and knowledge priorities relating to **immunology** into the table below, including research category (STA, short term applied; LTA, long term applied; BR, basic research) and justification. *Enter up to 8 priorities, one per line. Use the following format: Research Topic / Research Category (STA, LTA, BR) / Justification*

Research needs relating to vaccinology

19. Please outline gaps in knowledge relating to limitations of current vaccines *[free text]*
20. Please outline gaps in knowledge relating to research needed to improve current vaccines *[free text]*
21. Please outline gaps in knowledge relating to research needed to deliver novel vaccines *[free text]*
22. Please outline gaps in knowledge relating to additional research needs *[free text]*
23. Please detail specific research and knowledge priorities relating to **vaccines** into the table below, including research category (STA, short term applied; LTA, long term applied; BR, basic research) and justification. *Enter up to 8 priorities, one per line. Use the following format: Research Topic / Research Category (STA, LTA, BR) / Justification*

Research needs relating to pathogenesis and pathobiology

24. Please outline gaps in knowledge relating to limitations of current understanding of pathogenesis and pathology that could inform development of better countermeasures (integrated control, diagnostics and vaccines) *[free text]*
25. Please outline gaps in knowledge relating to additional research needs *[free text]*
26. Please detail specific research and knowledge priorities relating to **pathogenesis and pathobiology** into the table below, including research category (STA, short term applied; LTA, long term applied; BR, basic research) and justification. *Enter up to 8 priorities, one per line. Use the following format: Research Topic / Research Category (STA, LTA, BR) / Justification*

[SURVEY CLOSE]

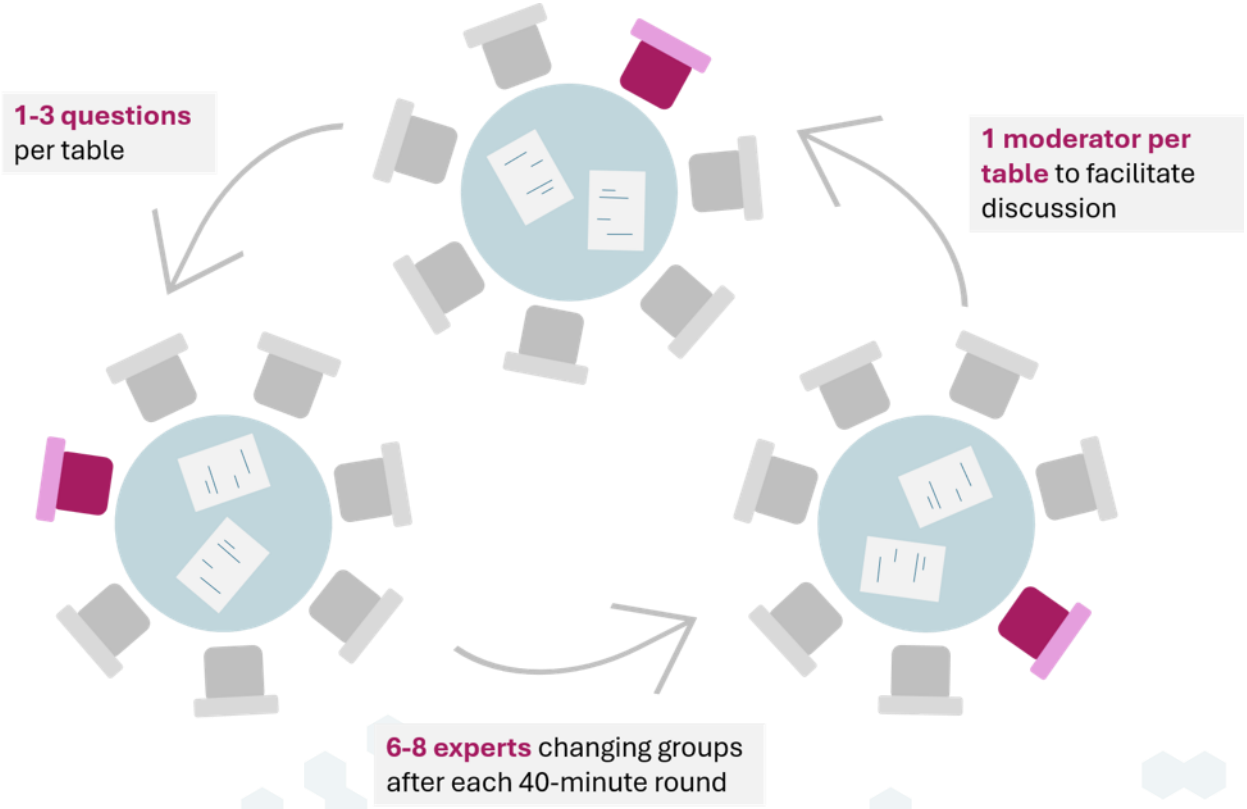
Annex 3: World Café methodology

A World Café methodology was used to facilitate structured discussion and identification of research gaps relating to diagnostics, vaccines, and integrated control strategies for capripoxviruses. For each thematic session, participants were divided into three breakout groups and asked to discuss a set of pre-defined questions relating to specific research challenges and evidence gaps. Each discussion round lasted approximately 40-minutes, after which participants rotated to a different table. The process was repeated until all participants had contributed to each discussion topic within the thematic session (Figure 1). Table moderators remained at their assigned table throughout the session. They were responsible for facilitating discussions, recording key points, and presenting outputs during the plenary session.

The World Café approach enabled participants to build on the contributions of previous groups, refine emerging ideas and identify areas of agreement and disagreement. Findings from each table were presented to the wider group, during plenary, allowing discussions to be validated, expanded and consolidated.

The complete list of research needs identified across the workshop will be reported in the research roadmaps, following validation by the STAR IDAZ Scientific Committee, and published on the STAR IDAZ IRC website.

Figure 1. World Café methodology

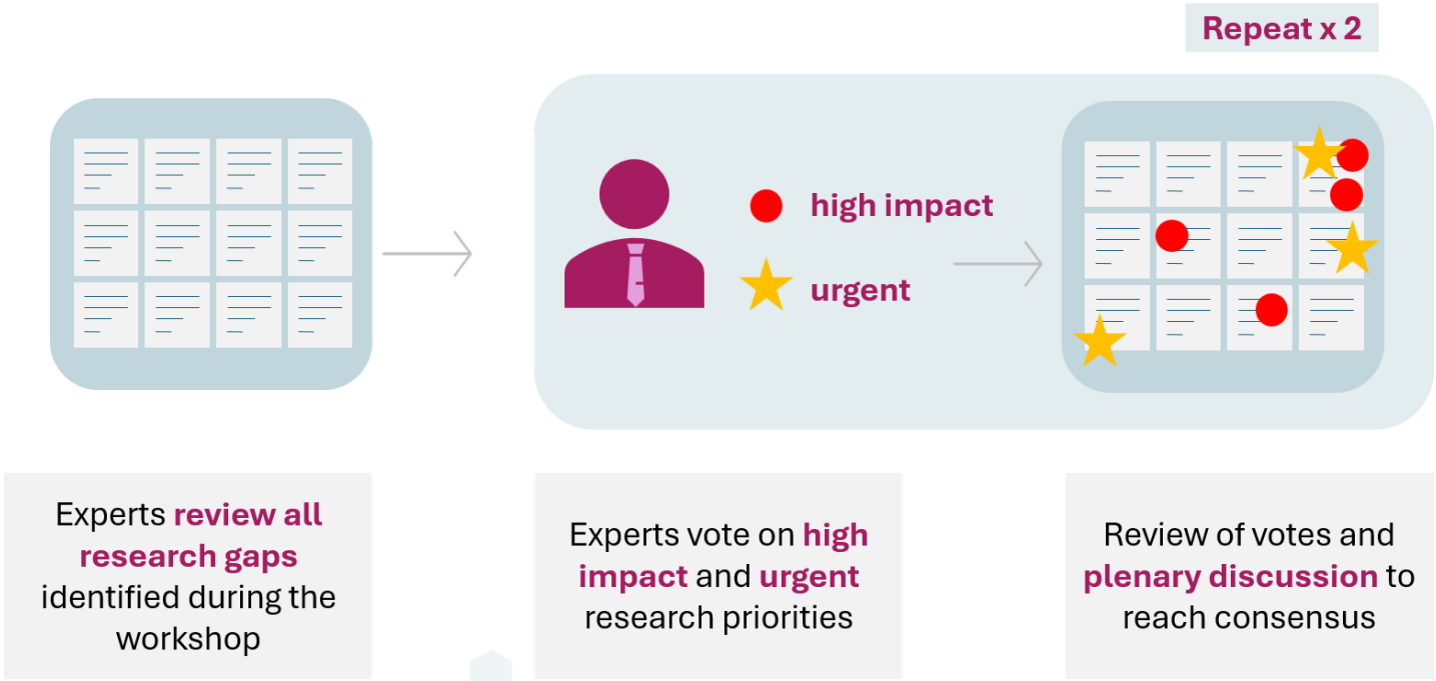


Annex 4: Prioritisation methodology

Participants were presented with a consolidated list of research needs generated during the World Café activity and invited to assess each item according to urgency and potential impact using a multi-round, sticker-based voting system. For the first round of the prioritisation activity, each participant was allocated 7 red stickers and 4 gold star stickers, used to vote on 'high impact' and 'urgent' research gaps, respectively. 'High impact' gaps were considered to be capable of yielding significant improvements in disease prevention, surveillance, diagnosis or control, if addressed; and 'urgent' research gaps were those considered important for addressing current disease control challenges. The voting exercise was repeated, with plenary discussions held in between rounds to review the results, clarify priorities, and help build consensus among participants. On the second round of voting, participants were allocated an additional 5 (high impact) and 2 gold (urgent) stickers (Figure 2). This approach enabled participants to consider both individual and collective perspectives when identifying the most important research priorities for future investment and international collaboration.

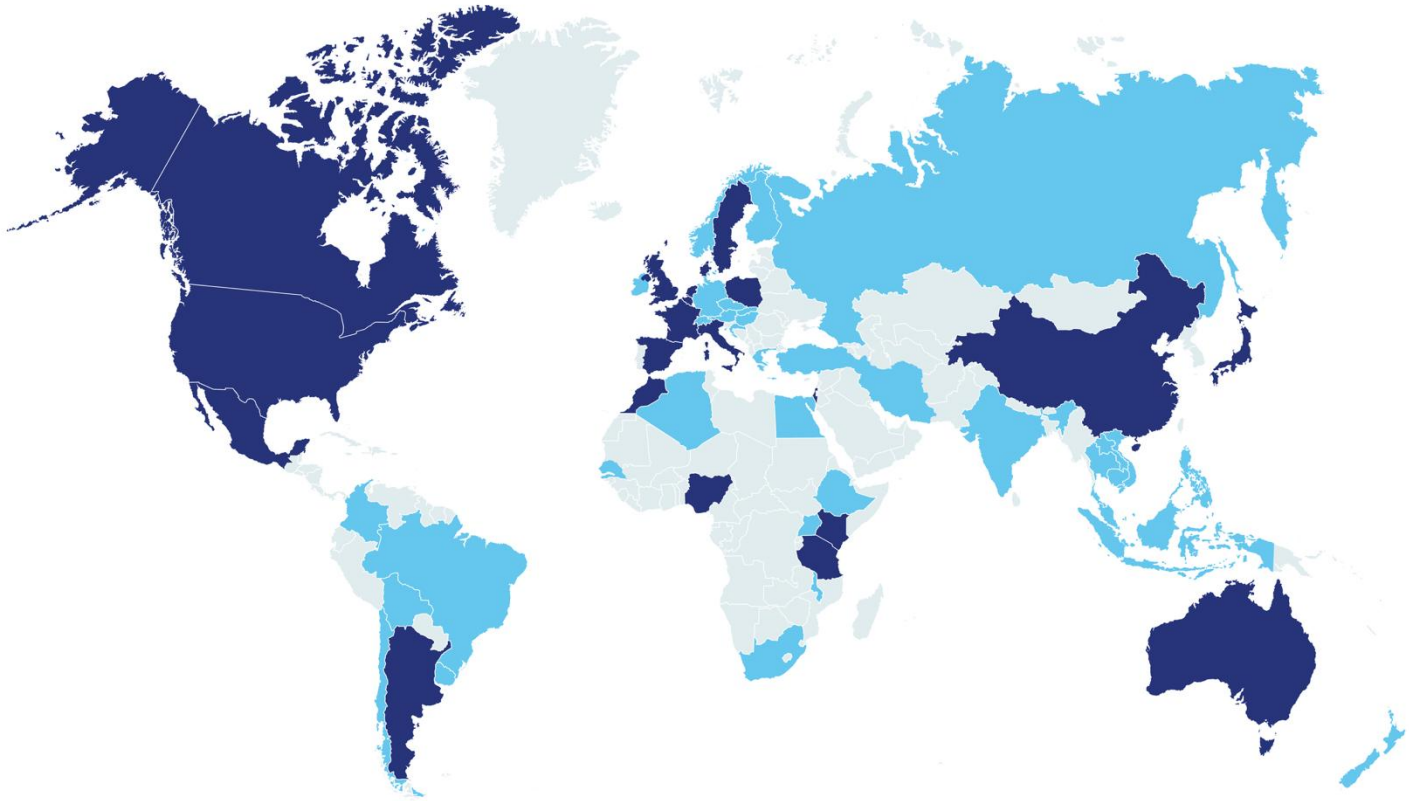
The outputs of the prioritisation activity will be reported in an executive summary *(in progress)* and disseminated to STAR IDAZ IRC Partners, research funders, and other key stakeholders to support future research coordination and investment.

Figure 2. Prioritisation activity



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