Food and Agriculture Organization of the United Nations

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european commission for the control of foot-and-mouth disease

Open Session of the Standing Technical Committee of the EuFMD

Book of abstracts

OS20, Virtual event

8,10,15,17 December 2020 and 16 February 2021

European Commission for the Control of Foot-and-Mouth Disease

SUPPORT

Support | Private

Contents

FOREWORD

Dear colleagues,

In recent years, Foot-and-mouth And Similar Transboundary animal diseases (FAST) have made frequent and unprecedented inter-continental and inter-regional incursions that have not always been contained. This has affected the livelihoods of millions of livestock keepers and placed new demands on those working in public and private delivery of animal health services.

How have the approaches and tools adapted to these events? What is being doneto better forecast FAST disease spread, to target surveillance and control measures, and to communicate risks? How can livestock business and livelihoods be protected - and maintained, at every level, in regions coping with persistence of FAST diseases, or frequent re-introductions? How can we better integrate this intelligence into national, regional and even farm-level biosecurity and risk mitigation actions, given the economic climate and environmental drivers for movements of animals and animal products from regions affected by FAST diseases?

The Open Session 2020 consisted in virtual sessions focused on animal mobility forFAST risk mapping, addressing risk change and forecast, vaccine security and critical resources for emergency management, and resilience to long-term FAST crises. The focus remained on FMD, but similar TADs were also considered such asPeste des Petits Ruminants, Sheep and Goat Pox, Lumpy Skin Disease, Rift Valley Fever, and Bovine Ephemeral Fever). Furthermore, there is so much to learn fromCOVID for FAST disease management - and from each other, on how to work efficiently without travel and on biosecurity and behavior change - that is relevant to discuss. For each session, keynote presentations and short interventions were proposed. A space for e-posters was made available.

Following the open session, workshops were organized in January to reflect, discuss and work on the conference outcomes and a final closure day was organized to share the conclusions of the OS20.

Keith Sumption
Executive Secretary
EuFMD

Fabrizio Rosso
Deputy Executive Secretary
EuFMD

AGENDA

08 December Official opening

Morning (09:30 – 11.00 am)

9:30-9:40	***Dr. F. Rosso,*** *Deputy Executive Secretary.* *European Commission for the Control of Foot-and-Mouth Disease (EuFMD)* ***Dr. J. Angot,*** *Inspecteur général de santé publique vétérinaire, EuFMD*	
9:40-9:45	**Dr. M. Stone,** *Deputy Director General International Standards and Science, OIE*	
9:45-9:50	**Dr. A. Füssel,** *DG SANTE/G2, European Commission*	
9:50-9:55	**Dr. K. Sumption,** *Chief Veterinary Officer FAO, Executive Secretary EuFMD*	
9:55-10:10	**Dr. M. Blake,** *Chief Veterinary Officer Ireland, EuFMD President*	
10:10-10:20	**Dr. S. Zientara,** *Head of the Research Unit, ANSES, President Standing Technical Committee of the EuFMD*	
Setting the Scene for the Open Session		
10:20-10:40	**Dr. D. King** *Head of the Vesicular Disease Reference Laboratory Group, The Pirbright Institute (TPI)*	Global Foot-and-Mouth Disease situation
10:40-10:50	**A. Bataille** *Researcher virologist* *The French Agricultural Research Centre forInternational Development (CIRAD)*	Geographic distributionof Peste des Petits Ruminants

10:50-11:00	**Dr E. Tuppurainen** *Head of the Field Studies Working Group* *Friedrich-Loeffler-Institut (FLI)*	Lumpy Skin Disease: a challenge for three continents
11:00-11:15	**Round table**	

8 December Session 1 Measuring animal movements and drivers for FAST disease risk mapping

Morning (11.30 - 13.00) **Chair: Prof. James Wood**

11:20-11:30	**Introduction** by the Chair: Prof. James Wood	
Keynote 11:30-11:50	**Prof. R. Kao** *Professor of Veterinary Epidemiology and Data Science,* *University of Edinburgh*	Quantifying the role of livestock movements for the transmission of RVF in Northern Tanzania.
Keynote 11:50-12:10	**Dr. A. Apolloni, Dr. A. Delabouglise** *Modeller/Health economist* *The French Agricultural Research Centre for International Development (CIRAD)*	Modelling and predicting national and regional animal mobility affecting livestock's diseases circulation. A comparison from studies in north/west Africa and southeast Asia.
12:10-12:20	**N.C. Cárdenas** *PhD student* *Sao Paulo University*	A multi-species contact-network model: between-farm disease spreading among bovine, small ruminants and swine populations.

12:20-12:30	**Dr. D. Ekwem** *University Of Glasgow*	Tracking livestock movements to understand the patterns and risks of foot-and-mouth disease spread in traditionally managed systems in east Africa.
12:30-12:40	**Dr. G. Guyver-Fletcher** Phd Student *The University of Warwick*	A model exploration of carrier transmission sufficient for maintenance of endemic FMD.
12:40-13:00	**Round table** moderated by James Wood, Corissa Miller and Paolo Motta	

Afternoon (15.00 - 17.00) Chair: Prof. James Wood

Keynote 15:00-15:20	**Dr. E. Valdano** *Postdoctoral Researcher* *French National Institute of Health and Medical Research (INSERM)*	Analyzing cattle trade networks from 13 European countries, and predicting their vulnerability to outbreaks.
15:20-15:30	**Dr. C. Squarzoni-Diaw** *Epidemiologist* *The French Agricultural Research Centre for International Development (CIRAD)*	A participatory qualitative risk assessment to estimate the risk of introduction and spread of transboundary animal diseases in scarce-data environments and the major role of animal mobility.
15:30-15:40	**Dr. F. Wanyoike** *International Livestock Research Institute (ILRI)*	Impact of environmental changes and disruption of production and price variations on animal mobility, movement patterns and spread of FAST diseases.
15:40-15:50	**Dr. R. Aguanno** *The Food and Agriculture Organization (FAO)* *Prof Doctorate Student* *Royal Veterinary College (RVC) London*	Participatory mapping of animal mobility patterns using FAO's epidemiology value chain platform.

15:50-16:00	**Dr. B. Vidondo** *Researcher* *University of Bern*	Early warning of infectious disease outbreaks on cattle-transport networks.
16:00-16:30	**Round table** moderated by James Wood, Bouda Ahmadi and Paolo Motta	

10 December Session 2 From risk to actions: making them happen

Morning (11.00 - 13.00) Chair: Prof. Katharina Staerk

10.50-11.00	**Introduction** by the Chair: Prof. Katharina Staerk	
Keynote 11:00- 11:20	**Dr. E. Snary** *Head of Epidemiological Sciences. Animal and Plant Health Agency (APHA)*	Cross-validation of generic risk assessment tools:an ASF case study.
Keynote 11:20- 11:40	**Dr. M. Tildesley** *Associate Professor University of Warwick*	The use of foot-and-mouth disease models indisease free and endemic settings: prediction, control and targeting of interventions for emerging outbreaks.
11:40-11:50	**Dr. A. Cabezas** *Responsable du statutdes maladies Service Des Status, Office international des Epizooties (OIE)*	An analysis of recognitions, suspensions, and recoveries Of Official Foot-And-Mouth Diseasefree status and identification of possible associated factors for fast and sustained recoveries.
11:50-12:00	**Dr. R. Palumbo, Dr. R. Condoleo** *Istituto Zooprofilattico Sperimentale delle Regioni Lazio e Toscana (IZSLT)*	Ranking FMD Hazard using expert knowledgeelicitation and PCP activities.
12:00-12:10	**Dr. N. Mapitse** *Office internationaldes Epizooties (OIE)*	The Global FMD control strategy, progress,challenges and opportunities.

12:10-12:20	**Dr. L. Corbellini** *Associate Professor Universidade Federal do Rio Grande do Sul (on sabbatical leave) (IICA)*	Planning Foot and Mouth Disease surveillance system in Brazil: a shift to free zones where vaccination is not practised.
12:20-12:50	**Round table** moderated by Katharina Staerk, Corissa Miller and Nick Lyons	

Afternoon (15:00 - 17.00) Chair: Prof. Katharina Staerk

Keynote 15:00-15:20	**Dr. K. Rich** *International Livestock Research Institute,(ILRI)*	Methods for economic evaluation of surveillance, prevention and control measuresconsidering TADs risk and cost of mitigation measures.
Keynote 15:20-15:40	**Dr. L. Boden** *Professor in Population Medicine and Veterinary Public Health Policy Deputy Director of EPIC, Scottish Government's Centre of Expertise on Animal Disease OutbreaksThe Royal (Dick) School of Veterinary Studies and The Roslin Institute*	Effective risk communication for better preventive measures. Barriers, opportunities and strategies to ensure adequate response torisk change.
15:40-15:50	**Dr. T. Knight-Jones** *Senior Scientist International Livestock Research Institute (ILRI)*	When Is FMD Vaccination in Endemic SettingsProfitable?
15:50-16:00	**Dr. N. Lyons** *Veterinary Epidemiology Consultant University of Liverpool/EuFMD*	Economic Considerations for AdvancementThrough The Progressive Control Pathway: Cost-Benefit Analysis of FMD Control In Punjab Province, Pakistan.
16:00-16:10	**Dr. A. Railey** *Postdoctoral Fellow Indiana University*	Household and market impacts of foot-and-mouth disease at the Uganda-Tanzania border.

16:10-16:20	**Dr. K. VanderWaal** *Assistant Professor* *University of Minnesota*	Forecasting the Spread of Viruses in Swine In The U.S.: Translating Movement and Environmental Data to Actionable Information.
16:20-16:50	**Round table** moderated by Katharina Staerk, Bouda Ahmadi and Nick Lyons	

15 December Vaccine security and critical resources for emergency management

Morning (11:00 - 13.00) Chair: Dr. Sten Mortensen

10:50 -11:00	**Introduction** by the Chair: Dr. Sten Mortensen	
Keynote 11:00-11:20	**Dr. S. Hamilton** *Director, Epidemiology and One Health, Australian Government*	How much is enough? Modelling and other methods to guide investments in preparedness for transboundary animal diseases.
Keynote 11:20-11:40	**Dr. D. Sammin** *Director, Laboratory Services of the Department of Agriculture, Food and the Marine*	Diagnostic supply chain issues: lessons from COVID19 for animal health.
11:40-11:50	**Dr. N. Singanallur** *Commonwealth Scientific and Industrial Research Organization*	Systems immunology-based approach to study early immune responses to emergency foot-and-mouth disease vaccination in pigs.
11:50-12:00	**Dr. S. Watson** *European Commission for the Control of Foot-and-Mouth Disease (EuFMD)*	Developing an analytical model to predict FMD vaccine demand for endemic countries.

12:00-12:10	**L. Quiroz** *Emergency Program Manager at California Department of Food and Agriculture* **Dr. P. Hullinger** EuFMD	California FMD vaccination planning.
12:10-12:20	**Dr. B. Sanz-Bernardo, Dr. M. Grant** *The Pirbright Institute/EuFMD*	FASTer vaccination: assessing level of preparedness.
12:20-12:50	**Round table** moderated by Sten Mortensen, Corissa Miller and Bouda Ahmadi	

Afternoon (15:00 - 17.00) Chair: Dr. Sten Mortensen

Keynote 15:00-15:20	**Dr. M. J. Francis** *BioVacc Consulting Ltd*	From Bench to Field: Rapid Veterinary Vaccine Development and Platform Technologies.
Keynote 15:20-15:40	**Dr. P. Hudelet** Head, Technical Service *Boehringer Ingelheim Animal Health*	Solutions to vaccine security - a manufacturer's perspective.
15:40-15:50	**Dr. A. King** *Director, International Veterinary Health. Merck Animal Health*	Prioritization of vaccines – approaches to maximizing impact.
15:50-16:00	**Dr Khorchani** *Médecin Vétérinaire* *Inspecteur Régional, Direction Générale des Services Vétérinaires* *Ministère de l'Agriculture* *République Tunisienne*	Evaluation of human resources needed and comparison with human resources available to control foot and mouth disease outbreaks in Tunisia using emergency vaccination.

16:00-16:10	**Dr. A. S. Asfor** *The Pirbright Institute (TPI)*	Development of a peptide Elisa for specific detection of foot-and-mouth disease virus-neutralizing antibodies: can a test in this format replace VNT?
16:10-16:20	**Dr. C. Ezeasor** *Lecturer* *University of Nigeria*	Intranasal vaccine application methods influence the immune responses in goats following intranasal *peste des petits ruminants* vaccination: clinic pathological and immune histochemical finding.
16:20-16:50	**Round table** moderated by Sten Mortensen, Bouda Ahmadi and Pamela Hullinger	

17 December Session 4 Resilience to long term FAST crises: the importance of animal welfare, supply chain and business continuity

Morning (11:00 – 13.00) Chair: Dr. Germán Cáceres Garrido

10:50-11:00	**Introduction** by the Chair: Dr. Germán Cáceres Garrido	
Keynote 11:00-11:20	**Dr. F. Reviriego** *DG for Health and Food Safety of the European Commission*	Improving business continuity in the EU - the regulatory and policy challenges.
Keynote 11:20-11:40	**Dr. J. Vaarten** *Executive Director Federation of Veterinarians of Europe (FVE)*	Tackling FAST diseases through a public-private partnership.
11:40-11:50	**Dr. R. García** *Former president of the Association of Government Veterinarians (UK)*	Veterinary services wellbeing – a key element of resilient FAST crises.
11:50-12:00	**Dr. M. G. Garner** *Commonwealth Scientific and Industrial Research Organization (CSIRO)*	Comparing surveillance approaches to support regaining free status after a foot and mouth disease outbreak.

12:00-12:10	**T. Marschik** *PhD Student* *University of Veterinary Medicine Vienna*	The epidemiological and economic impact of a potential outbreak of foot-and-mouth disease in Austria.
12:10-12:20	**María de la Puente Arévalo** *European Commission for the Control of Foot-and-Mouth Disease (EuFMD)*	Supporting preparedness to crises...in times of crisis
12:20-12:50	**Round table** moderated by Germán Cáceres, Corissa Miller and María de la Puente Arévalo	

Afternoon (15:00 - 17.00) Chair: Dr. Germán Cáceres Garrido

Keynote 15:00-15:20	**A. Meyer and Dr. C. Faverjon** *Ausvet Europe*	Compartmentalization as a tool for improved resilience to TADs introduction: a case study.
Keynote 15:20-15:40	**Dr. A. Murray** *DVM, MPVM, PhD* *Supervising Veterinarian* *California Department of Foodand Agriculture, United States*	Continuity of Business during Transboundary Animal Diseases – Lessons Learned from California's Implementation of the Secure Food Supply Program.
15:40-15:50	**Dr. A.Rivera** *Pan American Center for Foot-and-Mouth Disease and Veterinary Public Health (PANAFTOSA-PAHO/WHO)*	Control of an outbreak of foot and mouth disease in Colombia 2017-2018, lessons learned.
15:50-16:00	**Dr. G. Savioli,** *Veterinary Officer Swiss Armed Forces*	A methodology to estimate indirect costs associated with a possible outbreak of TADs in Switzerland.

16:00- 16:10	**Dr. D. Bickett-Weddle** *Associate Director Center for Food Security and Public Health (CFSPH), Iowa State University*	Secure food supply planning in the U.S.-continuity of business during a transboundary livestock disease outbreak.
16:10- 16:20	**Dr. K. Mintiens** *European Commission for theControl of Foot-and-Mouth Disease (EuFMD)*	Impact of on-farm biosecurity level in pig herds on the spread and control of foot and mouth disease.
16:20- 16:50	**Round table** moderated by Germán Cáceres Bouda Ahmadi and Maríade la Puente Arévalo	

17 December Official closure

17:00 – 17:15

	Dr. F. Rosso, *Deputy Executive Secretary.* *European Commission for the Control of Foot-and-Mouth Disease (EuFMD)*	Opening
	Dr E. Brocchi *Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna (IZSLER)*	A multiplex lateral flow device for on-field identification and serotyping of FMD virus
	Dr. K. Sumption, *Chief Veterinary Officer FAO, Executive Secretary EuFMD*	End of Session Remarks
	Dr. F. Rosso	Conclusion and upcoming events

POSTER SESSION

8 December Session 1 Measuring animal movements and drivers for FAST disease risk mapping

Dr. S. M. Jamal, *Department of Biotechnology* *University of Malakand,* *Pakistan*	Spread of foot-and-mouth disease virus serotype o/me-sa/ind-2001e sub-lineage in Pakistan.
Dr. P. Bastiaensen, *Programme Officer* *World Organization for Animal Health (OIE)*	Is African swine fever returning to Africa? A back-of-the-envelope analysis of 15 years of WAHIS data.
Dr. S. Mielke, *Center for Epidemiology and Animal Health (CEAH)*	Predicting foot-and-mouth disease virus in tropical endemic settings using an agent-based modeling framework.
Dr. A. J. Adedeji *National Veterinary Research Institute*	Risk factors associated with sheeppox and goatpox seroprevalence and identification of high-risk areas in selected states of northern Nigeria.
Dr. R. M. F. De Jong, *Royal Veterinary College, UK*	Epidemiological investigation of foot-and-mouth disease outbreaks in a bear rescue center in Vietnam in 2011.
G. Silva, *Master's student in experimental epidemiology,* *University of São Paulo*	Coverage of slaughterhouse surveillance for bovine tuberculosis through network analysis of cattle movements in Brazil.
Dr. R. Bradhurst, *CEBRA Research Fellow* *School of Biosciences* *The University of Melbourne*	Modelling the spread of transboundary animal disease in and between domestic and wild swine populations.

Dr. I. Mugezi, *Veterinary Inspector Department of Animal Health, Ministry of Agriculture*	Risk of foot-and-mouth disease spread through cattle movements in Uganda.
U. Gunasekera, *Research Assistant University of Minnesota*	Molecular surveillance of foot and mouth disease virus through slaughterhouse in Vietnam.
Dr. K. Absalanfard, *Ph.D of Epidemiology*	Survey on 10 years foot and mouth disease outbreaks in Bushehr province, Iran.
D. Lazarus, *Doctoral student University of Pretoria Faculty of Veterinary Science Department of Production Animal Studies*	Goat movements within the foot-and-mouth disease protection zone of south Africa.
Dr. E. A. Foglia, *PhD* *Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna*	The role of local and regional livestock movements in foot-and-mouth disease spread in east Africa.
Dr. T. Chaligava, *Ministry of Environmental Protection and Agriculture of Georgia*	Foot-and-mouth disease risk mapping in Georgia.
Dr. T. Makara, *Department of Animal Health and Veterinary Public Health of the General Directorate of Animal Health and Production*	Epidemiological study of foot and mouth diseases in Prey Veng province, March 2018-August 2019.

10 December Session 2 From risk to actions: making them happen

Dr. J. Udahemuka, *Lecturer* *University of Rwanda*	Risk factors associated with FMD endemicity in eastern Rwanda.
K. StCharles, *Research Professional* *Secure Food Systems Team* *UMN College of Veterinary Medicine* *Department of Veterinary and Biomedical Sciences.*	Workload schedules, biosecurity practices, and communication preferences of truck drivers transporting pigs and their potential implications on disease spread in the United States.
Dr. C. Colenutt, *Senior Postdoctoral Scientist* *The Pirbright Institute*	Foot-and-Mouth disease virus surveillance at markets and abattoirs in Cameroon using environmental sampling.
Dr. P. Compston, *PhD student, Royal Veterinary College,* *Veterinary Epidemiology, Economics and Public Health Group*	Factors influencing decision-making for foot-and-mouth disease control in Kenya.
Dr. David Lefebvre, *Scientist, DVM, PhD* *Exotic viruses and Particular Diseases*	Complex circulation of foot-and-mouth disease virus in cattle in Nigeria.
Dr. T. Aliyeva, *Azerbaijan Food Safety Institute.*	Comparison of FMD serosurveillance results in Azerbaijan during 2016 – 2019.
Dr. W. Probert, *Researcher* *University of Oxford*	Vote-processing rules for combining rankings of control interventions from multiple models.
Dr. Y. Tao, *Postdoctoral Fellow* *UC Santa Barbara, US Intelligence Community*	Misspecifying operational delays may produce biased forecasts: a retrospective analysis of the 2001 FMDV outbreak in the United Kingdom.

Dr. S. Messori, *Chargé de mission* *World Organization for Animal Health (OIE)*	Focusing the global research effort to deliver the required tools and strategies for FMD control.
Dr. D. Hadžović *Senior Associate for Veterinary Epidemiology at Veterinary Office of BiH*	Evaluation of a brucellosis control strategy in small ruminants in Bosnia and Herzegovina.
Dr. S. Yadav, *FMD Technical Specialist and Quantitative Risk Assessor, EuFMD*	Evaluation of the impacts of 'time to detection' of a foot-and-mouth disease incursion in Central Europe using EuFMDIS modelling tool.
Dr. A. Bulut, *Veterinary FMD Expert* *FMD Institute*	A new approach on outbreak investigations for the control of foot-and-mouth disease (FMD) in Anatolian region of Turkey.
Dr. S.I. Turgut, *Veterinarian* *Sap Institute Müdürlüğü/ANKARA Agriculture and Foresty Ministery*	Monitoring to combat foot-and-mouth disease virus serotype O from 1999 to the present in Turkey.
Dr. O. Nekouie, *Department of Infectious Diseases and Public Health, City University of Hong Kong*	Modeling of freedom from peste des petits ruminants (PPR) and sheep and goat pox (SGP) in Thrace.
Dr. A. Dekker, *Senior scientist* *Wageningen Bioveterinary researchWBVR-Lelystad*	Survival of FMDV in the environment and its role in virus transmission.
Dr. G. Torres, *Head of the Science Department at World Organization for Animal Health (OIE)*	The GF-TADS initiative for the global control of African swine fever.

Dr. P. Motta, *Veterinary* *EuFMD*	Historical review of FMD virological surveillance and lessons since the establishment of the joint FAO and OIE global FMD control strategy (2012-2019).
Dr. E. Chevanne, *FMD Risk Management Specialist* *EuFMD*	Bovine ephemeral fever in the European neighborhood between 2015 and 2019, a web-based survey among EUFMD trainees.
Dr C. Albanello, *Senior Trainer* *Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise "G. Caporale"*	Modelling virtual training methods to enhance entomological surveillance for rift valley fever and other mosquito-borne Arboviroses in Libya: a transferable approach.
Dr. O. Mtaallah, *Epidemiologist* *Ecole Nationale de Médecine Vétérinaire* *(ENMV)*	A new approach to fight against foot and mouth disease in Tunisia using a spatial model and a zoning approach.

15 December Session 3 Vaccine security and critical resources for emergency management

Dr. C. Hamers, *Director Scientific Support and Trial Management,* *Boehringer Ingelheim Animal Health*	Maternally derived antibodies to FMD in cattle: is interference on FMD vaccination appropriately considered?
Dr. C. Alvarez *Assay scientist* *Boehringer-Ingelheim*	FMD serological blocking Elisa based on VHH for post-vaccination monitoring.
Dr. A. Capozzo *Principal Researcher* *Consejo Nacional de Investigaciones Científicas y Técnicas, (CONICET)*	Indirect Elisas based on purified viral particles that measure different aspects of the antibody response as alternatives to the currently used serological methods.

Dr. C. Turco, *Institute of Virology and Technical Innovations. (INTA- CONICET)*	Filtration assisted luminometric Elisa (fal-elisa) applied to the detection of foot-and-mouth disease virus non-structural proteins in formulated vaccines.
Dr. F. Mansilla, *Institute of Virology and Technical Innovations. (INTA- CONICET)*	Avidity Elisa provides a good correlate with the virus neutralization tests in foot-and-mouth disease vaccinated buffaloes (bubablus bubalis).
Dr. M. I. Barbaruah, Director Vet Helpline India Pvt Ltd	Animal disease emergency management -a rapid documentation of learning based on government response related to recent animal disease outbreaks in Assam (India).
Dr. C. Croton, *Veterinary Officer, Epidemiology and One Health Animal Health Policy Branch Department of Agriculture, Water and the Environment*	Oculus quest virtual reality demonstration to support FMD training.
Dr. S. H. Park, *Veterinary Researcher* *Animal and Plant Quarantine Agency*	Swine protection in the early stage with intradermal vaccine against type a foot-and-mouth disease virus isolated in Korea, 2018.
Dr. A. Shaw, *Senior Post Doc* *The Pirbright Institute*	Exploring Foot-And-Mouth disease virus antibody affinity using Bio-layer Interferometry.
You Jin Han	Development of solid-phase competition Elisa for detection of type-a foot and mouth disease virus antibodies.
L. Comtet, *R&D Manager / Quality Assurance Manager* *IDvet*	A pan-serotype solid phase blocking Elisa prototype for detection of structural protein antibodies: a solution for emergency supply of FMD SP diagnostic kits?

Dr. D. Kwon, *Foot and Mouth* *Disease Diagnostic Division, Animal and Plant Quarantine Agency*	Comparison of diagnostic performances of three commercial Elisa kits for detection of antibodies to foot-and-mouth disease virus type-o.
Dr. Mi-Young Park *Deputy Head of Status Department* *Head of the Science Department at World Organization for Animal Health (OIE)*	Duration of immunity in cattle and pigs under national vaccination programme against foot-and-mouth disease virus.
Dr. Seung Heon Lee *Center for FMD Vaccine Research*	Development of a liquid-phase blocking Elisa based on foot-and-mouth disease virus a/yeoncheon/2017 for post-vaccination sero-monitoring.
Dr. Seung Heon Lee *Center for FMD Vaccine Research*	Correlation between serological titer and protection in pigs vaccinated with FMD serotype a vaccine.
Dr. Seung Heon Lee *Center for FMD Vaccine Research*	Evaluation of the antigenic relatedness between foot-and-mouth disease vaccines and currently circulating viruses in southern East Asia.
Dr. Seung Heon Lee *Center for FMD Vaccine Research*	The changes of serological cross-reactivity between homologous and heterologous booster Foot-and-Mouth disease vaccination in pigs.
Dr. Seung Heon Lee *Center for FMD Vaccine Research*	Experimental evaluation of foot-and-mouth disease o SKR vaccine: protective efficacy and serological performance in pigs.
Dr. C. Potzsch, *Consultant veterinary epidemiologist* *EuFMD*	FMD risk reduction in Transcaucasia and neighboring countries – an example of successful regional cooperation.

Dr. E. A. Foglia, *PhD, Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna*	Field trial to estimate effectiveness of vaccination program against foot-and-mouth disease in Transcaucasian countries – Georgia and Armenia.
Dr. A. Dekker, *Senior scientist, Wageningen BioveterinaryresearchWBVR-Lelystad*	Neutralizing antibody response poor predictor of heterologous protection.

17 December Session 4 Resilience to long term FAST crises: the importance of animal welfare, supply chain and business continuity

Dr. S. Fèvre, *Programme Manager – Veterinary paraprofessionals,* *Capacity Building Department*	Empowering veterinary paraprofessionals in Africa for better control of TADS.
Dr. P. Durr, *Veterinary epidemiologist* *CSIRO-Australian Centre for Disease Preparedness*	Spread: deciphering farm-to-farm FMD transmission through a big data decision support system.
Dr. P. Compston, *PhD student* *Royal Veterinary College*	How do you define a foot-and-mouth disease outbreak in an endemic context? a case study from Nakuru County, Kenya.

Additional Session Diagnosis and virus characterization

Dr. A. Shaw, *Senior Post Doc* *The Pirbright Institute*	Enhanced complete genome sequencing of foot-and-mouth disease virus using probe enrichment.
L. Comtet, *R&D Manager / Quality Assurance Manager* *IDvet*	Ready-to-use solid phase blocking Elisa kits for detection of specific antibodies to FMDV Serotypes O, A, Asia1.
L. Comtet, *R&D Manager / Quality Assurance Manager* *IDvet*	Proven performances for FMDV NSP antibody detection with the id screen® FMD NSP competitive Elisa.
L. Comtet, *R&D Manager / Quality Assurance Manager* *IDvet*	A New FMDV antigen Elisa using Multiserotype-reactive monoclonal antibodies.
Dr. Eun-Jin Choi, *Senior researcher* *Animal and Plant Quarantine Agency*	Validation of recombinant protein-based Elisa for detection of antibodies to foot-and-mouth disease virus type-o.
Dr. J. Lee, *Foot-and-mouth disease division, Animal and Plant Quarantine*	Development of lineage-specific real-time RT-PCR for the recent FMDV, Asia/sea-97 In South Korea.
Dr. B. La, *Animal and Plant Quarantine Agency, Ministry of Agriculture, Food and Rural affairs, Republic of Korea*	Enhanced diagnosis efficacy of a newly developed Elisa kit for FMDV in pool 1Region.
Dr. H. Lee, *Animal and Plant Quarantine Agency, Ministry of Agriculture, Food and Rural affairs, Republic of Korea*	Genetic characterization of serotype and genetic relatedness of foot-and-mouth disease viruses in South East Asia.
Dr. N. Knowles, *Head of Molecular Epidemiology* *The Pirbright Institute*	Development of a new expert-curated foot-and-mouth disease virus nucleotide sequence database.
Dr. P. Eblé, *Senior scientist* *Wageningen Bioveterinary Research (WBVR)*	Comparison of use of primary cells and cell lines for virus isolation assays for FMDV.

AGENDA

Dr. G. Pezzoni, *Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna (IZSLER)*	Diagnostic Performance Of Foot-And-Mouth Disease Virus Detection And Serotyping Assays With Field Samples From East Africa
Dr. S. Grazioli, *Biologist* *Istituto Zooprofilattico Sperimentale Lombardia ed Emilia Romagna (IZLSER)*	A Multiplex Lateral Flow Device For On-Field Identification And Serotyping Of Foot-And-Mouth Disease Virus
Dr. S. Baselli, *Biotechnologist* *Istituto Zooprofilattico Sperimentale della Lombardia e Dell'Emilia Romagna (IZLSER)*	Serological Elisas based on monoclonal antibodies as diagnostic tools for lumpy skin disease.
Dr. D. Blight, *Department of Production Animal Studies, Faculty of Veterinary Science, University of Pretoria*	Genetic Analysis Of The 2013/14 Sat2 Foot-And-Mouth Disease (FMD) outbreak in Mpumalanga Province, South Africa.
Dr. E. Brown, *Research assistant* *The Pirbright Institute*	Characterizing Foot-And-Mouth Disease virus in clinical samples using Nanopore sequencing.
Dr. Fadia Y.Khalifeh *Veterinarian* *University of Baghdad*	Elisa Techniques For FMD.
Dr. A. Ludi *The Pirbright Institute*	A review of the WRLFMD's proficiency testing scheme.
Dr. F. Maree *Specialist Researcher, Agricultural Research Council*	Biological variance of sat2 foot-and-mouth disease viruses.
Abdel-Hamid Bazid *MVSc. / PhD* *Virology lecturer-Faculty of Veterinary Medicine* *University of Sadat City*	Assessment of potency and effectiveness of hepta-valent FMD vaccine oil adjuvanted (isa 206) in Egypt.
Dr. Hyun Mi Pyo, *Vet. Research officer* *Animal and Plant Quarantine Agency*	Establishment secondary standards for FMD serotype o SP antibody Elisas

Session I

Measuring animal movements and drivers for FAST risk mapping

SESSION I

Morning session

QUANTIFYING THE ROLE OF LIVESTOCK MOVEMENTS FOR THE TRANSMISSION OF RVF IN NORTHERN TANZANIA.

R. Kao, G Chaters, W. de Glanville, L. Matthews, J. Nyarobi, E. Swai, S. Cleaveland, & P. Johnson.

The buying and selling of livestock represents a substantial contribution to the income and livelihood of the people who husband them, however these movements also represent a risk of infectious disease transmission. While the health and commercial costs of disease means that there is incentive to control them, those affected by these costs are often not those most responsible for causing them. Thus market forces cannot be relied upon to restrict disease transmission, and policy-based interventions to prevent pathogen spread are necessary. Modern data- driven approaches to livestock management mean that in many higher income countries, data on livestock movements are collected routinely and stored digitally, and so they can readily be used to inform disease control efforts. However in Tanzania, as with many other LMICs, data on movement patterns must be generated. Here, I describe the collection and analysis of a substantial dataset generated from paper records, which is used to generate a 'synthetic' dataset that replicates key features of recorded patterns of movements to represent livestock movement patterns across northern Tanzania. A combination of network analysis and simulation is then used to determine key locations that can be targeted for control of many diseases including the important zoonosis, Rift Valley Fever (RVF). We show that targeting control efforts at locations that are critical because of either their role in the network of cattle movements or the inherent local risk of transmission can provide similar gains in control efficiency. While further investigations are necessary to corroborate these results, they suggest that multiple levers may be available to manage this and other livestock diseases. Efficient control of livestock diseases in areas with limited data and resources available is essential and here, by demonstrating the potential utility of livestock movement data in targeting interventions, this provides an argument for routine collection of such data. This will be especially important for ongoing assessment of risks as we face a future of increased uncertainty in living with environmental and land use change.

MODELLING AND PREDICTING NATIONAL AND REGIONAL ANIMAL MOBILITY AFFECTING LIVESTOCK'S DISEASES CIRCULATION. A COMPARISON FROM STUDIES IN NORTH/WEST AFRICA AND SOUTH-EAST ASIA.

Andrea Apolloni[1], Alexis Delabouglise[1]

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We are going to present some of the results from our recent works on animal mobility in 2 contrasted Regions: West Africa and South-East Asia. In both cases we tried to understand what the driving factors are behind observed mobility patterns. Different methodologies where used in the 2 contexts.

Live animals trade is in most of the West and North African countries one of the main economics activities. In general, the consumption and production areas are several hundred km apart. Due to the absence of infrastructures, animals are sold alive at local markets to traders, and then moved to capital or coastal cities where they are slaughtered and butchered. Because of this, livestock mobility is an intrinsic component of the farming systems in the region, aiming at optimizing the availability of natural resources (grasslands, surface water) which shows a highly seasonal pattern for a given grazing area. Livestock mobility in the region is a complex phenomenon involving several temporal (from days to months) and spatial scales (from a few km to reach local markets, to international transhumance or trade movements).

The possibility of providing a reliable picture of livestock mobility in the area is hindered by the fact that few quantitative data are collected.

We are presenting the results of the analysis of data provided by Veterinarian services in West and North Africa countries on ruminant's mobility. We used complex network approach to describe mobility patterns and a suite of models (gravity, ERGM) to understand its driving factors of animal mobility. The analysis shows the existence of largest transboundary communities of movement that could facilitate the spread of the disease in Region. The analysis has shown the existence of 2 important periods for mobility: a routine one, and the period around the religious festivity of Tabaski (during which a young male sheep is slaughtered in each family). The mobility drivers include environmental factors (conditioning the availability of natural resources), commercial reasons (demand and market price), economical (gdp difference between producer and consumer areas) and social factors like the Tabaski celebration.

In several countries of Southeast Asia, the control of major infectious diseases of poultry is hampered by the complexity of the poultry trading networks connecting millions of small-scale producers to consumption centers. These networks involve a large number of itinerant traders transporting small numbers of birds and live bird markets where commercial transactions occur and poultry from different places are mixed together. Importantly, the trade of infected poultry is suspected to be a driver of the propagation of major diseases like highly pathogenic avian influenza. The poultry trade has a well-established seasonal component. In Vietnam, the demand for poultry meat peaks during the lunar New Year festival period (in January-February). However, farm-level events driving the trade of poultry are poorly understood.

We present the results of an analysis performed on the data from a longitudinal survey performed over a sample of small-scale poultry farms in southern Vietnam. Fifty-three farms were visited monthly during a 20-months period. Data related to poultry production was extracted during these monthly visits. The data included poultry population size, introduction and removal of poultry, and events affecting the flocks like mortality with specified disease symptoms. We used a mixed-effect generalized additive model enabling the prediction of the rate of harvest (sale or slaughter) of broiler chickens flocks, based on a set of independent variables. This model enabled us to specify the relationship between the age of broilers and their likelihood of being sold. In larger flocks, the slope was steeper, meaning that farmers with a larger production scale tend to sell their flocks at a faster rate.
Crucially, for small flocks, the occurrence of an outbreak of disease-related mortality - in the same farm, during the same month or one month before – increased the probability of sale. This increase was even larger in case of sudden death of chickens – i.e. a suspicion of highly pathogenic avian influenza.

A MULTI-SPECIES CONTACT-NETWORK MODEL: BETWEEN-FARM DISEASE SPREADING AMONG BOVINE, SMALL RUMINANTS AND SWINE POPULATIONS.

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Introduction
Many infectious diseases infect multiple species and persist through a combination of within- and between-species transmission dynamics and processes. Here, we explore the epidemiological impacts of host-specific disease spread dynamics, among farms raising multiple livestock species: cattle, buffalo, pigs, sheep and goat.

Materials and methods
We reconstructed multiscale stochastic susceptible-infected network-based transmission model for within-farm dynamics and between-farm animal movements. A wide range of introduction scenarios was simulated on the empirical network. To mimic an initial stage of an introduced foreign animal disease we generated 100 runs over available 2-year network starting with 1.000 infected farms. Infection was then started randomly in farms with only swine, only cattle, only small ruminants and final scenario it started in farms with all species. The model was used to simulate control actions based on the identification of farms mode likely to be infected by its contact network.

Results
The largest epidemic had 45% infected swine farms whiten the first six months of simulation. We found that epidemic sizes were governed by which species the index was seeded to. As expected, the swine contact network was the most prone to spread disease, with a simulated prevalence of over 60% at the end of second year of simulation, followed by small ruminants' and cattle with prevalence over 20% and 10% respectively.

Discussion
The size of epidemics initiated in cattle and small ruminants generated a higher amount of infection into other single species farm holdings. This work highlights the relevance of other than cattle farms in the between-farm transmission of possible foreign animal disease, i.e., Foot-and-Mouth disease. These results may serve as basic data in the planning of national or regional to designing risk-based targeted surveillance strategies considering a multi-species approach.

TRACKING LIVESTOCK MOVEMENTS TO UNDERSTAND THE PATTERNS AND RISKS OF FOOT-AND-MOUTH DISEASE SPREAD IN TRADITIONALLY MANAGED SYSTEMS IN EAST AFRICA

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Introduction
Livestock are essential to food security and livelihoods in sub-Saharan Africa, but suffer from poor productivity due to infectious diseases such as foot-and-mouth disease (FMD). FMD is endemic in this part of Africa, and outbreaks are frequent, driven mostly by unrestricted livestock movements. To control endemic FMD, comprehensive information on the patterns of spread through herd contacts is needed. However, data on livestock movements across the landscape, and how and where contact occurs remain limited.

Materials and methods
We deployed Global Positioning System (GPS) collars on cattle in 52 different herds to understand fine-scale movements and between-herd contacts in rural areas of western Serengeti, Tanzania, representative of agro pastoral systems in East Africa. We used the telemetry data to characterize the patterns of movements and identify locations of interactions between herds that suggest FMD flashpoints. In addition, we examined patterns of contact across a range of spatiotemporal scales, relevant to different FMD transmission scenarios.

Results
We observed that daily movement of cattle increased with herd size and rainfall. Herd contact rates were highest at large spatial and temporal scales. Furthermore, contact was greatest away from household locations, during low rainfall and close to dipping points. Generally, there were higher contacts proximal to resource areas such as grazing and water holes, but only for smaller spatiotemporal contact scales.

Discussion
We demonstrate how widespread movements could heighten the risk of endemic FMD spread. Given that risk is directly related to contact, the probability of FMD spreading between herds could be four times higher when virus survival in the environment increases from one to up to 24 hours. Our results point at times and locations of greatest FMD transmission potential and that could be targeted through tailored control strategies, for example when rainfall levels are low, and around dipping and water points.

A MODEL EXPLORATION OF CARRIER TRANSMISSION SUFFICIENT FOR MAINTENANCE OF ENDEMIC FMD.

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There are many factors which might contribute to the persistence of FMD as an endemic disease in many regions. One such factor is persistently infected livestock – animals from whom virus can be isolated more than 28 days after infection, also known as carriers. Despite anecdotal evidence of transmission from carrier animals, and recent evidence that oropharyngeal fluid from such animals can transmit infection, experiment after experiment has consistently failed to demonstrate transmission via contact-challenge. It is clear that if carrier animals can infect naïve animals, the per-capita probability of such an event must be very low.

We investigate the required intensity of transmission from carrier animals to sustain transmission of FMD, and whether this minimum intensity can be consistent with the repeated failure to demonstrate transmission from carrier animals in many experimental settings. Using a realistic model of FMD transmission explicitly modelling transmission within and between farms, as well as real shipment records and farm locations from the Republic of Turkey, we simulate the spread of FMD with different intensities of carrier spread, as well as combinations of other relevant parameters, and measure how likely the persistence of FMD over the duration changes as these parameters vary.

The model finds that it is theoretically possible for carrier animals to contribute towards persistence even at very low transmission values, and that the average duration of the carrier state is the parameter with the greatest effect on FMD persistence, as well as the average duration of disease immunity. However, more work needs to be done to understand the dynamics of FMD spread with and without carrier animals.

SESSION I

Afternoon session

MAPPING POPULATION AND PATHOGEN DYNAMICS

A. Tatem[1]

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The rapid ongoing changes in global connectivity are having profound effects on disease spread. Growing volumes and reach of travel and trade are enabling pathogens to move from one side of the planet to another in record time. Examples of how this rising connectivity has led to the rapid spread of pathogens affecting people, livestock and crops are becoming prevalent, with strong evidence for the dispersal of many zoonotic viruses being human-mediated. This connectivity is not homogenous across space and time however, and an ability to capture data on human and livestock distributions, changes in these, and their movement patterns can be valuable in developing preparedness plans and models for strategic planning. Professor Tatem will present the work of World Pop (www.worldpop.org) and collaborators in the integration of geospatial data for mapping population distributions, dynamics and connectivity, and the use of these data for obtaining epidemiological insights and planning interventions.

ANALYZING CATTLE TRADE NETWORKS FROM 13 EUROPEAN COUNTRIES, AND PREDICTING THEIR VULNERABILITY TO OUTBREAKS

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Trade-driven animal displacements among cattle holdings drive the likelihood, shape, and speed of outbreaks. Past works analyzed cattle networks in several countries, highlighting complex interactions between structure, function, and dynamics. A comprehensive study, linking features of cattle trade networks to their vulnerability to the spread of infectious diseases, is however still missing. Such study requires large datasets across different countries and years, to highlight global markers of cattle trade networks, as well as region-specific patterns. The main problem is data availability: cattle trade data are not public, and their access requires ad hoc agreements. I will present a collaborative platform that, using a bring code to the data approach, overcomes the strict regulations preventing data sharing, and allows an effective comparative analysis. Analyzing data from 13 European countries, we extract a set of synthetic indicators that quantifies shared features, and differences, among countries, and across years. We then show that these indicators can predict vulnerability of a specific national market to the spatial spread of a wide range of infections. Our work is a first step to building data-driven risk assessment tools that can be integrated into monitoring policies, with minimal data sharing requirements.

IMPACT OF ENVIRONMENTAL CHANGES AND DISRUPTION OF PRODUCTION AND PRICE VARIATIONS ON ANIMAL MOBILITY, MOVEMENT PATTERNS AND SPREAD OF FAST DISEASES.

F. Wanyoike[1]

Pastoralism and transhumance account for a large share of livestock production in the world especially Asia and Africa. These systems are characterized by high mobility of both animals and herders in search of pasture and water and marketing. Projections show that these mobilities are likely to continue and even increase with time due to climate change and rising demand for livestock products. With the increased mobility the risk of spread of FAST diseases is expected to rise. There is therefore need to invest in animal movement and disease surveillance and control systems especially in developing countries where these tend to be rather weak.

A PARTICIPATORY QUALITATIVE RISK ASSESSMENT TO ESTIMATE THE RISK OF INTRODUCTION AND SPREAD OF TRANSBOUNDARY ANIMAL DISEASES IN SCARCE-DATA ENVIRONMENTS AND THE MAJOR ROLE OF ANIMAL MOBILITY

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Introduction
We present a participative qualitative risk assessment framework to detect hotpots for risk of introduction and spread of transboundary infectious animal disease on a national scale. The framework was developed though regional training-action workshops and field activities with an involvement of national animal health services.

Material and methods
To estimate the risk of introduction, we use the epidemiological status of neighboring countries and accessibility to major cities. In addition, we consider the highest in-degree measure of transboundary animal movements directed to a given epidemiological unit. To estimate the risk of spread we consider the highest degree and betweenness of national animal movements to detect high-risk connections between different epidemiological units. Depending on the disease, additional spatial factors such as watering points, animal density, etc. may be used. Finally, experts categorize and combine the spatial risk factors into ordinal levels of risk per epidemiological unit.

Results
We estimated the risk of introduction and spread of foot-and-mouth disease (FMD) in Tunisia as part of a series of workshops between 2015 and 2018. Out of the 2,075 Tunisian imadas, 23 were at a very high risk of FMD introduction; and 59 were at a very high risk of FMD spread. To validate the model, the results were compared to the FMD outbreaks notified by Tunisia during the 2014 FMD epizootic. Using a spatial Poisson model, we showed that the relative risk of FMD occurrence was thus 3.2 higher for imadas in the very high and high spread-risk categories than for imadas in the low and negligible spread-risk categories.

Discussion
Our results show that our framework can be a useful decision-support tool for risk-based disease surveillance and control, in particular in scarce-data environments where animal mobility has a major role of disease spread.

PARTICIPATORY MAPPING OF ANIMAL MOBILITY PATTERNS USING FAO'S EPIDEMIOLOGY VALUE CHAIN PLATFORM

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Introduction
Studies relating to animal movement patterns and are often conducted by academic authors, with dissemination of findings limited to grey literature and scientific journals. Consequently, objectives and outcomes may not incorporate the priorities of surveillance system actors or communicate results to stakeholders. The Food and Agriculture Organizations has developed a digital and interactive medium to facilitate and empower capacity-building efforts related to market profiling and animal movement under its Epidemiology Value Chain (EVC) Platform, enabling users to maintain a live, online, and dynamic tool that can store, analyze, and display a magnitude of different data.

Materials and methods
'Open-source' electronic collection systems (e.g.EpiCollect5) allow national veterinary services to enter value chain locations and movement patterns. Data is continuously collected through interviews, expert opinion, or retrospectively via the collation of movement permits. Various 'plug-in' applications allow for the visualization of data via maps, statistics, or graphs. These are created in conjunction with national epidemiology units to ensure relevance for selecting and planning intervention options. Lastly, the application allows for dissemination of data to engage key stakeholders.

Results
Over 1000 bird markets and network connections were identified, profiled, and analyzed across Viet Nam, Democratic Republic of the Congo, Ethiopia, Uganda, Rwanda, and Mozambique. Data collection in Ghana continues in conjunction with the national epidemiology unit, including expansion to livestock markets and other value chain nodes.

Discussion
The mapping of epidemiological significant locations such as markets, abattoirs, and border points along with seasonal and quantified animal movement flows can be utilized by veterinary services to plan and run prevention and control interventions. The tool can rapidly increase country capacities to identify high risk locations, i.e. those in need of urgent biosecurity improvements or those that need to be targeted through surveillance. Furthermore, data can be updated in real-time to maintain the cost efficiency and effectiveness of interventions.

EARLY WARNING OF INFECTIOUS DISEASE OUTBREAKS ON CATTLE-TRANSPORT NETWORKS

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Introduction
Surveillance of infectious diseases in livestock is traditionally carried out at the farms, which are the typical units of epidemiological investigations and interventions. In Central and Western Europe, high-quality, long-term time series of animal transports have become available and this opens the possibility to new approaches like sentinel surveillance. By comparing a sentinel surveillance scheme based on markets to one based on farms, the primary aim of this paper is to identify the smallest set of sentinel holdings that would reliably and timely detect emergent disease outbreaks in Swiss cattle.

Materials and methods
Using a data-driven approach, we simulate the spread of infectious diseases according to the reported or available daily cattle transport data in Switzerland over a four-year period.

Results
Investigating the efficiency of surveillance at either market or farm level, we find that the most efficient early warning surveillance system [the smallest set of sentinels that timely and reliably detect outbreaks (small outbreaks at detection, short detection delays)] would be based on the former, rather than the latter. We show that a detection probability of 86% can be achieved by monitoring all 137 markets in the network. Additional 250 farm sentinels, selected according to their risk, need to be placed under surveillance so that the probability of first hitting one of these farm sentinels is at least as high as the probability of first hitting a market. Combining markets and 1000 farms with highest risk of infection, these two levels together will lead to a detection probability of 99%.

Discussion
We conclude that the design of animal surveillance systems greatly benefits from the use of the existing abundant and detailed animal transport data especially for highly dynamic cattle transport networks. Sentinel surveillance approaches can be tailored to complement existing farm risk-based and syndromic surveillance approaches.

Session II

From risk to actions, make them happen.

SESSION II

Morning session

CROSS-VALIDATION OF GENERIC RISK ASSESSMENT TOOLS: AN ASF CASE STUDY

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Introduction

Risk assessments are often developed to assess the risk for a single disease and introduction pathway. However in recent years, generic risk tools have been developed that can assess the risk of incursion for multiple pathogens via multiple pathways. A collaborative project provided an opportunity for cross validation of several generic risk tools, each assessing an identical incursion scenario using, where possible, the same input data.

Materials & Methods

Seven generic RA tools were used to assess the incursion risk of African swine fever (ASF) virus to the Netherlands and Finland for the epidemiological situation in 2017 and for two hypothetical scenarios in which ASF cases were reported in wild boar and/or domestic pigs in Germany. The generic tools ranged from qualitative risk assessment tools to stochastic spatial risk models but were all parameterized using the same global databases for disease occurrence and trade in live animals and animal products. The risks for each country and scenario were calculated for each tool, for the three pathways most in common (trade in live animals, trade in animal products, and wild boar movements); relative risks were computed, and then compared across tools.

Results

For the 2017 situation, all tools evaluated the risk to the Netherlands to be higher than Finland for the live animal trade pathway, the risk to Finland the same or higher as the Netherlands for the wild boar pathway, while the tools were inconclusive on the animal products pathway. All tools agreed that the hypothetical presence of ASF in Germany increased the risk to the Netherlands, but not to Finland.

Discussion

The case study illustrated that conclusions on the risk of ASF virus incursion were similar across the generic RA tools, despite differences observed in calculated risks. It was concluded that the cross-validation contributed to the credibility of the results.

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THE USE OF FOOT-AND-MOUTH DISEASE MODELS IN DISEASE FREE AND ENDEMIC SETTINGS: PREDICTION, CONTROL AND TARGETING OF INTERVENTIONS FOR EMERGING OUTBREAKS.

M. Tildesley[1]

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Introduction

Mathematical Models are often used for infectious disease outbreaks to inform contingency planning and to advise policy makers during ongoing outbreaks. However, in emerging outbreaks, there is significant uncertainty in how a disease may spread and limited data may be available. Whilst models play a role in planning, it is important to explore what a model ***can do***, as well as what a model ***can't do***. In regions where foot-and-mouth disease is actively circulating, models can be used to investigate what is driving transmission. In such settings, data are often incomplete and models can establish how resources may be targeted to rapidly collect data and reduce uncertainty in future predictions.

Methods

In this presentation, we explore the predictive power of models during outbreaks and how uncertainty affects the impact of intervention policies. We also discuss the importance of defining the ***objective*** of control – the optimal policy may be highly dependent upon what a policy maker is intending to achieve. By analyzing the spatiotemporal pattern of outbreaks and livestock movements in endemic settings, we construct maps that can be used for determining future risk.

Results and Discussion

We show that during the early stages of FMD outbreaks, the uncertainty in spread results in an ability to accurately predict the impact of interventions. This uncertainty is resolved after the first 2-3 weeks of an outbreak. We show that reinforcement learning can be used to determine an optimal control policy dependent upon the current state of the outbreak. By analyzing outbreak data in Turkey, we show that modelling can be used to determine future risk and inform monitoring campaigns. Mandatory recording of livestock movements can have a significant effect upon predicting risk – community analysis of movement networks can enable future targeting of surveillance policies that take into account transmission risk through livestock movements.

AN ANALYSIS OF RECOGNITIONS, SUSPENSIONS, AND RECOVERIES OF OFFICIAL FOOT-AND-MOUTH DISEASE FREE STATUS AND IDENTIFICATION OF POSSIBLE ASSOCIATED FACTORS FOR FAST AND SUSTAINED RECOVERIES

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Introduction
Foot-and-mouth disease is the first disease that the OIE established an official list of free territories since 1996 which has helped facilitate the trade of animals and animal products from those territories. Since 1996 there have been suspensions of FMD-free status which have impacted the livestock industry of the territories affected. The objective of this study is to identify associated factors with the time-to-recover the FMD-free status after suspension.

Materials and methods
Historical applications submitted (between 1996 and 2020) by OIE Members for FMD-free status recognitions and recoveries were used as the main source of data. Only FMD-free status suspensions due to outbreaks were considered. Data regarding Member socio-economic characteristics, livestock production systems, FMD outbreak characteristics, and control strategies were targeted for the analysis. Duration of time-to-recover the FMD-free status was estimated using Kaplan-Meier survival curves. A Cox Proportional Hazard model was used to identify factors associated with the time-to-recover the FMD-free status after suspension.

Results
A total of 163 territories have been granted an official FMD-free status during the study period. The study population consisted of 45 FMD-free status suspensions. Africa and the Americas accounted for over 50% of FMD-free status suspensions while over 70% of them occurred in territories FMD free without vaccination. The study noted that implementing stamping-out or vaccination to-kill shortened the time to recover the FMD-free status compared to vaccination to-live policy. Other variables associated with the outcome were the income level, veterinary service capacity, time taken to implement measures and disposal of last case, borders with FMD-infected territories, and time elapsed since last FMD-free status suspension.

Discussion
This analysis will be used to improve the OIE standards for FMD and will contribute to policy processes of OIE Members for FMD control and elimination targeting fast and sustained recoveries. It will also provide useful indicators to improve capacity development services to OIE Members within the OIE PVS Pathway and through Public Private Partnerships for disease control.

RANKING FMD HAZARD USING EXPERT KNOWLEDGE ELICITATION AND PCP ACTIVITIES. (JOINT PRESENTATION[1])

A RANKING TOOL TO BETTER CHARACTERIZE THE FMD HAZARD[1]

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Introduction
The Progressive Control Pathway (PCP) is aiming at assisting endemic countries in the progressive control of FMD based on specific Stages (from 0 to 4) reflecting the level of FMD control implemented. A spreadsheet-based questionnaire, named Self-Assessment Tool (SAT), assists countries to locate in which stage they are. However, countries placed in the same Stage can significantly differ in the level of implementation of control activities in place which in turn may suggest that the level of hazard that the country may represent (for itself or for its neighbors) can vary. Thus, the aim of the study is to develop a user-friendly tool that is able to capture such differences.

Materials and methods
The 93 statements from the SAT indicate whether specific actions have been implemented in the country. The hazard ranking tool assign a weight to such statements under the assumption that the impact of the associated actions is not the same within and between stages. The SAT statements weights were derived from an Expert Knowledge Elicitation and the Hazard Score is expressed as a percentage ranging between 0% and 100%. The capacity of discrimination of the tool was assessed using the SAT outputs from 6 FMD endemic countries using as hazard qualitative qualifiers the following: Negligible (0%-2.5%); Very low (3.6%-9.9%); Low (10%-24.9%); Medium (26%-49.9%) and High (50%-100%).

Results
All 6 tested countries belonged to a similar PCP stage and the tool returns scores ranging between 44.5% and 88.8%.

Discussion
The results highlight that the tool is able to discriminate the level of implementation of specific actions in the different countries. The tool is also simple to use, quickly to update and easy to understand for the risk managers.

AN EXPERT KNOWLEDGE ELICITATION (EKE) TO WEIGHT THE IMPACT OF THE STAGE-SPECIFIC ACTIVITIES WITHIN THE FMD-PROGRESSIVE CONTROL PATHWAY (PCP) [2]

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Introduction

The progress along the Foot-and-Mouth disease (FMD) PCP is assessed through a questionnaire named Self-Assessment Tool (SAT). The SAT is structured in 93 stage-specific statements related to activities that should be implemented to initially gain an understanding of the epidemiology of FMD (Stage 1), that in turn should lead to implement a risk-based control plan (Stage 2) and finally to implement a Control Programme (Stage 3) aiming at FMD country or zonal freedom. An Expert Knowledge Elicitation (EKE) exercise was performed to identify which statements have a major impact on the risk posed by the country to its neighbors due to uncontrolled FMD under the assumption that each of the specific-stage statement contributes differently to meet the key outcomes of the stage (within stage weight) and that each stage have a different impact on the overall disease prevention, surveillance and control (between-stage weight) activities.

Materials and methods

Eight experts were elicited remotely by using the Delphi method through a questionnaire provided via email. They were asked individually to estimate: i) the within stage weight of each statement by providing three values (from 0 to 1), namely the most probable value (MPV), the minimum and the maximum values, and ii) the between-stage weight by indicating (in percentage) the contribution of each stage to the effective reduction of FMD load in a generic country.

Results

Most of the statements (76.3%) were considered important according to the MPV mean value (MPV score between 0.7 and 0.9). The mean weight shows that stage 3 was considered to contribute more (59.4%) compared to stage 2 (28.7%) and 1 (11.9%), respectively.

Discussion

While the weight differences between the statements are small, there was a remarkably higher weights that the experts assigned to stage 3, indicating (as expected) that certain statements have a significantly higher impact on the capacity to progressively reduce the FMD load.

THE GLOBAL FMD CONTROL STRATEGY, PROGRESS, CHALLENGES AND OPPORTUNITIES

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Foot-and-mouth disease (FMD) still occurs in large parts of Africa, the Middle East and Asia, and the countries that are free of FMD today remains under constant threat of an incursion. The FAO and OIE Global FMD Control Strategy has been operational since its launch in 2012. The specific goal of this strategy is not only to reduce the impact of FMD on animal health and production in endemic countries, but also to maintain the official FMD-free status of Members already OIE recognized. The strategy has three components: a) improving global FMD control; b) strengthening Veterinary Services; c) controlling other TADs.

Progress in FMD control has been shown in the implementation of the strategy at national, regional and international levels. The strategy thus far has been successfully applied in about 80 affected Members where FMD is still endemic, with currently 9, 31, 26 and 4 countries or zones in the Progressive Control Pathway (PCP) stages 0, 1, 2 and 3, respectively. 10 countries/zones advanced to OIE official status or had their official control programmes endorsed by the OIE. This is a significant improvement compared to 28 and 5 Members that were in PCP stages 0 and OIE status respectively in 2012.

In addition to surveillance and diagnostics, Members in PCP stages 0-2 in particular require capacity building to conduct socio-economic impact assessments, cost benefit analysis to justify investments in FMD control to policy makers, and risk assessment for strategic guidance to FMD control for prioritizing limited resources. The support from international and development partners, regional and specialized organizations is therefore crucial to assist and guide evidence-based policies for FMD control.

The regional strategies for TADs control being developed jointly by FAO and OIE provide an opportunity for partners and stakeholders to be part of the process and develop capacity within the Members to achieve the objectives of the Global FMD Control Strategy by 2027.

In this paper, the achieved milestones, success stories, lessons learned, challenges and opportunities including the impact of COVID-19 in the implementation of the strategy are discussed.

PLANNING FOOT-AND-MOUTH DISEASE SURVEILLANCE SYSTEM IN BRAZIL: A SHIFT TO FREE ZONE WHERE VACCINATION IS NOT PRACTISED

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Introduction
In 2017 the Ministry of Agriculture, Livestock, and Supply launched the strategic plan to acquire a Foot-and-Mouth disease (FMD) free country status where vaccination is not practised. The objective of this study is to describe the development of the strategic plan that will be applied in the surveillance system for FMD in Brazil.

Materials and methods
The principles of the surveillance are: outlining activities to reach clearly defined objectives and targeting them to the highest risk areas using spatial multi criteria risk models. A participatory approach was adopted utilizing focus groups meetings (FG) to obtain opinions about the risk model from the veterinarians of the State Veterinary Offices, and Design Thinking (DT) approach with the stakeholders to define the surveillance objectives and actions. The DT methodology had meetings during the "Ideation" phase to define the objectives and actions of the surveillance system, and four interviews were made during the "Empathize" step of the process.

Results
Six States were included in the initial stage of the plan. Based on the content analysis of the FG, two kinds of opinions were observed: opinions based on subjectivity and opinions based on objectivity and targeted to the conceptual logic of the risk model. The objectives defined were: i) Reduce the risks of introduction and exposure of an animal to the FMD; ii) Reduce the risks of dissemination; iii) Identify and communicate risks; iv) Early detection. Several perceptions were gathered in the "Empathize" step, for example, the need for changing behavior during the inspections by the veterinarians.

Discussion
The surveillance system planning is currently ongoing. The participatory approach has been used to engage the participants from both the public and private sectors. We believe that the search for solutions-oriented by the objectives, definition of risk areas to increase the effectiveness, and empathy are important elements for the success of the program.

SESSION II

Afternoon session

METHODS FOR ECONOMIC EVALUATION OF SURVEILLANCE, PREVENTION AND CONTROL MEASURES CONSIDERING TADS RISK AND COST OF MITIGATION MEASURES.

K. Rich [1]

NOT AVAILABE

EFFECTIVE RISK COMMUNICATION FOR BETTER PREVENTIVE MEASURES. BARRIERS, OPPORTUNITIES AND STRATEGIES TO ENSURE ADEQUATE RESPONSE TO RISK CHANGE.

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This era has been characterized as one of acceleration due to the exponential growth of globalization, climate change and technology [1]. There are increasing risks associated with (re)emergence of novel and existing animal and zoonotic diseases, and high uncertainty about when and where these may emerge first, and who may be most affected. Access to "Big Data" offers the potential to fast-track decision-making during outbreaks and there is a corresponding demand for high-speed technocratic approaches to policy-making.

Risk assessments, which evaluate the potential effectiveness of risk reduction strategies, may be technically robust but fail in practice if they do not take into account the lived experience of relevant stakeholders and wider society shouldering the burden of these risks. There is a professional and moral imperative for scientists and decision-makers to address risk perceptions, values and beliefs of different audiences in order to close knowledge gaps and communicate risk appropriately.

This presentation explores the role of risk communication and its aims, and considers effective strategies, barriers and opportunities for operationalization. It concludes that effective communication, with the appropriate audiences and at the right time, leads to better and more ethical risk management.

[1] Coined by Thomas Friedman in Thank You For Being Late: An Optimist's Guide to Thriving in the Age of Accelerations (2016)

WHEN IS FMD VACCINATION IN ENDEMIC SETTINGS PROFITABLE?

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Introduction
Vaccination is central to FMD control in many endemic settings. Yet the financial justification of this approach varies. In this study we assessed how FMD vaccination affects herd-level income considering various cattle production systems in different endemic settings.

Materials and methods
A stochastic partial-budget calculator was designed to assess the change in farm income from FMD vaccination. Expected FMD impact without vaccination was compared to costs and reductions in impact with vaccination. Model inputs included incidence, production losses, treatment and vaccination costs, and vaccine effectiveness. Data for parameterization were obtained from field studies, literature and expert opinion. Data was available on the losses incurred due to FMD for a range of husbandry systems in different countries, but data on FMD incidence and vaccination effectiveness often had to be estimated.

Results
In some settings FMD vaccination was expected to greatly increase herd-level income. In others it tended to reduce herd-income. This was greatly influenced by the importance of milk production, the frequency of FMD outbreaks, vaccine effectiveness, and vaccination costs.

Discussion
Although some farmers should invest in FMD vaccination, for others vaccination-based control only makes sense if it is at least partly funded by others as part of a wider FMD control programme. Furthermore, as incidence and risk reduce, the incentives for individuals to invest in vaccination diminish expanding the need for public or sector- level funding to further progress FMD control. A calculator with associated framework and guidance are provided to help stakeholders to identify information gaps and estimate the financial incentives for FMD vaccination in different settings.

ECONOMIC CONSIDERATIONS FOR ADVANCEMENT THROUGH THE PROGRESSIVE CONTROL PATHWAY: COST-BENEFIT ANALYSIS OF FMD CONTROL IN PUNJAB PROVINCE, PAKISTAN

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Introduction

Livestock are an important part of the Pakistan economy where foot-and-mouth disease (FMD) is endemic. In 2015, Pakistan was placed in stage 2 of the Progressive Control Pathway (PCP) and there are considerations on advancement to stage 3 and establishing a disease-free zone within Punjab province. This requires significant investment and the paper reports on a cost-benefit analysis (CBA) undertaken to assess this change.

Materials and methods

The CBA framework considered costs based on normal aspects of programmes including mass vaccination, quarantine stations, and an individual animal identification system. Benefit streams included averted farm-level losses, treatment costs and improved prices from better access to export markets. Farm-level models were created to estimate the impact of FMD through reduced milk production, offtake rates, and changes in herd value. A separate beef feedlot model considered changes in animal value and extended time to finishing. Individual farm-level impacts were estimated over a 5-year period whilst the CBA was conducted over a 20-year period.

Results

At the production system level, the lowest impacts were among smallholder farms at a median estimate of 197,000PKR (1,196USD) and 449,000PKR (2,722USD) in subsistence and market-oriented systems respectively. The largest losses were among the corporate farms, with a median of 894m PKR (5.4mUSD). The CBA indicated a median benefit-cost ratio of 1.03 (90% central range 0.37-1.63) and a median net present value of 1.99 billion PKR (90% central range -37.7-37.0). The greatest cost was due to vaccination related activities at 56% of the total.

Discussion

The results indicated on average that the investment would be economically profitable, although there is a high degree of variation due to both variation and uncertainties regarding disease control and production loss issues. PCP progression requires careful economic consideration and necessary data on disease impacts to make rational decisions on FMD control policy.

HOUSEHOLD AND MARKET IMPACTS OF FOOT-AND-MOUTH DISEASE AT THE UGANDA-TANZANIA BORDER

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Introduction
Foot-and-mouth disease (FMD) outbreaks occur persistently in Uganda and Tanzania. FMD is well-known to reduce livestock income and milk production. However, we differentiate the direct economic impacts 1) between households in Tanzania and Uganda; and (2) on households suffering FMD outbreaks compared to neighboring, uninfected households. This provides improved understanding of the scope of the problem to target local and regional control policies.

Methods
Data come from a 2018 survey of 264 households in the Kyaka and Nsunga wards (Tanzania) and the Endinzi, Lwamaggwa, and Kakuuto counties (Uganda). We use difference-in-difference estimation to evaluate incremental consumption and production impacts attributable to FMD by assessing household characteristics and related food prices on livestock/product sales and household consumption before and after an outbreak. Additional regressions serve as robustness checks.

Results
The temporal effect of an outbreak reduces livestock and livestock product sales. FMD outbreaks reduce milk but not necessarily beef consumption. On average, Uganda sells and consumes more livestock products than Tanzania. There is limited evidence of different impacts between households suffering an outbreak and those uninfected in the same region. Sensitivity analyses support the negative impact of milk prices on milk consumption during an FMD outbreak, while change in sales has a positive and significant impact.

Discussion
Our results find that FMD outbreaks in endemic border regions reduce milk consumption in households that report FMD in the herd and households in the surrounding area. The impact holds across counties, despite country-level differences in outbreak response and milk markets. Beyond milk, we do not find significant differences across FMD infected households and uninfected households. Market activity likely mitigates differing impacts on households in the endemic regions. Stabilizing milk prices during an outbreak will likely have a larger impact on household nutritional security than directing relief directly to infected households.

FORECASTING THE SPREAD OF VIRUSES IN SWINE IN THE U.S.: TRANSLATING MOVEMENT AND ENVIRONMENTAL DATA TO ACTIONABLE INFORMATION

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Introduction
Although foot-and-mouth disease (FMD) has been absent in the U.S. for decades, the recent introduction and rapid spread of porcine epidemic diarrhea virus (PED) provides a template for understanding dynamics of a large-scale epidemic of an exotic "fast" disease in the U.S. swine industry, including opportunities for risk-based control. However, implementation of risk-based measures is complicated given the rapidly changing nature of animal movements and multi-faceted environmental risk factors. Our objective is to forecast the risk of PED at the farm-level to promote data-informed disease management.

Materials and methods
We developed a machine learning platform to forecast (two-weeks-in-advance) the probability that a sow farm will become infected with PED using animal movement data, environmental risk factors, and weekly farm-level incidence from ~10% of the U.S. sow population. We also analyzed the length of outgoing infection chains within movement networks to quantify the potential spread of a newly introduced disease, such as FMD.

Results
Our pipeline detects ~20% of PED outbreaks that occur, and has a ~70% positive predictive value. The most important predictors were animal movement factors, including movements into neighboring farms <5-km of focal farms, followed by environmental factors. Infection chains originating from a single farm reached, on average, ~5 farms within six months, but upwards of 650 farms in extreme cases.

Discussion
Our forecasting platform generates weekly farm-level forecasts of PED risk that account for recent animal movements, present disease distribution, and environmental factors. The incorporation of behavior of (e.g., movements received by) neighboring farms is unique, and captures local spatial dynamics that are often overlooked in analyses of livestock networks. This platform forms the foundation for near real-time disease prediction and mapping, promotes data-informed and targeted disease prevention and management strategies, and can be readily adapted to other newly introduced FAST diseases.

Session III

Vaccine security and critical resources foremergency management.

SESSION III

Morning session

HOW MUCH IS ENOUGH? MODELLING AND OTHER METHODS TO GUIDE INVESTMENTS IN PREPAREDNESS FOR TRANSBOUNDARY ANIMAL DISEASES

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Decisions to invest in resources to prepare for transboundary animal disease emergencies are challenging. In countries like Australia where outbreaks of transboundary animal diseases occur infrequently, it may not be cost-effective to pre-emptively employ large numbers of personnel and invest in stockpiles of material. This presentation will review Australia's 25-year program of epidemiological modelling for transboundary diseases. It will also discuss examples where epidemiological modelling, simulation exercises and performance assessments/standards have been used to guide contingency planning, investment in vaccine banks, laboratory management in emergencies, and surveillance for diseases such as Foot-and-Mouth disease, highly pathogenic avian influenza and equine influenza.

DIAGNOSTIC SUPPLY CHAIN ISSUES: LESSONS FROM COVID19 FOR ANIMAL HEALTH

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During the COVID-19 pandemic, animal health laboratories have assisted the public health authorities in many countries in increasing national molecular testing capacity and in developing other diagnostic capabilities for SARS-CoV-2.

In Ireland, the Department of Agriculture Food and the Marine (DAFM) Laboratories has worked closely with the National (human) Virus Reference Laboratory (NVRL), a private animal health laboratory (Enfer Labs) and the Health Services Executive (HSE) over the course of this pandemic.

In the early months after the first diagnosis of COVID-19 in Ireland, these efforts were focused on adapting laboratories and molecular testing capability ordinarily used for animal disease control programmes, to testing human clinical specimens for SARS-CoV-2 RNA.

Recently, the focus of this “One Health” collaboration has changed from laboratory-based SARS-CoV-2 RNA testing to the application and evaluation of rapid detection methods for SARS-CoV-2 antigen in specific high-risk settings for COVID-19 such as meat processing plants.

Supply chain issues, specifically the availability of reagents for automated extraction of nucleic acids, was a limiting factor and a challenge in national efforts to scale up molecular testing capacity during the first half of 2020. On the flip side, the large number of rapid test kits for SARS-CoV-2 antigen that have recently come to market, with the main advantage of detecting those individuals who are probably infectious. However they present a different type of challenge for public health authorities – how to quickly assess and select the most appropriate test kits for different purposes in a fair, objective and robust manner that complies with public procurement guidelines and to prove their application in “real world” situations. While verification and validation methodologies to compare tests are well established, comparison of testing strategies is more challenging.

SYSTEMS IMMUNOLOGY-BASED APPROACH TO STUDY EARLY IMMUNE RESPONSES TO EMERGENCY FOOT-AND-MOUTH DISEASE VACCINATION IN PIGS

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Introduction

Pigs play an important role in the epidemiology of FMD in endemic countries where the species is abundant. In disease free countries, the virus amplifier role of pigs is a concern, should an incursion occur. Although vaccination is an option, improved tools are required to measure immune responses and predict correlates of protection. Previous results have shown that the intradermal (ID) vaccine delivery route provides comparable protection as compared to intramuscular (IM) vaccination, without causing local granulomatous reactions at the site of vaccination. We aimed to compare the immunological outcome of the different routes of vaccine delivery using a Systems Immunology (SI) based approach to analyze the transcriptomic data by studying the differentially expressed genes in peripheral blood mononuclear cells (PBMCs).

Materials and Methods

Groups of pigs (*Sus scrofa domesticus*) received a prime only IM or ID monovalent vaccination and blood was collected 3 days prior and 3 days post vaccines (dpv). PBMCs were isolated and messenger RNA sequenced. Transcribed genes were grouped according to biological function in the context of known Blood Transcriptome Modules (BTMs).

Results

Although there were no detectable FMDV-specific antibody responses in either of the two vaccine groups at 21 and 28 dpv, there was a notable difference in the extent to which the two vaccination routes modulated innate and adaptive immune responses. IM and ID vaccination promoted BTM families involved in natural killer and T- cell differentiation, activation, signaling, co-stimulation and proliferation. ID vaccination further positively modulated dendritic cell antigen processing, presentation and activation; type I interferon response; and inflammatory responses and complement activation. Interestingly B-cell development and differentiation, B-cell receptor signaling and immunoglobulins were negatively modulated in both groups when comparing 3 day post- and pre-vaccination gene expression.

Discussion

The novel SI approach provides a tool to measure the early immune responses in vaccinated pigs, before antibodies are detected. Expansion of this work is required to correlate the detection of these early responses to booster vaccination and downstream protection from challenge.

DEVELOPING AN ANALYTICAL MODEL TO PREDICT FOOT-AND-MOUTH DISEASE VACCINE DEMAND FOR ENDEMIC COUNTRIES

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Introduction
Foot-and-mouth disease (FMD) is caused by a picornavirus, affecting cloven-hoofed animals. It is recognized to have large economic impacts due to reduced productivity, food security and access to international trade.Vaccination against FMD is a significant part of any endemic country's control strategy as it aims to reduce clinical disease and transmission from infected livestock. However, there is often a supply and demand mismatch with the FMD vaccine. There are several factors contributing to this, including limited information on current and future vaccine doses a country requires for their control strategy. Quantification of the size of the FMD vaccine demand, particularly in endemic settings, is therefore of increasing importance.

Material & Methods
A quantitative modelling approach was developed considering indicators of increasing demand, such as estimated growth of livestock populations and progress of disease control policy linked to the projected FMD Progressive Control Pathway (PCP) stage. The model is a stochastic one written in R language. The OIE WAHIS database was used along with experts' opinion, sought by designing and implementing a Delphi study, to determine the extent of vaccine coverage as well as the reduction in number of outbreaks for each PCP stage. The model splits vaccine demand into two categories; prophylactic vaccination and reactive vaccination. Predicted vaccine doses were then calculated using country specific data on current FMD outbreaks, livestock population and density.

Results
Full model descriptions and preliminary results will be presented in the OS20 session.

Discussion
Further development of this tool will be conducted to increase accuracy of the vaccine dose numbers and identify the most cost-effective investments in quality vaccine production. This model will provide support to the global efforts against FMD by providing projected estimates about FMD vaccine demand at national and global levels in the upcoming year.

CALIFORNIA FMD VACCINATION PLANNING

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Introduction
The goal of an emergency FMD vaccination campaign is to suppress virus replication in high-risk susceptible animals by rapidly vaccinating a high proportion (≥85%) of the at-risk population. The selected vaccination strategy will dictate the disposition of vaccinated animals, which may be euthanasia/disposal, slaughter for consumption, or living out useful lives, or any combination of these. Preparing for such a vaccination campaign, through developing a response/implementation plan and procedures, is essential.

Materials and methods
The California FMD Vaccination Plan involves a multi-disciplinary group with the appropriate authority and FAD response expertise. This group will consider outbreak characteristics and advise the State Animal Health Official as to whether emergency vaccination is warranted.

Results
According to the current plan, California will receive, sort, store, maintain cold chain, distribute vaccine and maintain appropriate animal ID, tracking and documentation associated with the vaccination campaign. The location of the state vaccine warehouse will be as close as practical to where the vaccine is to be deployed, but outside control areas. Vaccine storage and handling requirements are stipulated in the state's FMD Vaccination Plan and the National Veterinary Stockpile Plan.

Discussion
To effectively implement a responsive FMD vaccination plan in a timely manner requires significant preplanning. Other elements requiring further planning and standardization include animal identification standards and requirements for tracking vaccinated animals/movement permits, tracking required for animal products derived from vaccinates, standards for employing third part logistics companies to support vaccine handling and distribution, and prioritizing amongst animal populations when vaccine is scarce.

FASTer VACCINATION: ASSESSING LEVEL OF PREPAREDNESS.

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Introduction

Scoping work was carried out to gather information on the state of preparedness for emergency vaccination for FAST diseases in EuFMD Member Nations (MN); and on the issues that constrain them from inclusion of vaccination in their plans. Different aspects of emergency vaccination were investigated including vaccination strategies, access to vaccines and operational preparedness. The scope of the work was category 1 FAST diseases which is Foot- and-Mouth Disease (FMD), Lumpy Skin Disease (LSD), Peste des Petits Ruminants (PPR) and Sheep and Goat Pox (SGP).

Materials and methods

An online questionnaire was sent out to 39 EuFMD member nations plus three additional European countries. The online tool SurveyMonkey® was used and the data was analyzed using R. The questionnaire was aimed at risk managers/ contingency planners.

Results

The response rate was 15 out of 42 countries. Some examples of preliminary key findings were that the level of planning for emergency vaccination is higher for FMD than PPR and SGP, many of the responding countries rely on the EU bank with no other arrangements to source vaccines, not all countries have a system to perform a rapid evaluation and approval of vaccines for emergency use, a relative high number of member nations would choose a vaccinate-to-cull strategy over a vaccinate-to-live strategy for FMD and over 50% of countries have an exit plan for FMD but only one country has stated they have an exit plan for PPR or SGP.

SESSION III

Afternoon session

FROM BENCH TO FIELD: RAPID VETERINARY VACCINE DEVELOPMENT AND PLATFORM TECHNOLOGIES

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Introduction

This Keynote Presentation will describe the veterinary vaccine development process. It will cover steps from bench to field and go on to discuss a few ways in which the standard process can potentially be accelerated. It will then briefly review novel vaccine platform technologies and provide an example of a "One Health" approach to vaccination.

Veterinary Vaccine Development Process and Accelerated Development

Different stages of the commercial development process will be presented from new product considerations and early discovery through to feasibility, full development and product registration (www.vaccinedevelopment.org.uk). A few potential ways in which this process could be accelerated will then be discussed with specific reference to the research & development, manufacturing and regulatory stages.

Platform Technologies and a "One Health" vaccine

A selection of recombinant vaccine platform technologies covering killed/inactivated and live/attenuated approaches will be briefly reviewed and an example of a "One Health" approach to Rift Valley Fever vaccination utilizing a ChAdOx1 non-replicating virus vector will be presented. This will include data on the safety, efficacy and stability of the vaccine and a summary of some of the unique attributes of this novel platform technology for use in both livestock and humans. The significance of new vaccine technologies within veterinary medicine will be discussed and some biotechnology breakthroughs that have occurred within veterinary vaccines will be reviewed.

Conclusion

Finally, a few key messages related to future veterinary vaccine development will be covered and this summary will include market considerations, commercial requirements, end-user benefits and the importance of novel technologies.

SOLUTIONS TO VACCINE SECURITY - A MANUFACTURER'S PERSPECTIVE.

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Vaccine security is not guaranteed when quality vaccines are not available to serve the demand in due time. This is often the case for some products like FMD vaccines, for which sales forecasts are unreliable, sudden peaks in demand can occur because of outbreaks, and there is a lack of inventory at the manufacturers'. This situation could be addressed by the constitution of banks, which are a unique business model well suited to address sudden and unplanned surges in demand for vaccine.

Banks have been established at least for FMD, Bluetongue, rabies, PPR, LSD and avian influenza vaccines. Banks can made of antigen, which then has to be formulated into vaccine by the manufacturer, or of vaccine stocks.

Today the FMD antigen bank model is mostly used by FMD-free countries, as an insurance against an outbreak on their territory. Initiatives are ongoing to mutualize efforts and put in place shared banks, even though allocation rules are often difficult to set.

Banks are also a good model for endemic countries, not only to absorb sudden surges in demand, but also as a trigger for externally-funded pilot vaccination campaigns to demonstrate their benefits. With the support of international organizations, countries could be incentivized to put in place the proper infrastructure for vaccination, which will then make their control programs sustainable.

PRIORITISATION OF VACCINES – APPROACHES TO MAXIMISING IMPACT

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The often-accepted approach to FMD vaccination campaigns is that it is important to vaccinate as many animals as possible against as many strains as may occur in the country. However, this approach is subject to resource limitations. For instance, with constrained budget then cheaper, low quality vaccines may be purchased, or with the limited veterinary manpower then unskilled operatives may be used.

Modelling shows that high quality vaccines will eliminate disease quicker than low quality vaccines and is cost effective. Prioritization is therefore imperative, but first we need to understand what prioritization means as this can take different forms. Once we have defined prioritization then two elements become key, one is the understanding of where the disease is occurring, ie surveillance, and the other is predicting need, i.e. forecasting. Finally we can consider examples of prioritization such as the focus on areas where the greatest spread may occur or targeting the strain most likely to be of current risk.

The goal of all players is to control FMD as quickly as possible to reduce the impact of the disease and to remove the risk to disease free areas. Prioritization of vaccine usage is an important component in achieving that goal. During this talk we highlight these points and open the discussion on how best to implement these approaches.

EVALUATION OF HUMAN RESOURCES NEEDED AND COMPARISON WITH HUMAN RESOURCES AVAILABLE TO CONTROL FOOT-AND-MOUTH DISEASE OUTBREAKS IN TUNISIA USING EMERGENCY VACCINATION

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Introduction
Foot-and-Mouth disease (FMD) is a highly contagious viral disease that affects domestic and wild artiodactyl animals and causes considerable economic losses related to outbreak management. In Tunisia, the last FMD outbreak took place in 2018-2019. The effectiveness of control measures implemented against FMD depends, in particular, on the human resources used to implement them. The main aim of this study was to determine and compare the necessary and available human resources to control FMD outbreaks in Tunisia using emergency vaccination and assess whether there was a gap. To do this

Materials and methods
We developed a reference grid of necessary human resources for the management of one FMD-infected premise in Tunisia. Field surveys, conducted in the 24 governorates of Tunisia, allowed quantifying the available human resources for each category of skill considered in the reference grid. For each governorate, we then compared available and necessary human resources to implement vaccination according to eight scenarios mixing global or cattle-targeted vaccination and different levels of human resources.

Results
The comparison of available and necessary human resources showed vaccination-related tasks to be the most time-consuming in terms of managing an FMD outbreak. Increasing the available human resources using appointed private veterinarians allowed performing the emergency vaccination of animals in the governorate in due time, especially if vaccination was targeted on cattle.

Discussion
This study was carried out in the context of a changing animal health sector in Tunisia, due to discussions on the reform of veterinary services, it could provide support to the authorities and an inventory of the human resources that could be mobilized to properly adapt and optimize the control strategy in the event of a FMD outbreak in Tunisia. The reference grid developed here could be used by the governorates to help authorities properly prepare for a potential FMD outbreak.

DEVELOPMENT OF A PEPTIDE ELISA FOR SPECIFIC DETECTION OF FOOT-AND-MOUTH DISEASE VIRUS-NEUTRALISING ANTIBODIES: CAN A TEST IN THIS FORMAT REPLACE VNT?

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Introduction

The gold standard test to assess post vaccination responses is the virus neutralization test (VNT). The use of VNT is constrained by the need for high containment facilities, well trained staff and the time taken to prepare cells and reagents. In contrasts to the high inter serotype-specificity of the VNT, the structural protein ELISA suffer from low serotype-specificity. Development of simple, specific tests, such as a peptide ELISA, that mimic the measurement of neutralizing antibodies could offer an attractive approach to measure post-vaccination responses.

Materials and methods

An indirect ELISA using a synthetic peptide (PPR LTD, UK) representing the site 1 on the G-H loop of FMDV serotype O as antigen was developed and optimized. Initial validation on monovalent serotype O sera (n = 5) and known inter-serotypic cross-reactive monovalent serotype A sera (n= 5) has been carried out. A correlation between the peptide ELISA and the VNT titre was performed using GraphPad Prism version 8.

Results

The G-H loop peptide was able to specifically react with homologous sera without inter-serotypic cross reactivity with the monovalent serotype A sera despite the cross-reactive response seen with these sera in other ELISA formats. Within serotype O, the sera from different animals vaccinated or infected with different serotype O strains varied in its reactivity to the peptide, emphasizing that this variation could be due to sequence variation at the fingerprints of the epitope used or due to quantitative differences in the neutralizing antibody level as measured by VNT which correlate to certain extent with the OD values.

Discussion

The preliminary data suggests that the G-H loop peptide could be a surrogate model for detecting specific neutralizing antibodies that might correlate with VNT titres and overcome the cross reactivates observed in other ELISA platforms. More in-depth validation with different serotypes needs to be carried out. One limitation of this approach could be the detection of only a fraction of the total neutralizing antibody response is measured, since the assay only targets one out of five known neutralizing antigenic sites of FMDV.

INTRANASAL VACCINE APPLICATION METHODS INFLUENCE THE IMMUNE RESPONSES IN GOATS FOLLOWING INTRANASAL PESTE DES PETITS RUMINANTS VACCINATION: CLINICOPATHOLOGICAL AND IMMUNOHISTOCHEMICAL FINDINGS

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Introduction
Intranasal administration of *Peste des petits ruminants* (PPR) vaccine as a potentially effective means for mass vaccination has been experimentally demonstrated to induce strong mucosal and systemic immune responses in goats. However, little is known about the influence of intranasal PPR vaccination application methods on the induction of immune response in goats. This study compares the influence of two different intranasal vaccine application methods on the immune responses in goats.

Materials and methods
Twenty, male, PPR immunologically naive West African dwarf goats were divided into four groups (n=5). Groups A and B were vaccinated intranasally (IN) with live attenuated PPR vaccine (Nigeria 75/1) by either nasal dropper (Group A) or nasal spray (Group B) methods and compared with the subcutaneous route vaccination (Group C) and unvaccinated control (Group D) for 28 days.

Results
PPR blocking ELISA based on the H-antigen demonstrated high-titres of PPRV-specific antibodies in all vaccinated animals regardless of vaccination route with peak mean percentage inhibitions of 79.3% (day 14); 69.8% (day 21) and 86.6% (day 21) for IN-Drop; IN-Spray and Subcutaneous vaccination groups, respectively. Pulmonary histomorphological assessment showed the development of bronchus-associated lymphoid tissues (BALT) in IN-Spray Group only. PPR Immunohistochemistry showed PPR viral antigens in the lymphoid cells of the germinal centers of the BALT. PPRV antigen was also detected in the spleen and mediastinal lymph nodes of all vaccinated animals after 28 days post-vaccination.

Discussion
The findings of this study shows that the choice of application methods for intranasal PPR vaccine delivery is essential in the induction of immune response and suggests that the IN-Spray method may hold greater potential for earlier induction of systemic immune response as well as pulmonary protection against the pneumonic form of the disease.

Session IV

Resilience to long term FAST crises. The importance of preparedness and planning to help ensure animalwelfare, supply chain and business continuity in prolonged emergency responses.

SESSION IV

Morning session

RESILIENCE TO LONG TERM FAST CRISES: THE IMPORTANCE OF ANIMAL WELFARE, SUPPLY CHAIN AND BUSINESS CONTINUITY IN PROLONGED EMERGENCY RESPONSES

IMPROVING BUSINESS CONTINUITY IN EUROPE - THE REGULATORY AND POLICY CHALLENGES.

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Ensuring a satisfactory degree of business continuity in the context of moderate to long lasting epidemics of major animal diseases such as FAST is a challenge worldwide. In the EU, business continuity of farming is part of the wider concept of resilience to animal diseases and is fully embedded into the EU policies for sustainability of the food chain like the Farm to Fork Strategy under the Green Deal.

Improving business continuity requires deep knowledge of the structural factors (the value chain, the stakeholders, the legislative framework, resources...) and the disease-specific factors (related to the disease agent, its epidemiology, the disease control measures...) affecting business continuity in each concrete situation.

The EU has developed a wide range of measures of different nature along the past decades to tackle animal diseases within its animal health policy ensuring business continuity.

Three major tools/policies constitute the pillars for business continuity in the EU and deserve specific attention: *Biosecurity, Regionalization (zoning) and Vaccination.*

A brief description of the EU general policy and regulatory aspects and also some more specific policy and regulatory aspects related to the implementation of *Biosecurity, Regionalization (zoning) and Vaccination* are presented and illustrated with examples.

TACKLING FAST-DISEASES THROUGH A PUBLIC-PRIVATE-PARTNERSHIP.

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Food-and-mouth disease **A**nd **S**imilar **T**ransboundary (FAST) animal diseases are a constant threat to the European livestock sector. They do not only cause large animal health and welfare problems, they are also disruptive for private partners of the livestock production value chain, as well as for public authorities and institutions involved. Successful prevention and control of FAST diseases requires the involvement and collaboration of private and public partners.

A group of 8 European organizations - representing farmers, breeders, traders, feed producers, renderers and the animal health sector - supported by EuFMD, has set up a platform against FAST diseases. The platform seeks communication and collaboration with public partners in a Public-Private-Partnership, and listed items for debate including:

- reconsidering criteria for application of emergency vaccination and creating a lever for keeping vaccinated animals in the food chain;
- incentivizing biosecurity on farms for preventing FAST diseases;
- capacity on farms, in test laboratories, on rendering plants, etc. in the face of FAST disease outbreaks;
- biosecurity management in the feed chain.

This initiative is well in line with EuFMD Workplans Phase V 2019 – 2021, which aims to establish Public and Private Sector Platforms (PPSP) for FAST diseases. With the support of EuFMD, the private stakeholders wish to invite their public stakeholders' partners and academia to a series of workshops and simulation exercises that addresses specific aspects of FAST disease prevention and control.

REDUCING FMD'S POTENTIAL IMPACT: THE BENEFITS OF TARGETING AUSTRALIAN CONTROL MEASURES

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Introduction
Developments in control of highly infectious diseases improve emergency response efforts by targeting the response according to risk. For example, advances in surveillance testing and sampling deliver their results by more precisely targeting their populations. Here, targeted implementation of trading zones and vaccination are examined.

Materials and methods
Proposed trading zones for FMD at the state level are determined using multiple tools. Incursion scenarios for FMD in Australian states are simulated using the AADIS model to identify the geographic extent of potential outbreaks, the number of animals infected, and the duration. The disease spread information is used to identify the boundaries of trading zones for the incursion scenario where vaccination is determined to have a significant effect on reducing disease impacts relative to stamping out. The number of animals infected provide the supply shock. The outbreak duration data is combined with historical export data to calculate the share of Australian exports embargoed. The market impacts -- changes in equilibrium quantities and prices -- of the supply shock and zoned export embargos are simulated within ABARES' Ag Emission partial equilibrium model of Australian agriculture.

Results
Reductions in export embargoes for smaller outbreaks controlled by stamping out range from 20 to 80 percent should Australia effectively implement trading zones at state levels. Decreases in estimated producer revenue losses are between AUD 3 billion and AUD 9 billion less than losses under a national embargo. For a larger outbreak where vaccination is utilized along with trading zones, reductions in producer losses are AUD 4 billion compared to a larger outbreak where stamping out is used with trading zones.

Discussion
Results emphasize the importance of jurisdictional and outbreak characteristics in determining trading zones and targeting of vaccination. Economic analyses identify how additional investments in design and implementation would be of value to countries.

COMPARING SURVEILLANCE APPROACHES TO SUPPORT REGAINING FREE STATUS AFTER A FOOT-AND-MOUTH DISEASE OUTBREAK

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Introduction

Following an FMD eradication program, surveillance will be required to demonstrate that the program has been successful. The World Animal Health Organization (OIE) provides guidelines including waiting periods and appropriate surveillance to support regaining FMD-free status. Serological surveillance is the recommended method for demonstrating freedom but is time consuming and expensive. New technologies such as real-time reverse transcription polymerase chain reaction (RT-qPCR) tests and sampling techniques such as bulk milk testing (BMT) of dairy cattle, oral swabs, and saliva collection with rope tethers in piggeries could enable surveillance to be done more efficiently.

Materials and methods

Epidemiological modelling was used to simulate FMD outbreaks, with and without emergency vaccination as part of the response, in Australia. Baseline post-outbreak surveillance approaches for unvaccinated and vaccinated animals based on the European FMD directive (EU 2003) were compared with alternate approaches in which the sampling regime, sampling approaches and/or the diagnostic tests used were varied. The approaches were compared in terms of the resources, time taken, cost, and effectiveness i.e. ability of the surveillance regime to correctly identify the infection status of herds.

Results

In the non-vaccination scenarios, the alternative approach took less time to compete and cost less, with the greatest benefits seen with larger outbreaks. In vaccinated populations, the alternate surveillance approaches significantly reduced the numbers of herds sampled, the total number of tests done and costs of the post-outbreak surveillance. There was no reduction in effectiveness using the alternate approaches, with one of the benefits being a reduction in the number of false positive herds.

Discussion

Alternate approaches to FMD surveillance based on non-invasive sampling methods and RT-qPCR tests have the potential to enable post outbreak surveillance substantiating FMD freedom to be done more quickly and less expensively than traditional approaches based on serological surveys.

THE EPIDEMIOLOGICAL AND ECONOMIC IMPACT OF A POTENTIAL OUTBREAK OF FOOT-AND-MOUTH DISEASE IN AUSTRIA

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Introduction
An outbreak of foot-and mouth disease (FMD) in an FMD-free country with substantial export volume of livestock and livestock products, such as Austria, would likely have serious consequences on national economy. This could be mitigated by a rapid intervention to control disease spread. The objectives of this study were to assess the epidemiological and economic impact of FMD outbreaks in Austria by simulation studies, to evaluate the effect of various control strategies and to assess the resources that would be required to respond to an FMD outbreak in Austria.

Materials and methods
The multi-country FMD outbreak simulation model EuFMDiS was used to simulate a potential FMD outbreak in Austrian regions with both low and high livestock densities. The consequences on the Austrian economy were evaluated by a model, which combines the economic results from EuFMDiS with our own calculation of costs. Direct costs linked to the implementation of several control strategies under consideration, as well as the indirect costs caused by production losses and international trade restrictions were estimated. A sensitivity analysis was performed on potential influential input parameters.

Results
The results showed that there is a significant influence of the livestock density of the affected region on the dynamics of the outbreak and its economic impact. Comparison of different control strategies suggested that, from an economic point of view, implementation of additional control measures would be efficient if the epidemic started in an area with high livestock density. Analysis of the simulations demonstrated that success of control measures depends substantially on the adequate availability of resources and the speed of intervention. The vast majority of financial losses associated with an FMD outbreak could be attributed to export losses. Surveillance cost accounted for the largest share of the costs linked to the control strategies.

Discussion
The current study indicates that control of an FMD outbreak may be improved by implementation of a contingency strategy adapted to the affected region and by consideration of a range of factors evaluated in this work.

SESSION IV

Afternoon session

COMPARTMENTALISATION AS A TOOL FOR IMPROVED RESILIENCE TO AFRICAN SWINE FEVER INTRODUCTIONS

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The current pandemic of African Swine Fever (ASF) has caused major losses to the swine industry worldwide. Compartmentalization is one of the available tools to address the threat to business continuity posed by ASF to the industry. Although compartments have been implemented for various diseases and production types, no ASF- free swine compartment has been published by OIE to date.

First, we outline the advantages of the approach as well as general challenges for implementation of an ASF-free swine compartment. ASF risk management ranges from prevention, preparedness and early detection activities in disease-free territories to response and eradication after disease introduction has occurred. We discuss the role for zoning and compartmentalization within this spectrum and specific challenges associated with compartmentalization (e.g., zero downtime, acceptance by the Veterinary Authority and trading partners).

Then, we discuss two aspects of compartmentalization, which are central for successful implementation: biosecurity and disease surveillance, using an illustrative example from North America. Both components are designed to provide evidence that compartment products are free from ASF virus. Biosecurity should be sufficient to mitigate the risk of introduction of virus via all potential routes such as people, fomites, live pigs, pork products and proximity pathways. Implementation of biosecurity measures should be thoroughly documented and auditable. Options for disease surveillance include barn-based observational surveillance, which is able to both support early detection and demonstrate freedom from ASF.

Last, we discuss the relevant stakeholders, roles and responsibilities involved in the development of an effective national ASF compartmentalization programme. Such programme should include a governance structure, standards for biosecurity, surveillance and traceability, auditing requirements and national ASF surveillance. While integrated swine production systems lend themselves well to compartmentalization, substantial work is required to develop such a programme. Benefits go beyond ASF preparedness, including an improved partnership between industry and government.

CONTINUITY OF BUSINESS DURING TRANSBOUNDARY ANIMAL DISEASES – LESSONS LEARNED FROM CALIFORNIA'S IMPLEMENTATION OF THE SECURE FOOD SUPPLY PROGRAM

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The California Department of Food and Agriculture (CDFA) in the United States manages and implements the Secure Food Supply (SFS) Program. The Program is envisioned as a "shield" that protects California agriculture during a Foreign Animal Disease or Notifiable Animal Disease outbreak and provides a pathway to economic survival for the industry through the permitted movement of animals and animal products. While the SFS Program is managed at the state level, it is implemented at the individual premises, rather than a compartment, level. The SFS Program is designed to allow businesses that are unaffected by the disease (i.e. negative for the disease) but located within a quarantine Control Area to maintain some business operations in order to maintain economic viability. The foundation of the Program is enhanced biosecurity that protects the premises and keeps disease out as well as ensures a safe product is leaving the premises. CDFA has been working on SFS planning for many years. During a recent, prolonged outbreak of virulent Newcastle disease in California, CDFA had the opportunity to operationalize the SFS Program. Over the two-year disease response, the Program had many successes, faced several challenges, and identified lessons learned to carry forward to enhance our state animal agricultural industry's disease preparedness.

CONTROL OF AN OUTBREAK OF FOOT-AND-MOUTH DISEASE IN COLOMBIA 2017-2018, LESSONS LEARNED.

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Introduction

The internal risk of foot-and-mouth disease in South America is located in the north of the Andean sub region. In June 2017, an outbreak of foot-and-mouth disease was detected in the department of Arauca (municipality Tame) and it was the beginning of a complex epidemic event that was completed in October 2018. This work presents a descriptive analysis of the sanitary actions that were carried out for its control and eradication and to reduce the impact of eventual new incursions.

Materials and methods

For this situation analysis, the information of the epidemiological investigations carried out, including serological studies, and the control and prevention actions implemented, is used as input.

Results

Between June 20 and July 11 of 2017, three outbreaks were reported in two departments of the country. These outbreaks were controlled by stamping out, quarantine of the affected municipalities, with the prohibition of movement and implementation of checkpoints, resulting in the formation of a containment zone. After 14 months without new cases, in September 2018 an outbreak was detected in the containment zone, and in October, another two in two border departments. These events showed flaws in the control strategy and it was decided to add an emergency vaccination.

A total of 5,464 animals were euthanized. Serological studies verified that, after emergency vaccination, the bovine population was highly protected, and no evidence of viral transmission was found. A new control and prevention strategy was conceived according to the risk and the epidemiological situation of the area.

Discussion

The formation of the containment zone to reduce the impact of the outbreak and the causes that led to its suspension are discussed. It is argued about the modification of the strategy to overcome the health emergency and the implementation of a new zoning of the country to mitigate the impact of possible new incursions.

INDIRECT COSTS ASSOCIATED WITH A POSSIBLE OUTBREAK OF AFRICAN SWINE FEVER IN SWITZERLAND

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Introduction
African swine fever (ASF) is a transboundary animal disease associated with high economic, trade and food security relevance. While direct costs of outbreaks of transboundary animal diseases are often well understood, little information is available about indirect and/or consequential costs of control measures. In this study, a spreadsheet model was developed to estimate the indirect consequential costs of ASF in domestic pigs and wild boars, considering different outbreak scenarios in Switzerland.

Materials and methods
First, qualitative interviews were conducted with international stakeholders to identify the sectors that may be indirectly affected by an ASF outbreak and how this impact can be characterized. Various outbreak scenarios in domestic pigs and wild boar were defined, and Swiss stakeholders were interviewed to gather data on the economic impacts in these scenarios. Finally, a cost-calculator model was used to estimate the indirect costs of an ASF outbreak in Switzerland and a decision-tree model was used to analyze various scenarios given incursion probabilities.

Results
Interviews with international stakeholders demonstrated that actors beyond the pig value chain were also indirectly affected by ASF, including, for example, the timber industry, agricultural insurance companies and feed crop producers. Important drivers for indirect costs in Switzerland were consumer demand, slaughter restrictions and biosecurity requirements.

Discussion
The findings demonstrate that the impact of an ASF outbreak will be felt well beyond the pig farms directly affected. Changes in consumer demand will impact the entire pig value chain. Furthermore, certain measures, including biosecurity measures (e.g. compulsory indoor housing) or transport restrictions for healthy pigs may lead to significant indirect consequential costs throughout the value chain. It is crucial for all stakeholders to be informed about the emergency measures that will be taken in an outbreak and their consequences to enable them to prepare for and mitigate their impacts.

SECURE FOOD SUPPLY PLANNING IN THE U.S. – CONTINUITY OF BUSINESS DURING A TRANSBOUNDARY LIVESTOCK DISEASE OUTBREAK

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Introduction

A transboundary disease outbreak in the U.S. would have immediate and long-lasting impacts on livestock and allied industries. Response plans include immediate movement restrictions for animals and their products that pose a risk of disease spread. This market disruption will impact food availability, animal welfare, and the economic viability of livestock producers. Balancing disease control efforts with business continuity is complex.

Materials and Methods

The USDA APHIS, the National Pork Board, and the American Sheep Industry Association contributed funding to university veterinarians to develop the Secure Food Supply Plans for Continuity of Business. National and international standards for disease control were reviewed. Subject matter experts were consulted. Stakeholders were identified from the dairy, swine, beef, and sheep industries, and state and federal regulatory officials to review and improve guidance documents. Workshops, field demonstrations, table tops and functional exercises were conducted. Frequent stakeholder webinars are held to collect feedback.

Results

The Secure Milk, Pork, Beef, Sheep and Wool Supply Plans were created to provide guidance to producers, packers/processors, regulatory officials and veterinarians for preparedness and response actions to promote business continuity during a U.S. transboundary animal disease outbreak. Each Plan has industry-specific materials to support contingency planning for movement restrictions, enhance biosecurity, and conduct surveillance. Pro-active risk assessments for milk and pork were conducted. Foundations for movement permitting were created for livestock premises with no evidence of infection. All resources are available online at: www.securefoodsupply.org.

Discussion

The negative animal health, welfare, and economic repercussions will be significant if a transboundary disease is introduced to the U.S. The Secure Food Supply Plans for Business Continuity provide a framework for the livestock industries, state and federal officials to build resiliency now. It is up to stakeholders to put effort into preparedness planning and implementation to increase their likelihood of maintaining business continuity.

IMPACT OF ON-FARM BIOSECURITY LEVEL IN PIG HERDS ON THE SPREAD AND CONTROL OF FOOT-AND-MOUTH DISEASE

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Introduction

Interest in biosecurity has risen considerably over the last decade in parallel with increasing food trade, outbreaks of transboundary animal diseases, and increasing antimicrobial resistance. Enhancing biosecurity is crucial for both preventing and controlling FAST diseases. In this paper we describe the impact of enhancing biosecurity on pig farms on simulated foot-and-mouth disease epidemics (FMD) in Ireland, using the EuFMDiS model.

Materials and methods

EuFMDiS is a continental-scale modelling platform of livestock disease spread and control that simulates transmission within and between countries. EuFMDiS considers on-farm biosecurity as a protective measure for indirect and local disease spread between herds. It is parameterized as a biosecurity weight of the destination herd that influences the probability of this herd to become infected.

The biosecurity weights are derived from a FMD biosecurity score that is estimated for different pig herd types in Ireland based on the data that are collected by Biocheck.Ugent®, a risk-based scoring system for evaluating the quality of on-farm biosecurity. To estimate the impact of enhanced on-farm biosecurity on the spread and control of FMD, the minimum value of the FMD biosecurity score were truncated at a higher value, simulating a compulsory implementation of additional biosecurity measures on all farm.

Results

The mean (min/max) FMD Biosecurity Score estimated from the Biocheck.Ugent data for Irish pig herds (n=254) was estimated at 63% (41%; 83%), which is higher than the mean Score for pig herds (n=2066) in all European countries that participate in Biocheck.Ugent, i.e. 62% (18%, 96%). Truncating the minimum Score for Irish pig herds to 50% resulted in reduction in size and duration of FMD outbreaks in Ireland.

Discussion

This pilot study shows the potential positive impact of implementing on-farm biosecurity management systems on the resilience to FAST disease outbreaks. The study requires further elaboration but can potentially contribute to solutions for business continuity during epidemics.

Posters

Session I

COVERAGE OF SLAUGHTERHOUSE SURVEILLANCE FOR BOVINE TUBERCULOSIS THROUGH NETWORK ANALYSIS OF CATTLE MOVEMENTS IN BRAZIL.

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Introduction

In regions with a low prevalence of bovine tuberculosis, slaughterhouse surveillance plays an important role in disease detection. Farms that send animals to slaughterhouses are constantly monitored by this surveillance. However, since animals can be traded between different premises, the outreach of this system is not limited to these premises only, but could potentially reach indirect trade partners as well. This work aims to estimate and characterize the cattle herd that could be monitored directly and indirectly by the inspection routine and identify premises and regions that are not being covered by the slaughterhouse surveillance.

Materials and methods

An animal movement contact network was reconstructed from a Brazilian state's cattle movement database. This database includes information concerning 79,685 premises, 813,011 movements and 17,157,376 animals moved throughout the year of 2015. We identified the number of premises and animals under direct and indirect slaughterhouse surveillance in this state, determining also the set of premises that were not monitored at all.

Results

According to preliminary results, slaughterhouses were connected up to 5 indirect neighbors in the trade network. 23.8% of the premises sent animals to slaughterhouses, which represents 15.6% of the state's cattle premises and 15.5% of the state's total amount of cattle. 65.6% of the premises in the state moved animals, and 21.6% of those were not connected to slaughterhouses (either directly or indirectly), and therefore unable to be reached by the slaughterhouse surveillance. In total, 48.5% of the state's premises and 35% of the state's cattle were not covered by the slaughterhouse-based surveillance system.

Discussion

Network analysis is a useful tool to understand the outreach of the slaughterhouse-based surveillance system. Determining regions with poor coverage of this surveillance can help in the design of complementary surveillance components suitable to the reality of these populations.

EPIDEMIOLOGICAL INVESTIGATION OF FOOT-AND-MOUTH DISEASE OUTBREAKS IN A BEAR RESCUE CENTRE IN VIETNAM IN 2011

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Introduction
Foot-and-mouth disease (FMD) outbreaks were reported in 2011 in two housing facilities at a Vietnamese bear rescue center, affecting Asiatic black bears (*Ursus thibetanus*) and a Malayan sun bear (*Helarctos malayanus*).

Material and methods
Demographic data of all animals housed in the center at the time of the outbreaks (n=79) was collected, as well as blood samples drawn from 23 bears at different time points. Samples were tested for FMD non-structural proteins (NSP) and virus neutralization test (VNT). FMD cases were defined as animals showing FMD clinical signs. Epidemic curves and transmission maps were generated for each outbreak. Outbreak-specific incidence rates (IRs) were calculated and risk factors for showing clinical signs were identified. Time-dependent reproduction numbers (were estimated. The relationship between seroconversion and clinical signs was described over time and the time-to-detection of FMDV antibodies was analyzed using survival analysis.

Results
The IR was 2.63 (95% CI: 0.84-8.17) and 21.85 (95% CI: 12.94-36.89) per bear-year at risk in the first and second outbreak, respectively. Mean estimates peaked at 1.47 (95% CrI: 0.18-4.13) and 5.35 (95% CrI: 2.42-9.48) in the two outbreaks. There was strong evidence for a decrease in odds of showing clinical signs per year of age (OR=0.59, 95% CI: 0.41-0.84, p=0.004). All FMD cases seroconverted by VNT and 35.3% (n=6/17) were positive for NSP antibodies. Most bears not showing clinical signs (83.3%; n=5/6) seroconverted by VNT and 50% (n=3/6) showed antibody responses to NSP. Bears seroconverted as early as 9-days post clinical-onset and remained seropositive until the last tested serum sample collected 4.5 years after the outbreak.

Discussion
This study provides initial epidemiological parameters of FMD in bears. FMDV is easily spread between bears in proximity and is capable of causing clinical and subclinical disease, both of which appear to induce rapid and long-lasting immunity.

EPIDEMIOLOGICAL STUDY OF FOOT-AND-MOUTH DISEASES IN PREY VENG PROVINCE, MARCH 2018-AUGUST 2019.

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Foot-and-Mouth disease Prey Veng Provincial had been found, six cases of FMD were outbreak in 2017 and six of the 23 villages in 2017 and some of years. My study focus three purposes: to find the temporal and place, presence and type of FMD and farmers 'prevention and control of FMD.

The study, using the longitudinal study method and the Convenience sampling for sample collecting from animal. A total of 47 animal and lymph nodes were collected and 156 interviewees. According to the result of FMD outbreak, there are 5 districts: 10commune, 16 villages in Prey Veng province. Most cases occurred between January and March and May and August, and laboratory results showed positive results for FMD serotype (O). Farmers' knowledge and practice for FMD prevention are still limited, with most of them raising cattle still follow traditional practice and, on the other hand, less involved in vaccinations, and the circulation of traders buying cattle and livestock from one area to another the main causes of disease are also.

Therefore, the study on Epidemical of Foot-and-Mouth disease in Prey Veng province from March 2018 to August 2019 occurred in 5 different districts with Preah Sdach and Peam Chor district having a relation of cattle traffic and purchase. The samples collection result found positive of Foot-and-Mouth disease serotype (O pen Asia) and Foot-and-Mouth knowledge from farmer's understanding is still limited. It is recommended that the relevant institutions and farmers jointly and adequately vaccinate the animals as part of their efforts to reduce Foot-and-Mouth disease.

FOOT-AND-MOUTH DISEASE RISK MAPPING IN GEORGIA

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Introduction
Since 2019, EUFMD has implemented a programme in collaboration with the French Agricultural Research and International Cooperation Organization (CIRAD) aimed at improving the risk assessment capacity through risk mapping trainings in the Trans Caucasus and neighboring countries. Risk-maps, integrating animal mobility and other risk factors, are useful to target disease surveillance on specific risk hubs.
As an example of the initiative, a study was conducted in Georgia, which is at risk of foot-and-mouth disease (FMD) introduction from neighboring endemic countries.

Material and methods
In 2020, data was collected from 12 districts looking at seasonal migration, from 7 districts for live animal exports, from 24 districts for live animal imports, from 26 live animal markets and from 5 veterinary inspection points which is distributed throughout the country. The analysis was based on variables, which were derived from the Georgian National FMD Control Plan. All data was registered and analyzed in Q-GIS system.

Result
Analysis showed that 721,633 animals (98.8% small ruminants (SR); 1.1% large ruminants (LR) migrate every year from 12 municipalities in Eastern Georgia to seasonal pastures in southern Georgia. From 7 municipality in Eastern Georgia, a total of 524,739 animals (60.7% SR; 39.2% LR) were exported. 177,949 animals (96.8% SR; 3.1% LR) from 17 countries were imported to 24 municipalities in throughout Georgia. Data from 26 live animal markets showed that 1,372 animals (26.7% SR; 23.3% LR; 49.9% pigs are sold per week).

Discussion
In this study, high animal mobility and therefore a higher risk of FMD introduction and spread was identified in Eastern Georgia compared to the rest of the country. This confirms the current main focus of control efforts. Future regional risk maps from neigh boring countries in the frame of EuFMD/CIRAD cooperation will allow better predictions of disease risks and targeting of control measures.

GOAT MOVEMENTS WITHIN THE FOOT-AND-MOUTH DISEASE PROTECTION ZONE OF SOUTH AFRICA

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Introduction
Foot-and-mouth disease (FMD) is a transboundary animal disease that has a major impact on livestock production, regional and international trade and livelihoods of smallholder farmers in endemic settings. FMD can be transmitted through direct contact between animals, and thus between herds and flocks through animal movements.

Materials and methods
A cross-sectional survey using a semi-structured questionnaire was administered for the study. Independent-focus group discussions employing participatory mapping and semi-structured interviews were conducted among smallholder goat farmers within the FMD protection zone with vaccination of South Africa. Information on animal movements were collected with each origin and destination described as a node and respective connections between nodes as ties.

Results
Data were collected from 116 questionnaire respondents and 13 focus group discussions. Overall, 22% (95%CI: 16 – 31) of the questionnaire respondents moved new animals into their holdings during the previous 12 months while 56% (95%CI: 47 – 65) moved animals out of their holdings. A total of 134 participants attended the focus group discussions with 68% (91/134) being male and 32% (43/134) female. Participants reported 37 nodes and 78 ties with an overall livestock movement network density of 0.06 (SD 0.2) across the study area. There was more movement out of holdings among respondents within the study area relative to incoming movement of livestock. Four locations within the (currently suspended) FMD-free zone of the country had connections with goat movements from the study area. Sixty percentage (95%CI: 51 – 69) of respondents were unaware of the need to obtain official veterinary movement permits.

Discussion
Goats are moved without official movement permits to the FMD free zone of the country. Since goats are susceptible to FMD, these movements put the country at risk of future outbreaks within the FMD free zone. We recommend that education programmes and risk-based control measures be implemented to prevent the spread of FMD and other transboundary disease.

IS AFRICAN SWINE FEVER RETURNING TO AFRICA? A BACK-OF-THE-ENVELOPE ANALYSIS OF 15 YEARS OF WAHIS DATA

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Introduction

Long regarded as a truly "African" disease, *African Swine Fever* (ASF) embarked on an unprecedented invasion of the (old) world, with a first introduction reported well outside its usual geographical range, in Georgia, in 2007. At the time, the ASF new lineage (genotype) II "Georgia 1/2007" had been traced back to strains encountered in Madagascar, Mozambique and Zambia mostly. Ever since, the new strain has spread throughout Europe, Russia, Eurasia and eventually Asia, with the major impact being felt in China, the world's premier pork producer.

Materials and methods

The author reviewed both *immediate notifications* (IN) and *six-monthly reports* (SMR) of ASF since the inception of the OIE's *World Animal Health Information System* (WAHIS) in 2005.

Results

WAHIS-based data since 2005 indicate that "exceptional epidemiological events" related to ASF, i.e. mostly outbreaks, have been reported at a consistent, low rate, until 2017 – 2018, when the number of such IN started to increase. Over the years, 43 outbreaks warranting an immediate notification have been reported to the OIE by 17 African countries. The increase in immediate notifications is not mirrored by a similar increase in outbreaks reported in the SMR, usually where countries deem that ASF is endemic.

Discussion

Whereas an increase in immediate notifications could point to a higher virulence of the circulating viruses and/or higher sensitivity of African suids to the Georgia strain, there is no evidence to support this at this stage. Genotype II, linked to the Georgia strain, in a 2018 Africa review by Penrith *et al.* is still only being reported in the initial countries-of-origin, along with Mauritius (2007 – 2008 outbreaks). Another hypothesis is that the higher number of immediate notifications is simply a reflection of a considerable increase in (smallholder) pig production, as evidenced by WAHIS population data for much of the affected countries on the continent, showing impressive population growth in countries such as Chad, Malawi and Senegal (upward from 500% over a decade).

MODELLING THE SPREAD OF TRANSBOUNDARY ANIMAL DISEASE IN AND BETWEEN DOMESTIC AND WILD SWINE POPULATIONS

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Introduction
The challenge of planning for transboundary animal disease outbreaks can be compounded by the complex epidemiological interplay between livestock, wild animals, and the environment. Wild boar populations can form direct and indirect spread pathways for contagious livestock diseases such as FMD, ASF and CSF, both within and between countries. In this paper we describe the development of a decision support tool to assist disease managers explore the sometimes unpredictable interface between domestic pigs and wild boar.

Materials and methods
EuFMDiS is a continental-scale modelling platform of livestock disease spread and control that simulates transmission within and between countries. It has been designed to support emergency animal disease planning in Europe, with the spread and control of FMD in seven central European countries used as a test case. In this study, EuFMDiS was extended to include the spread of livestock disease in a wild boar population and between domestic pigs and wild boar. The test case for the study was the spread and control of CSF in Spain. Key aspects of the conceptual model are presented, including the representation of wild boar ecology over time and space, and regional and seasonal influences on the spread of disease between wild boar groups, and between wild boar and domestic pigs.

Results
The wild boar population in Spain was represented as a raster-based time series of population counts per 2 km2 grid cell. The spread of disease between wild boar groups was represented by jump-diffusion spread pathways informed by regional and seasonal influences on contact and transmission. The spread of disease between domestic pig herds and wild boar groups was represented by bi-directional spatial kernels informed by regional, seasonal, and production system influences on the risk of transmission.

Discussion
The study produced a functional prototype of the spread and control of CSF in Spanish domestic and wild swine. A key modelling outcome was the successful fusion of an existing agent-based model of livestock disease transmission with a new geographic automata model of wildlife disease transmission.

MOLECULAR SURVEILLANCE OF FOOT-AND-MOUTH DISEASE VIRUS THROUGH SLAUGHTERHOUSE IN VIETNAM

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Introduction
The genetic and antigenic diversity of foot-and-mouth disease virus (FMDV) poses a significant challenge to successful control in endemic countries. The objective of this study was to evaluate sampling of asymptomatic livestock at slaughterhouses as a strategy for molecular surveillance of FMDV in Vietnam. Specifically, we investigated the extent to which viruses recovered from slaughterhouses reflect the diversity found in the source population, and whether they can serve as sentinels for the early detection of emerging outbreak strains.

Materials and Methods
Oropharyngeal fluid (OPF) samples were collected from 944 asymptomatic cattle and buffalo in two slaughterhouses at bi-monthly intervals in Long an and Tay Ninh provinces from 2017 to 2019. Sequences of the VP1 region were obtained from 72 animals, all of which were assumed to represent sub-clinical infection. To characterize viral diversity in the source population, sequences obtained from longitudinal sampling of OPF from farms (2015-2017) from eight provinces were also included. Outbreak sequences from clinical cases were available from 2009 to 2019 from passive surveillance and GenBank. A time-scaled phylogenetic tree was created for serotypes O and A using BEAST.

Results
Within a given serotype, time-scaled trees showed that a series of viral clades emerged, spread, and subsequently declined over time. For several serotype O clades that included outbreak, slaughterhouse, and farm sequences, subclinical slaughterhouse sequences pre-dated the outbreak sequences by 2-6 months. For other clades, sequences isolated from animals without clinical signs from farms clustered with older outbreak sequences, suggesting the sub-clinical circulation of the viral strain may occur up to 18 months after the observed outbreak.

Discussion
In endemic regions, routine sampling at slaughterhouses may provide a cost-effective means for molecular surveillance to identify circulating and emerging FMDV strains. Within this study, virus sequences obtained in this manner provided a subset of the diversity present in other regional viral populations.

PREDICTING FOOT-AND-MOUTH DISEASE VIRUS IN TROPICAL ENDEMIC SETTINGS USING AN AGENT-BASED MODELING FRAMEWORK

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Introduction
Foot-and-Mouth Disease virus (FMDV) the causative agent of foot-and-mouth disease (FMD), is a high priority infectious disease that requires extensive planning in disease-free countries and zones to develop and maintain prevention and control strategies. Although the virus and disease have been intensively studied, viral persistence in tropical environments, has largely been overlooked and assumptions regarding viral persistence are primarily based on limited data from decade's old research.

Materials and Methods
Our previous meta- and survival analysis of literature and subsequent regression analysis of field data suggests that FMDV could persist in tropical settings when high temperatures and high relative humidity (RH) exists. Such conditions exist in many regions with high FMDV circulation, leading us to question how FMDV environmental survival influences disease dynamics as an indirect route of transmission in these settings. To assess this question, we incorporated movement data and viral decay equations in an agent-base model of FMD in the Far North Region of Cameroon.

Results
Simulation using both density- and frequency-dependent models illustrated that indirect transmission defined seasonality better than animal movement, accounting for 25 and 29% of infections in sedentary herds, respectively and 1.2% of infections in mobile herds (in both methodologies). Though indirect transmission seems to define seasonality, direct transmission contributes more infections to the overall impact of the epi-endemic. Additionally, we found contradictions in owner reported infections for sedentary and mobile herds when making comparisons to the predicted epi-endemic transmission resulting from indirect spread.

Discussion
In sedentary herds, owner reported infections, occurring early in the dry season, did not align with predicted transmission. However, in mobile herds the predicted epi-endemic transmission did align with these owner reports, suggesting that disease dynamics differ by herd type. Current data suggests that countries should consider climatic influences when developing risk calculations, but increased field studies and comparisons with epi- endemic data are needed.

RISK FACTORS ASSOCIATED WITH SHEEPPOX AND GOATPOX SEROPREVALENCE AND IDENTIFICATION OF HIGH-RISK AREAS IN SELECTED STATES OF NORTHERN NIGERIA

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Introduction
Sheeppox and goatpox (SGP) are transboundary, highly contagious infections affecting sheep and goats with characteristic clinical signs. SGP affect large populations of small ruminants in Africa, Asia and the Middle East and, as a result, jeopardize farmers' livelihoods and contribute to rural poverty. Despite their importance, studies looking at factors that increase the risk of sheeppox virus and goatpox virus (SGPV) exposure and infection are limited.

Material and Methods
A cross-sectional study was conducted in three states of Northern Nigeria (Bauchi, Kaduna and Plateau) to assess the extent and geographic distribution of SGP seropositivity in backyard small ruminant flocks. In addition, identify factors associated with higher risk of SGP and hot spot areas at higher risk of SGPV exposure.

Results
Sera samples from 1,800 small ruminants originating from 300 households were collected and 29 (1.6%) were found to be seropositive for SGP. Positive animals came from 19 households. Spatial scan statistic identified eastern Bauchi to be an area of high risk and farms within this cluster were 8.8 times more likely to have at least one animal seropositive than farms outside the cluster ($p<0.001$). At the animal-level, three significant clusters were found corresponding largely with the farm-level cluster, with the addition of a small cluster in the northern tip of Kaduna and South Plateau. The odds of being seropositive were higher in older animals (>24months; OR=8.0, $p=0.008$) and small ruminants with a history of clinical SGP (OR=16.9, $p=0.01$). Bringing new small ruminants into the household and having a history of SGP in the herd were the main risk factors identified at household level. However, the odds decreased by a third ($p=0.05$) if time between bringing animals into the household and sampling was over a year.

Discussion
Results from this study can provide key inputs to design risk-based surveillance and intervention programmes in the area.

RISK OF FOOT-AND-MOUTH DISEASE SPREAD THROUGH CATTLE MOVEMENTS IN UGANDA

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Introduction
Foot-and-mouth disease (FMD) is endemic in Uganda, and the country is following the Progressive Control Pathway for FMD control to identify key risks and reduce the impacts of the disease. Pastoral and trade-related movements play a key role in the spread of FMD in East Africa where borders are porous and movement control limited, and the districts along the Uganda-Tanzania border have frequent cattle movements particularly during the dry seasons. During 2018 and 2019, legal movements alone from the Ugandan border districts to areas characterized by semi-intensive (urban-peri urban) and agro-pastoral livestock production in 40 districts country- wide involved more than 43,000 heads of cattle.

Materials and methods
The World Organization for Animal Health (OIE) risk assessment framework was applied to qualitatively assess the risk of FMDV spread from the border districts through live cattle movements. Risk pathways were developed to assess the likelihood of entry and exposure, and identify to key factors and husbandry practices that facilitate the introduction and transmission of FMDV in cattle.

Results
The likelihood of release of FMDV from the border districts was assessed to be high, via movements of cattle for grazing, breeding and slaughter purposes. Subsequently, the likelihood of exposure of cattle to FMDV was estimated to be high in agro-pastoral areas and low in semi-intensive, urban-peri urban areas.

Discussion
The findings from this assessment will inform the national risk-based strategic plan for the control of FMD. Targeted vaccination, construction of infrastructure in livestock markets, farms and along stock routes, increasing collaboration among veterinary inspectors and agriculture police, and strengthening epidemio-surveillance data collection, analysis and dissemination were identified as key control measures. This risk assessment methodology can be applied to inform risk-based control strategies of other, similar diseases.

THE ROLE OF LOCAL AND REGIONAL LIVESTOCK MOVEMENTS IN FOOT-AND-MOUTH DISEASE SPREAD IN EAST AFRICA

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Introduction
Foot-and-mouth disease (FMD) threatens livelihoods of subsistence farmers in Africa. Livestock movements to access resources (grazing/watering) and markets facilitate viral spread. Combining phylogenetic analyses with information on village connectivity through livestock movements can reveal sources of introduction and untangle dynamics of spread. In order to test this, we investigated FMD outbreaks in northern Tanzania in 2018.

Materials and methods
Samples from cattle showing FMD clinical signs were collected and processed by virus isolation, antigen typing and VP1 sequencing. Data on inter-village connectivity through communal resource areas and markets were generated through participatory mapping. The evolutionary history was inferred using Bayesian Markov Chain Monte Carlo methods.

Results
In 2018 circulation of serotypes O and SAT2 occurred in two distinct areas. Introduction of serotype O was linked to a neighboring market. Type O isolates belonged to topotype O/EA-2 and formed a cluster involving only Tanzanian and Kenyan viruses, whilst earlier (2014) O variants fell in another clade including viruses from the wider East African region (Tanzania, Uganda, Kenya and Zambia). SAT2 isolates belonged to topotype SAT2/IV and formed a specific clade clustering within a larger lineage comprising earlier viruses (2012, 2016) of eastern African origin. Local spread of both O and SAT2 viruses was traced back to communal resource areas shared amongst the affected villages.

Discussion
Inter-village connectivity through regional and local livestock trade as well as shared resource areas is high and responsible for FMD spread. Circulation of type O viruses in 2014 points to wider (regional) trade-associated networks. Transboundary movements between Kenya and Tanzania likely triggered 2018 outbreaks. While the origin of SAT2 viruses was less clear, local circulation of both serotypes was linked to communal resource areas. The identification of connectivity points offers opportunities for targeted interventions that would enable livestock mobility, hence animal survival and subsistence economy.

SPREAD OF FOOT-AND-MOUTH DISEASE VIRUS SEROTYPE O/ME-SA/Ind-2001e SUB-LINEAGE IN PAKISTAN

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Introduction

Foot-and-mouth disease virus (FMDV) causes a highly contagious vesicular disease of cloven-hooved animals leading to livestock production losses and disruption to international trade. Due to a high mutation rate, new FMDVs constantly emerge and pose challenges to control strategies. Furthermore, incursion of FMDVs also occurs from one geographical area to another even into previously FMD-free regions. Identification of circulating strains is an essential step towards the global eradication of FMD. The present study aimed to determine the nature of the FMDVs circulating in North-western Pakistan.

Materials-methods

Epithelium or vesicular fluid samples were collected from suspect clinical cases of FMD and tested using FMDV-antigen specific LFDs. Positive samples were further tested using serotype-specific Ag-ELISAs. The VP1-coding sequences were generated from the selected samples to further characterize the FMDVs. Phylogenetic trees were constructed using the VP1-coding sequences and other sequences from public databases.

Results and Discussion

FMD is endemic in Pakistan and three serotypes of FMDV are responsible for outbreaks in the country. These viruses belong to pool 3. However, some viruses detected in the present study belong to the O/ME-SA/Ind-2001e sub-lineage, which is native to India, Bhutan, Sri Lanka and Bangladesh and belongs to pool 2. The Ind-2001e viruses were responsible for outbreaks in five different administrative units within two Provinces (Punjab and Khyber Pakhtunkhwa) of Pakistan. Viruses belonging to this sub-lineage were also detected in the Middle East (in 2015-16), South East Asia (in 2016-17), Russia (2016), China (in 2017) and Mauritius (in 2016) but were not detected in Pakistan prior to 2019.

SURVEY ON 10 YEARS FOOT-AND-MOUTH DISEASE OUTBREAKS IN BUSHEHR PROVINCE, IRAN

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Introduction

Iran is on stage 2 of FMD progressive control plan. An epidemiological survey did on 10years outbreaks of FMD disease in bushehr province for assessing effectiveness of control program and risk assessment as a main part of disease control strategy.

Materials and methods

Data of recent 10years of outbreaks and vaccination gathered using GIS-VET and archive in veterinary office. Further Information collected by expert opinion and veterinary officers. Data arranged and analyzed using Excel office 2010, spss 22 and stata 15. Mapping of disease did by Arc-Gis.

RESULT

Mean monthly incidence of FMD disease in Bushehr province was in range of zero to .27 (3 per 1000 epidemiological unite per month). Feedlot epi unite (cattle) had more risk of disease than other epi units with RR=15.82(95%CI 11.51-21.74). Cattle feedlot complex and epi unite with free range grazing cattle herds found as High risk area.

DISCUSSION

FMD has a hypo endemic occurrence in Bushehr province. Revealing Pattern of disease in domestic animal population and high risk area are key factors for disease control. Finding of this survey can be used for other study like value chain analysis and risk management

Session II

BOVINE EPHEMERAL FEVER IN THE EUROPEAN NEIGHBOURHOOD BETWEEN 2015 AND 2019, A WEB-BASED SURVEY AMONG EUFMD TRAINEES

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In January 2020, the EuFMD has conducted a transversal web-based survey among its trainee community to gain a better understanding of the Bovine Ephemeral Fever (BEF) situation, surveillance, and control in the 21 countries of European Union (EU) neighborhood (clustered in 4 regions), between 2015 and 2019; a period when reports of BEF in the scientific literature were scarce. Results will assist the identification of targeted activities for improved awareness and early detection capacity of FMD and Similar Transboundary Animal (FAST) diseases in the EU neighborhood.

The questionnaire includes 35 close-ended and open-ended questions divided into 7 sections: respondents' sociodemographic, BEF occurrence, BEF diagnosis, BEF surveillance, BEF vaccine availability and vaccination, legislation applicable to BEF control and finally, knowledge self-assessment and perception of BEF and interest in training. Answers provided to this survey cannot be considered as official replies from the respondents' institution or country.

A total of 270 EuFMD trainees responded to the survey (overall response rate of 17% (n=270/1612)). Official veterinarians were the most represented group among respondents, in all four regions. Forty percent of respondents reported previous experience with BEF. The disease was reported present or likely present at least one year between 2015 and 2019 in 12 countries, belonging to the four regions. The likely periods of BEF infections have been defined for each region. At least one of the three diagnostic assays for BEF was reported to be available in 11 countries. Passive surveillance for BEF has been conducted, or likely to have been conducted in 8 countries between 2015 and 2019, while active surveillance for BEF has been conducted, or likely to have been conducted in 7 countries during the study period. Culicoides surveillance is reported to be conducted in 4 countries. BEF vaccines were reported to be used or likely used in 7 countries of the EU neighborhood between 2015 and 2019. BEF was reported to be, or likely to be a notifiable disease in 7 countries. BEF was estimated to have a medium economic impact at farm level by the respondents.

The survey also explores BEF awareness and training opportunities for veterinarians in the EU neighborhood. Overall, respondents reported that the attention given to BEF was not sufficient, and assessed their own knowledge as poor on BEF epidemiology, diagnosis and control. Level of awareness on BEF among Official veterinarians, private veterinarians and livestock owners were reported to be low in all four regions. The survey report presents results that may assist laboratory and epidemiology networks in planning support activities, private stakeholders in identifying partnership opportunities, research groups in identifying knowledge gaps and training providers in addressing specific knowledge gaps

COMPARISION OF FMD SEROSURVEILLANCE RESULTS IN AZERBAIJAN DURING 2016 – 2019

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Introduction

One of main components of Risk Based National Strategy for prevention and control of FMD is biannual vaccination of large (LR) and small (SR) ruminants. For estimating of effectiveness of vaccination campaigns and for the determining the real situation regarding circulation of virus in the country there is carry out serosurveillance, detecting the level of antibodies to non-structural proteins (NSP-Ab) of FMD in susceptible animals as well as the evaluation of immunity level (SP-Ab) of vaccinated animals. This study aimed to compare of obtained results of the serosurveillance for 2016 - 2019.

Materials and methods

Samples were collected randomly and calculated by the WinEpi software by 95% confidence level with 4% of margin of. Totally of 1131 (LR) and 1136 (SR) serum samples in 2016, and 1323 (LR) and 1834 (SR) serum samples in 2019 were analyzed in Central Veterinary Laboratory of Azerbaijan Food Safety Institute for antibodies against NSP and SP.

Results

For 2016 the NSP-Ab prevalence was 2.63% and 2.56% for LR and SR ruminants respectively. SP-Ab results were 88.9% (A), 81% (O), 83,8% (Asia-1) for LR and 77,6% (A), 72,3% (O) for SR. A total of 5,14% LR and 5,89% SR samples were positive for NSP-Ab in 2019. In case of SP-Ab, the prevalence was higher in SR (68,2% (A), 66,6% (O)), than in LR (64,3% (A), 62,3% (O), 59, 6% (Asia-1)).

Discussion

Results indicated that NSP-ab prevalence level increased from 2016 to 2019. FMDV has circulated in country without evident clinical signs due to the annual vaccination of susceptible livestock were carried out. According to SP-Ab results in 2019, efforts should concentrate to select more effective vaccine and strengthening control measures during vaccination campaign. Local farmers' and field veterinarians FMD awareness should be improved (booklets, posters, trainings, workshops).

COMPLEX CIRCULATION OF FOOT-AND-MOUTH DISEASE VIRUS IN CATTLE IN NIGERIA

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Introduction
Nigeria is a large densely populated country in West Africa. Most of its livestock is raised in a pastoralist production system with typical long distance migration in search of water and feed. As the demand for animal products largely exceeds the domestic production, large numbers of livestock are imported from neighboring countries without sanitary restrictions. In Nigeria foot-and-mouth disease virus (FMDV) serotypes O, A and SAT2 are endemic since long time and FMDV serotype SAT1 is described again since 2015, after an absence of more than 30 years. Historically, outbreaks of FMD due to serotypes O, A, SAT1 and SAT2 were each time associated with trade of cattle entering Nigeria from neighboring countries.

Materials and methods
Samples from 27 outbreaks of FMD were collected in Nigerian cattle from 2012 till 2017 in 6 different States and in the Federal Capital Territory. FMDV was isolated and serotyped and further characterized by VP1 sequencing and phylogenetic analysis.

Results
Half of the outbreaks were characterized as FMDV topotype O/EA-3, while outbreaks with other serotypes and topotypes were – in descending order – less prevalent: A/Africa/G-IV, SAT1/X, SAT2/VII and O/WA.

Discussion
The genetic and phylogenetic analysis suggests a mixed origin of FMD outbreaks. Some outbreaks seem to be caused by sustained local transmission of FMDV strains present in Nigeria since a number of years ago, while other outbreaks seem to be related to repeated introductions of new FMDV strains, resulting from trade of cattle entering Nigeria from neighboring countries, with shorter periods of sustained transmission. The role of small ruminants and African buffaloes in the etiology of FMD in Nigeria is unclear. Our results indicate that systematic sample collection is essential to understand the complex concomitance of FMDV strains in Nigeria and essential to support the implementation of a vaccination-based control plan.

EVALUATION OF A BRUCELLOSIS CONTROL STRATEGY IN SMALL RUMINANTS IN BOSNIA AND HERZEGOVINA

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Introduction
B. melitensis in ruminants was first detected in Bosnia and Herzegovina in 1985 and it threatened to become a serious human health issue. Until 2009, in addition to passive surveillance, a test and slaughter strategy was implemented in ruminants, which did not bring the expected results. From 2009 onwards, a mass vaccination strategy was implemented.

The aim of this research is to evaluate the costs and benefits related to animal and human health of a *B. melitensis* control strategy in small ruminants in Bosnia and Herzegovina.

Methods
An epidemiological (SIR) and economic model was used to compare the vaccination program with a test and slaughter strategy.

Results
The vaccination strategy requires 75% less funds to control *B. melitensis*, and is the best option in terms of the estimated benefit-cost ratio and internal rate of return.

However, a test and slaughter strategy outperforms a vaccination strategy, in terms of faster reduction of prevalence, as well as in terms of the total benefits and net present value.

Discussion
Implementing a vaccination strategy to control *B. melitensis* in sheep and goat was from a veterinary, economic, and human health perspective the optimal decision.

If the costs of the intervention were shared between the sectors in proportion to the benefit to each, the public health sector would contribute 37%, which gives a cost-effectiveness of 328 Euro per DALY averted.

A vaccination strategy is not able to reduce the prevalence below 1% at herd level. Additional financial resources are required to totally eradicate *B. melitensis* by means of a test and slaughter strategy.

Ex ante and *ex post* evaluation of implemented strategies using epidemiological and economic decision support models can contribute to improve policy decision making and can assist both risk managers and policy makers in the prioritization of actions.

EVALUATION OF THE IMPACTS OF 'TIME TO DETECTION' OF A FOOT-AND-MOUTH DISEASE INCURSION IN CENTRAL EUROPE USING EUFMDIS MODELLING TOOL

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Introduction
Delayed detection of an incursion could escalate the magnitude of an epidemic and economic losses. The objective of this study was to assess the epidemiologic and economic consequences of different 'time to detection (TTD)' of an FMD incursion in Central Europe using the European Foot-and-Mouth Disease Spread Model (EuFMDiS).

Materials and methods
Using the EuFMDiS, FMD spread was simulated among 316,442 livestock herds distributed in Austria, Croatia, Hungary, and Slovenia. The outbreak was initiated from a large commercial beef herd (Herd size: 121) and transmission was modelled through direct and indirect contacts, local area and airborne spread mechanism. Three separate TTD of FMD incursion (day 14, day 21, and day 28) were considered for each of the four different FMD control strategies (Stamping out of infected holdings (SO) only, SO plus ring culling in 1 km radius of infected holdings (SO_RC), SO plus suppressive vaccination in 3 km radius of infected holdings (SO_SV), and SO plus protective vaccination in 3 km to 8 km (SO_PV; 5 Km donut shape)). Altogether, twelve model scenarios were developed and simulated for 365 days.

Results
With an increase in TTD from day 14 to day 28, the number of IH, ED, number of affected countries and total costs increased significantly ($p<0.05$). Among the control strategies, SO_RC had the least number of IH and shortest ED whereas SO had the largest number of IH and longest ED for all TTD scenarios. The median number of affected countries increased from 2 to 3 when the TTD was increased from day 14 to day 28. The disease control cost was highest for SO_SV strategy and lowest for SO strategy.

Discussion
The findings demonstrate the importance of early detection along with a chosen control strategy to reduce multi-country spread of FMD.

FACTORS INFLUENCING DECISION-MAKING FOR FOOT-AND-MOUTH DISEASE CONTROL IN KENYA

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Introduction
Decision-making within animal healthcare systems is influenced by social, political and economic factors, which are important when developing national disease control programmes. This study aimed to describe decision- making throughout the animal healthcare system for foot-and-mouth disease (FMD) control in Kenya.

Methods
Thirteen semi-structured telephone interviews, with stakeholders engaged in FMD control activities from public and private sectors, were conducted between July and September 2020. Using an interview guide, information was gathered on their experience of FMD and its control in Kenya, their organization's role in FMD control, interactions with other stakeholders, how FMD vaccination programmes functioned, and perceptions of strengths and weaknesses of current FMD control. Interviews were recorded, transcribed and analyzed thematically, categorizing concepts within the text. Five factors of FMD disease control were selected as key relationship descriptors and mapped by stakeholder: accountability, information about disease, financial flows, vaccine flow and strategic guidance.

Results
Lines of strategic guidance, flowing from international agencies through the Kenyan government's veterinary department to the county veterinary department, were reported as separate from accountability and financial flows, which travel between devolved county government and the county veterinary department. Informants identified this as a limitation, resulting in inconsistent prioritization of animal disease control. Private veterinarians were described as involved in disease-reporting and vaccination, but also as separate from official lines of guidance and accountability within this publicly-governed system. Information about disease was reported as flowing mostly one-way, from farmer and primary animal healthcare providers, towards government departments and international agencies. Participants identified programmatic strengths in development of national strategic document and integration of local resources and expertise into disease control.

Discussion
Participants discussed different ways in which public-private-partnerships could strengthen FMD control. Future stakeholder consultation will use these to consolidate recommendations, integrating strategies that promote two-way accountability mechanisms and information flow about disease.

FOCUSING THE GLOBAL RESEARCH EFFORT TO DELIVER THE REQUIRED TOOLS AND STRATEGIES FOR FMD CONTROL

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Introduction

The STAR-IDAZ International Research Consortium on Animal Health[1] (IRC) is a global initiative aiming to coordinate research at international level to contribute developing strategies and control tools for priority animal diseases. The STAR-IDAZ IRC partners (i.e. public and private research funders) identified priority diseases needing improved focus on research, and established Working Groups (WG) of experts to perform gap analyses on these diseases, and to draft research roadmaps to providing a structure and focus on where research is most needed, identifying bottlenecks and critical gaps.

Foot-and-mouth disease (FMD) is one of the STAR-IDAZ IRC's priorities, and the Global FMD Research Alliance (GFRA) acts as its WG. This paper presents the drafting process for FMD research roadmaps and highlights some of the key research priorities identified in the process.

Materials and methods

Three FMD research roadmaps (i- diagnostics, ii-vaccines, and iii-disease control strategies) were drafted, based on the GFRA research gaps analyses, following a standardized procedure[2]. Coherency and completeness of the draft roadmaps were preliminary assessed by the STAR-IDAZ IRC Scientific Committee and by GFRA experts. Then, a satellite workshop was organized after the 2019 GFRA Scientific Meeting to validate them.

Results

About 30 experts participated in the workshop, bringing a well-balanced range of specializations and wide geographical representation. The experts validated the roadmaps and identified priority research needs for each of them that were then published on the STAR-IDAZ IRC website.

Discussion

The whole process allowed consulting a broad range of experts, from different geographical and epidemiological settings. Overall, this participatory approach ensured the reliability of the identified needs and allowed the experts to feel ownership over the roadmaps. These roadmaps should be an extremely valuable tool to research funders and donors for developing future research calls, allowing to streamline efforts on most relevant topics, and accelerating the delivery of needed control tools.

[1] https://www.star-idaz.net/

[2] Entrican, G., Charlier, J., Dalton, L., Messori, S., Sharma, S., Taylor, R., & Morrow, A. (2020). Construction of generic roadmaps for the

FOOT-AND-MOUTH DISEASE VIRUS SURVEILLANCE AT MARKETS AND ABATTOIRS IN CAMEROON USING ENVIRONMENTAL SAMPLING

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Introduction
Active monitoring and understanding the epidemiology of foot-and-mouth disease virus (FMDV) form the foundations of control programmes in endemic areas. In many endemic areas, veterinary resources are limited, resulting in a requirement for simple sampling techniques in order to increase and supplement surveillance efforts. Environmental sampling provides such a method and requires little prior knowledge of the disease or experience of handling livestock. This study investigates the feasibility of using environmental sampling at livestock markets in an FMDV endemic setting.

Materials and methods
Environmental swab sampling methods developed for the detection of FMDV were used at cattle markets and abattoirs from six locations across Cameroon. A total of 1994 samples were collected. Testing for the presence of FMDV RNA was carried out at the Pirbright Institute (UK) using a panserotype specific rRT-PCR assay. Sequencing approaches were also used to assess suitability of samples for generating sequence data.

Results
8% (n=173) of samples were positive, with the majority of positive samples from two of the sampling locations (Douala, n=86/332 and Bertoua n=79/332). Sequencing of a relatively high titre sample using a probe enrichment approach resulted in the generation of sequence data, which allowed the sample to be identified as serotype O, EA-3 lineage.

Discussion
Environmental sampling provides a simple method for the detection of FMDV that avoids handling of livestock. Sampling at markets and abattoirs that are hubs for livestock movements presents an opportunity for broad-scale surveillance of livestock diseases, not just limited to FMDV. Environmental sampling could supplement surveillance of other diseases that are also the subject of eradication programmes, such as Peste des petits ruminants virus (PPRV). Sequencing environmental samples presents difficulties due to the low viral content of samples and poor quality of RNA. Developing sequencing protocols that overcome these issues could provide valuable information for surveillance programmes.

THE GF-TADs INITIATIVE FOR THE GLOBAL CONTROL OF AFRICAN SWINE FEVER

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African Swine Fever (ASF) has become a global threat impacting livelihood, food security, economic and rural development of many countries around the World.
The World Organization for Animal Health (OIE) in collaboration with the Food and Agriculture Organization of the United Nations (FAO) created a high-level technical Working Group (ASF-WG) under the Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs) to address the strategic challenges for the control of ASF. In July 2020 the Global Initiative for the control of ASF was launched as mandated by the Resolution N°33 at the 87th General Session of the World Assembly of OIE Delegates.
The Global Initiative was designed based on the lessons learnt from existing global animal disease control and eradication strategies under the GF-TAD. It provides a Logical Results Framework and an associated 2-year Operational Plan to achieve the global control of ASF. A Theory of change was developed understanding that control of ASF is feasible with the current risk mitigation tools, but for its success will require strong national leadership, regional support and a global coordination.
The Global Initiative defines 3 objectives:

- Improve the capability of countries to control ASF using International Standards and best practices:
- Establish an effective coordination and cooperation framework; and,
- Facilitate business continuity ensuring safe production and trade to protect food systems.

It identifies key success factors: A disease intelligence framework, effective risk communication, operational and technical capability and sustainable resources.
The priority areas for the ASF-WG are: support regional Standing Group of Experts, monitoring and evaluating the 2 year Operational Plan, support risk communication and strengthen coordination with public and private partners.
By working together, the global control of ASF is feasible and will contribute to achieving the United Nations Sustainable Development Goals, notably Goals 1 (No Poverty) and 2 (Zero Hunger).
In this paper, the Global Initiative and its contribution to the global control of ASF is discussed.

HISTORICAL REVIEW OF FMD VIROLOGICAL SURVEILLANCE AND LESSONS SINCE THE ESTABLISHMENT OF THE JOINT FAO AND OIE GLOBAL FMD CONTROL STRATEGY (2012-2019)

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The joint FAO and OIE Global FMD Control Strategy, launched in 2012, aims to reduce the impact of FMD on animal health and production in endemic countries and decrease the risk of reintroduction into free areas. Vaccination is an important tool for FMD control; the vaccination strategy should be designed according to the control objectives and resources available, and may be targeted to the sector(s) that will benefit most from control. Many FMD-free countries maintain vaccine banks stocked with vaccine antigens protective against the viral strains believed to pose the highest risk of incursion. Thus, virological surveillance and virus characterization are key to inform appropriate and effective targeted vaccination in affected areas, and to support the development of adequate contingency plans to limit the impact and spread of FMDV in free countries or zones.

The temporal evolution of the virological surveillance in the different FMDV Pools since the establishment of the Global Strategy was reviewed using sample submission and virus characterization data from the FAO/OIE reference laboratories network. Information was extracted from the annual reports of the World Reference Laboratory for Foot-and-Mouth Disease (WRLFMD) between 2012 and 2019, and was then used to identify key gaps in sample submission and viral characterization.

The number and trends of samples submitted, serotyped and sequenced indicate that the surveillance coverage is variable. Some gaps are consistent over time, highlighting inadequate virological surveillance and virus characterization, particularly in FMD virus Pools 2 (S. Asia), 5 (W. Africa) and 6 (Southern Africa). This analysis indicates there is a need for targeted intervention to improve virological surveillance, and that further investigation is required to better characterize the types of technical, logistical, capacity hurdles currently limiting the surveillance and diagnostics capacities in these regions.

MISSPECIFYING OPERATIONAL DELAYS MAY PRODUCE BIASED FORECASTS: A RETROSPECTIVE ANALYSIS OF THE 2001 FMDV OUTBREAK IN UNITED KINGDOM

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Introduction
Achieving rapid responses to premises targeted for interventions is critical to the provision of strong biosecurity measures and the overall success of FAST management programs. However, excess response delay has been a recurrent problem in past cases of livestock epidemics when mass depopulation was put into effect. In many models, the scheduling of control actions on individual farm was nevertheless assumed to closely mirror an idealized timeframe without reflecting the disconnection between policy advice and management reality caused by common logistical constraints.

Materials and methods
Using survival analysis, we examined the 2001 UK Foot-and-mouth Disease Virus (FMDV) management timeline to reveal factors that impeded timely culling and disposal activities. We subsequently applied the Warwick model to evaluate how increasingly accurate model representations of the response process can influence national outbreak predictions.

Results
We identified farm size and number of premises in the response queue as key contributors to local response delays. Our results further suggest that simple model descriptions of outbreak management, e.g. fixed, policy- conforming responses, may grossly underestimate outbreak severity and its long-term consequences.

Discussion
Our results suggest the value of basing expectations of response efficiency on time-dependent, premises-specific logistical constraints. Including such operational context in management models can help improve real-time forecasts and inform decision-making.

MODELLING OF FREEDOM FROM PESTE DES PETITS RUMINANTS (PPR) AND SHEEP AND GOAT POX (SGP) IN THRACE

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Introduction
Transboundary High-Risk Area Coordinated Epidemio-Surveillance Programme (THRACE) has been in place since 2013, including bordering areas of Bulgaria, Greece and Turkey, with the primary goal of providing continuous evidence of freedom from Foot-and-Mouth disease (FMD) and to early detect any possible incursions of FMD to this region. Collected data have regularly been analyzed using a deterministic model (Cameron Model) to estimate the probability of freedom from FMD over time. Although current surveillance activities include other FAST diseases, there has been no model in place to analyze the resultant data. The present study was conducted to estimate the probabilities of freedom from PPR and SGP by adapting the original Cameron model.

Materials and Methods
Meetings were held with representatives of Bulgaria and Greece to draw the most plausible input parameters required in adapting the model to the context of each country. These parameters were mainly based on available literature and opinion of regional experts. To partially account for the uncertainty around the parameters, a sensitivity analysis was conducted using two scenarios with the highest and lowest plausible values for the controversial input parameters in order to evaluate their impacts on the probability of freedom.

Results
The probabilities of freedom from both diseases under the two scenarios are currently estimated to be above 97% in Bulgaria and Greece. Differences between the two scenarios were minimal (approximately, 1%), indicating that output probabilities were quite robust to the variations in controversial inputs; e.g., surveillance component sensitivities and the likelihood of the incursion of PPR and SGP.

Discussion
The current surveillance systems seem to be adequate and reliable in providing ongoing evidence of freedom from PPR and SGP as well as early detection in case of possible occurrence in the Thrace regions of Bulgaria and Greece. The importance of passive surveillance component of the system is also reiterated by our result.

MODELLING VIRTUAL TRAINING METHODS TO ENHANCE ENTOMOLOGICAL SURVEILLANCE FOR RIFT VALLEY FEVER AND OTHER MOSQUITO-BORNE ARBOVIROSES IN LIBYA: A TRANSFERABLE APPROACH

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Introduction
Rift Valley Fever (RVF) is a mosquito-borne zoonosis which may cause significant losses for the livestock sector and have serious public health implications. Endemic in several African countries, it appeared in Libya in 2019, reporting several outbreaks. In the framework of the "HOLD-FAST" strategy, EuFMD – with the involvement of the Libyan NCAH, identified IZSAM - main promoter of the network ERFAN, which enhances veterinary research in Africa - as a reliable partner to cope with the emerging training needs. A pilot and innovative blended training course was designed, with a scalable approach for other Countries with similar needs.

Materials and methods
"Virtual Learning RVF and other Mosquito-borne arboviruses: entomological surveillance" is an innovative learning path delivered in 2020, during the Covid-19 pandemic. Based on interactive webinars, in-field and project work activities, its challenge was to recreate at distance laboratory training and mentoring methods to build veterinarians' capacities to integrate specific and transversal skills for a quality entomological surveillance: a new format designed to overcome the class and laboratory "borders", providing a fit-for-the-purpose, personalized and effective learning environment, and optimizing time and resources.

Results
The webinars were focused on the species of mosquitoes, their epidemiological role in the transmission of arboviruses and methods for collecting and analyzing samples. A key element was the use of HD Stereomicroscope in videoconferencing: learners were able to apply the identification techniques of the species of vectors and, through synchronous interaction tools (chat, Q&A, instant polls) their progresses were continuously monitored. The currently ongoing in-field project work is aimed at implementing entomological surveillance in risk locations, thanks to the constant backstop support of experts. A final follow-up will evaluate the learning outcomes and put the basis for an impact assessment.

Discussion
This project has designed a scalable model able to identify and address very target-specific learning objectives, in the past mainly satisfied through medium and long-lasting study visits in equipped laboratories. It opens new scenarios to provide laboratory researchers with concrete opportunities to immerge themselves into innovative and technology-based settings, overcoming traditional barriers. It may be adapted to any training context in which learners are expected to build their capacities in a lab environment.

MONITORING TO COMBAT FOOT-AND-MOUTH DISEASE VIRUS SEROTYPE O FROM 1999 TO THE PRESENT IN TURKEY

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Introduction

Foot-and-mouth disease virus (FMDV) causes one of the most devastating diseases in cloven-hoofed animals. It has got seven serotypes (A, O, C, SAT1, SAT2, SAT3, and Asia-1), and they grouped in seven pools according to the geographic distributions. Turkey is in the pool three (A, O, Asia-1). The mutation rate of the FMDV is very high, and there is no cross-protection the between serotypes. Sometimes protection may not occur even among different subtypes of the same serotypes. Therefore, the evolution of FMDV must be followed closely.

Materials and Methods

Fifty-five isolates and the vaccine strains were examined via viral protein 1 (VP1) coding sequences. Phylogenetic relationships were examined with the minimum-evolution method by using MEGA 6.06 software. Kimura 2-parameter nucleotide substitution model and bootstrap analysis done by using 2500 replicates of the dataset.

Results

Two different genotypes have identified where the pairwise distance was %9. There was seven amino acid difference detected, and three of them (137,140,141) were close to the G-H loop. The first one is O/ME- SA/Panasia-1 genotype with three sub-lineages (Iran2001, α, β) (1999-2006). The second one is O/ME-SA/PanAsia- 2 genotype with six sub-lineages (I(USK-06), II, TER-08, FAR-09, ANT-10, QOM-15, respectively)(2006-2020).

Discussion

Two genotypes belong to serotype O causes epidemics in Turkey since 1999. The O1 Manisa vaccine strain was used during the O/ME-SA/Panasia-1 genotype circulation. After the incursion of the O/ME-SA/PanAsia-2 genotype, O/TUR/07 vaccine strain was produced (2007). Nine amino acids are different between the vaccine strains, and five of them (138,139,140,141,142) are close to the G-H loop. Three of the eight changed amino acids between the first and the last subtypes of the PanAsia-2 genotype (USK-06, QOM-15) were located (133,140,141) close to the same antigenic site. Nevertheless, O/TUR/07 still matches with circulating strains and is still used as one of the prime vaccine strains in Turkey.

A NEW APPROACH ON OUTBREAK INVESTIGATIONS FOR THE CONTROL OF FOOT-AND-MOUTH DISEASE (FMD) IN ANATOLIAN REGION OF TURKEY

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Introduction

Foot-and-Mouth disease (FMD) is endemic in the Anatolian region of Turkey. In recent years, a national control strategy to achieve FMD free status has been implemented. One crucial component of this control strategy is the improvement of outbreak investigations (OI).

Materials and methods

Since FMD is currently endemic in the region, a comprehensive investigation under the lead of the Central Epidemiology and Monitoring Unit as described in the National Contingency Plan cannot be conducted for each outbreak.

Therefore, a standard operating procedure (SOP) describing a three stage OI plan has been developed. Here, outbreaks are prioritized in levels 1-3, depending on the epidemiological situation. As a result, a combination of specific measures, including data collection, source tracing, risk factor identification, study on effectiveness of control measures and economic evaluations are implemented depending on the identified OI level. The framework also identifies which levels of veterinary services, epidemiological teams and institutions are involved for each OI level. Further, to increase detection of outbreaks and reduce the number of unreported outbreaks, a clinical surveillance scheme was developed.

Results

The development of the OI and clinical surveillance schemes was part of a series of trainings jointly delivered by the General Directorate of Food and Control (GDFC) and the EuFMD to 262 veterinarians from all 78 provinces in Anatolia. EuFMD assistance to the GDFC aims to improve the ability of Turkey to control FMD, to promote progress along the Progressive Control Pathway for FMD control and subsequently to reduce the FMD risk in the country.

Discussion

The OI and clinical investigation scheme has been endorsed by the GDFC and since 2019, all outbreaks are investigated accordingly. By implementing this approach, elimination of clinical disease and virus circulation will be successfully achieved along to PCP stage 3. In future, this SOP could serve as a model for more animal diseases, including FAST (FMD and similar transboundary) diseases and more countries in the region.

A NEW APPROACH TO FIGHT AGAINST FOOT-AND-MOUTH DISEASE IN TUNISIA USING A SPATIAL MODEL AND A ZONING APPROACH

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Introduction

In this study, a spatial model was created to identify the areas that fit the World Organization for Animal Health (OIE) definition integrating artificial and natural obstacles and on knowledge of national and international experts to establishment of zoning for Foot-and-Mouth disease (FMD) control at a lower cost.

Material and methods

Eight national and international experts were asked to identify the obstacles and prioritize them in order of importance, characterized by a percentage weight between 0 and 100. These obstacles were mapped and combined, taking into account their relative importance, to create a friction map that makes it possible to visualize areas where animal movements are restricted.

Results

Consulting national experts led to the definition of three zones based on their socio-economic, climatic and epidemiological context which are; zone A “Cap bon”, Zone B “The kerkennah Archipalo” and zone C ” the island of Djerba”. Only Cap Bon is a favorable zone, with good climate conditions, characterized by regular rainfall, and fertile soil. Moreover, the peninsula is connected to the rest of the country by a national road, a railway and a 40 km highway, and could consequently be controlled.

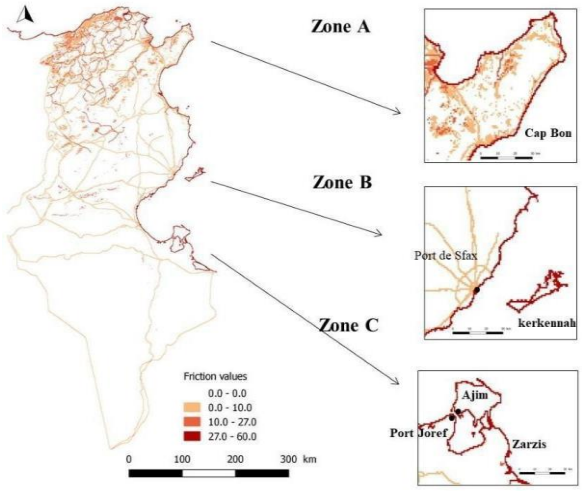

Figure 1: Friction map

Discussion

To meet the OIE recommendations, accompanying measures will be needed to insure the establishment and maintenance of the disease free status in the Cap Bon zone. A regional type approach resulting from this work could indeed be a major asset in identifying zonal regions in North Africa.

RISK FACTORS ASSOCIATED WITH FMD ENDEMICITY IN EASTERN RWANDA

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Introduction

In Rwanda, almost all outbreaks of FMD have started in Eastern Rwanda (Ngabonziza *et al*., 2010). Identifying the risk factors in this area will support government control efforts.

Materials and Methods

We used a questionnaire that covered several risk factors such as vaccinating calves, mixed farms (Megersa et al., 2009), breeding system and seasonality of FMD (Bronsvoort et al., 2004). Odds ratios (CI=95%) were estimated and QGIS was used to produce thematic maps.

Results

Based on farmers' perceptions, 85.31% (with $p < 0.01$) experienced more outbreaks during the major dry season. Univariate analysis revealed that mixed farming (OR = 1.501, $p = 0.163$), and natural breeding method (OR = 1.626; $p = 0.21$) were associated with the occurrence of FMD. The occurrence of FMD in the farms was found to be significantly associated with lack of vaccination of calves younger than 12 months in herds (OR = 0.707; $p = 0.046$).

Discussion

Failure to vaccinate calves younger than 12 months significantly increased the risks of FMD occurrence in the farms; this is consistent with previous studies (Dekker *et al*., 2014). Breeding methods can be responsible for the spread of FMD during outbreaks (Paton *et al*., 2018). However, testing and monitoring of bulls could reduce the risk (Guerin & Pozzi, 2005). We observed the AI centers used by the farmers usually screen the bulls for a range of animal infectious diseases including FMD; thereby reducing the risk of the disease transmission. The daily gathering of animals from different farms was an important trend that can be responsible for disease spread. Previous studies have also reported herd contacts at watering points as a risk of FMD (Bronsvoort *et al.,* 2004).

SURVIVAL OF FMDV IN THE ENVIRONMENT AND ITS ROLE IN VIRUS TRANSMISSION

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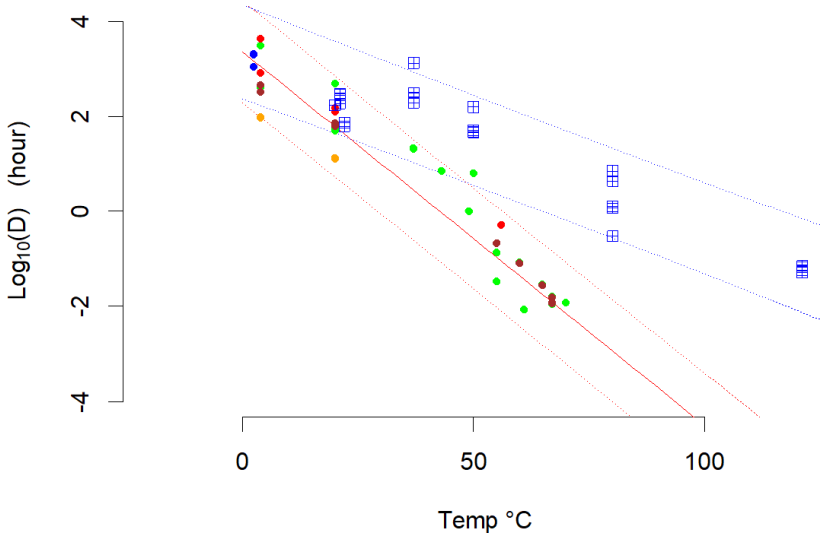
Introduction

In recent transmission studies with foot-and-mouth disease virus (FMDV) it has been shown that surviving virus in the environment plays an important role in the transmission of FMDV (Bravo de Rueda et al. 2015, Colenut et al. 2020). In some stables a decimal reduction time of 21 days was estimated. Surviving virus in the environment is most likely important in transmission of FMDV. Using literature data and laboratory analyses, we estimated the decimal reduction time (based on inactivation curves) of FMDV in both suspensions and on dry surfaces, to compare the results with the finding in the experiment.

Materials and methods

To estimate the decimal reduction time of FMDV in suspensions we collected, in a non-systematic manner, literature data from quantitative studies on titre reduction in suspensions under various circumstances. Literature data were supplemented with studies performed in our laboratory. To measure the decimal reduction time of FMDV on dry surfaces we produced coverslips with dried FMDV. For this 100 µl of FMDV strain A_{10}Holland was dried by air on sterile 9 x 32 mm coverslips in a class 2 safety cabinet for 2 – 3 hours. To test inactivation of FMDV, the coverslips were kept at various temperatures at various time intervals coverslips were collected in 1 ml cold medium and the titre of the remaining virus was determined. The logarithm of the decimal reduction time was plotted against the temperature.

Results



In the graph below the data of the FMDV inactivation in suspension is given with dots, the data of the dried FMDV is given by squares. The relation between temperature and the logarithm of the decimal reduction time, was clearly different between viruses kept in suspension compared to dried virus.

The results found the transmission study fall within the 95% prediction interval of both the virus kept in suspension as well as dried FMDV.

Conclusion

FMDV can survive in the environment and play a role in transmission of FMDV. FMDV that was dried was more stable than FMDV in suspension. Good disinfection of material that can contain FMDV is therefore necessary.

VOTE-PROCESSING RULES FOR COMBINING RANKINGS OF CONTROL INTERVENTIONS FROM MULTIPLE MODELS

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Introduction
Mathematical modelling is often used for informing decision-making in response to FMD outbreaks. Models are increasing in abundance. When multiple models provide recommendations, it is not clear what the best method of combining recommendations from models is. Previously, this has been resolved by aggregating model projections and then presenting rankings of control interventions based upon the aggregate projections. This approach presumes model outputs are directly comparable and implies a relationship between projected outcomes across models. However, differences in the way each model represents the epidemiological system may mean outputs are not directly comparable across models.

Materials and methods
We apply electoral vote-processing rules to combine rankings of interventions generated from models. By aggregating rankings of interventions, instead of aggregating model projections, any direct comparison of projections is avoided, as all comparisons of projections are made within each model. We investigate the performance of four rules: first-past-the-post, Alternative Vote, Coombs' method, and Borda count (a scoring system). We apply these in the context of a hypothetical foot-and-mouth disease outbreak in the United Kingdom using four stochastic individual-based models of FMD spread. Furthermore, we investigate how these vote-processing rules are influenced by the addition of models that are either biased (by only favoring one model) or random (by ranking interventions randomly).

Results
Each vote-processing rule chose the same intervention as when ranking interventions by the expected number of livestock culled. Coomb's method was least susceptible to adding a biased model. Including random models made no difference to the choice of best intervention until there were so many random models that the random fluctuations in preferences were greater than the original differences for the preferred intervention.

Discussion
Aggregating rankings of interventions from multiple models avoids directly comparing projections from different models. We suggest vote processing rules as a useful additional tool when combining recommendations from multiple models.

WORKLOAD SCHEDULES, BIOSECURITY PRACTICES, AND COMMUNICATION PREFERENCES OF TRUCK DRIVERS TRANSPORTING PIGS AND THEIR POTENTIAL IMPLICATIONS ON DISEASE SPREAD IN THE UNITED STATES

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Introduction

Because Foot-and-Mouth disease (FMD) may spread between pig premises via machinery and personnel, understanding actions of key players in between-premises pig movements is essential. The practices and communication avenues of United States (US) truck drivers (i.e., truckers) moving pigs between farms and abattoirs are not well explored. This study identified truckers' trends and their potential disease spread impact as well as disease-related communications between the US swine industry and truckers.

Methods

An online survey was administered by three US pork production companies to their contracted truckers. The survey asked 44 questions regarding preferences for receiving information from the greater swine industry, workload and hauling schedules, truck (i.e. trailer/cab) cleaning/disinfection (C&D) practices, and actions at farms and abattoirs.

Results

The majority of truckers cited pork producers, abattoirs, employers, and fellow truckers as information sources. Texting, then phone and email, were primary communication methods. The largest proportion of truckers delivered 6 to 10 hog loads weekly (37/80); with the majority (60/80) picking up at 5 to 7 farms weekly and delivering to 2 or more abattoirs weekly (63/80) from >2 companies (43/80). Almost all reported getting out to help load pigs on-farm (77/80) and unload at the abattoir (77/80). Typical C&D included washing trailers between every load (74/80) and cab cleaning either once daily (28/80) or once weekly (39/80). Reported PPE usage on-farm and at abattoirs was highly variable.

Discussion

Multimodal approaches may be necessary to reach and directly inform the entire trucking workforce with proper messaging from swine-focused groups and agencies. Based on truckers' workloads, in an FMD outbreak event, disease spread may be possible between multiple farms, abattoirs, and swine companies if no mitigation occurs. Transportation biosecurity exists, especially trailer C&D; however, areas of concern include truckers helping load and unload animals, especially when coupled with inconsistent PPE usage.

Session III

ANIMAL DISEASE EMERGENCY MANAGEMENT --- A RAPID DOCUMENTATION OF LEARNING BASED ON GOVERNMENT RESPONSE RELATED TO RECENT ANIMAL DISEASE OUTBREAKS IN ASSAM (INDIA)

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Introduction

The State of Assam, with 31.2 million people (2011), is the Gateway State of the strategically important North Eastern Region of India. The North Eastern Region of India shares 98 percent of its regional border with international neighbors such as China, Myanmar, Bhutan, and Bangladesh. As per the 20th Livestock census (2019), Assam's cattle and pig population is 10.9 million and 2.1 million, respectively. Assam's pig population is the highest among all the States of India.

The Government of India has notified the outbreak of African Swine Fever (ASF) in Assam on 19th May 2020. The event started during the latter part of January 2020 and is continuing. The state also reported a simultaneous outbreak of Lumpy Skin Disease (LSD) in cattle.

The management of ASF and LSD was a challenge, as the state had to prioritize control of the COVID situation and handle situations arising out of natural disasters like floods.

The paper is rapid documentation of learning related to animal disease emergency management in Assam, as observed by the author.

Documented learning

The paper documented key learning such as the (1) need for targeted communication of the big picture associated with an animal disease outbreak, (2) the importance of capacity building for data analysis related to risk mapping, prediction, and decision making, (3) the need for decentralization of decision making for first containment of disease (4) Need for capacity building for improved communication (5) Need for stakeholder engagement and inter-departmental collaboration (6) importance of scenario-based disease management protocol design and investment for ground awareness of the same (7) increase administrative empowerment of laboratories (8) Improved engagement with civil authority (9) Representative team building (10) Recognition of the benefit of GIS/RS based decision support system (11) Regular review of policy and legal framework.

AVIDITY ELISA PROVIDES A GOOD CORRELATE WITH THE VIRUS NEUTRALIZATION TESTS IN FOOT-AND-MOUTH DISEASE VACCINATED BUFFALOES (BUBABLUS BUBALIS)

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** Presenting author*

Introduction
Post-vaccination sero-monitoring of protective antibody levels in buffaloes entails the use of the Liquid-phase blocking ELISA (LPBE) that measures antibodies against structural viral proteins. We have developed an alternative assay, a single-dilution avidity ELISA (AE) aimed to detect high-binders to purified 140S-particles, which proved to be more specific than LPBE. Here we analyzed the kinetics of the antibodies induced by a single vaccination in two different buffalo herds (n=91 animals) for 120 days using the virus neutralization test (VNT), AE and LPBE.

Methods
Buffaloes from two farms ("A" and "B") located in Corrientes province, Argentina, were immunized as part of the national FMD-vaccination program using a tetravalent oil-adjuvanted commercial vaccine. Adult animals were re-vaccinated (A: n=25-; B: n=33) and calves (with or without maternal antibodies, "MatAbs") were primo-vaccinated (A: n=18-; B: n=15). Kinetics of humoral responses against two of the vaccine strains were assessed with individual serum samples at 0, 7, 14, 21, 30, 60, 90- and 120-days post-vaccination (dpv). Concordance between VNT and the ELISAs was assessed using Kappa value, considering the protection cut-off value for each assay and strain (n=530 samples).

Results.
The kinetics of antibodies were similar for both strains in the different assays considering all the categories in a single group, with an increase from 0 to 14 dpv, and remained within similar levels from thereon. Interestingly, VNT and AE detected a decay in the antibody response in calves with MatAbs that was significantly different from day 0 at 90 and 120 dpv. We found a considerable concordance between AE and VNT, (Kappa value=0.76) while only a moderate concordance was found with LPBE (0.56).

Conclusion
Avidity of antibodies can be measured using a simple single-dilution ELISA, yielding similar results than the VNT. AE might replace VNT for vaccine-immunity monitoring.

COMPARISON OF DIAGNOSTIC PERFORMANCES OF THREE COMMERCIAL ELISA KITS FOR DETECTION OF ANTIBODIES TO FOOT-AND-MOUTH DISEASE VIRUS TYPE-O

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Introduction

Three Foot-and-Mouth Disease (FMD) vaccines containing various serotypes and strains are routinely used under national vaccination programs in Korea. Furthermore, three commercial ELISA kits have been licensed for detection of antibodies against structural proteins (SP) of FMDV to estimate vaccine-induced immunity. These included PrioCHECK SP Type-O ELISA, accredited internationally and two domestic Solid-phase competitive ELISA kits coated with recombinant-protein based antigens. Since these various factors were involved, variability in serological test results owing to differences in the antigenic specificity of tests according to the particular virus strains and antibody reagents utilized in the tests may affect the reliability of serological result. Therefore, we investigated diagnostic performances of the three ELISAs used for sero-surveillance to identify appropriate test reagent for the relevant vaccine or field strains.

Materials and methods

PrioCHECK (Thermofisher-PrioCHECK SP-type O) and two ELISA kits (Median-VDPro FMDV Type-O Ab b-ELISA, BIONOTE FMD Type-O Ab ELISA) developed in Korea were used. They were evaluated using 684 sera collected from pigs and cattle vaccinated with three FMD vaccines containing either O_1-manisa+O3039+A_{22}-Iraq, O_1- primorskiy+A-Zabaikalskiy or O_1-Campos+A_{24}-Cruzeiro+A_{2000}Argentine and 214 sera from unvaccinated pigs experimentally infected with FMDV O/SKR/BE/2017 and O/SKR/AS/2019. Antibody titers were determined with the virus neutralization tests (VNT) as a reference criteria.

Results

Based on the tests of sequential sera from experimentally infected pigs, seroconversion occurred between 5 and 8 days post-infection (DPI) in three ELISA kits, similar to that (4~5 DPI) observed using the VNT. When applied to samples in vaccinated groups, all of three ELISA kits identified more positives than the VNT did and the two domestic kits yielded higher seropositivity than PrioCHECK kit did.

Discussion

When compared to the VNT, the results of this study suggested that the sensitivity of three ELISA kits are less affected by the specificity of virus strain used in the test. In addition, the result of higher seropositivity than the PrioCHECK kit for domestic kits reflects that various vaccines in use and field strains from outbreaks in Korea were considered in development of ELISA kits.

CORRELATION BETWEEN SEROLOGICAL TITER AND PROTECTION IN PIGS VACCINATED WITH FMD SEROTYPE A VACCINE

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Introduction

While the presence of neutralizing antibodies is generally used as a measurement of the immune response to foot-and-mouth disease (FMD) vaccination, a threshold level of neutralizing antibody titer (VNT) associated with possible protection is uncertain in pigs. This study aimed to determine whether the levels of VNTs following vaccination were able to predict levels of protection against FMD virus (FMDV) infection in the field.

Materials and methods

To collect datasets for analysis of the correlation between the VNTs of vaccinated animals and protection, an *in vivo* challenge study was conducted. 48 fattening pigs were challenged with FMDV A Sea-97/G2 lineage after vaccination with vaccine incorporated FMDV A Sea-97/G1 lineage. The relationship between protection ratio and VNTs was statistically established by logistic regression analysis. The expected percentage of protection for the vaccine was calculated with logistic regression using datasets from *in vivo* challenge study.

Results

The mean VNTs at 0-3 days post-challenge showed a much better correlation with the percentage of protected animals as compared to that of VNTs at 21- and 28-days post-vaccination. In a statistical analysis, it was evident that $\log_{10}$ VNT of 0.94 was associated with >80% of protection against infection with FMDV A Sea-97/G1 lineage.

Discussion

In the case of FMDV A Sea-97/G2 lineage, the antibody titers in vaccinated pigs upon early challenge were indicative of the level of protection. However, further studies are necessary to secure more serological data to set the criterion for predicting the protection of FMD based on the level of VNTs.

DEVELOPMENT OF A LIQUID-PHASE BLOCKING ELISA BASED ON FOOT-AND-MOUTH DISEASE VIRUS A/YEONCHEON/2017 FOR POST-VACCINATION SERO-MONITORING.

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Introduction
A liquid-phase blocking ELISA (LPBE) has been standardized to be used for serological assessment of herd immunity against foot-and-mouth disease virus (FMDV) because this assay is a relatively simple procedure and cost-effective compared to virus-neutralization test (VNT). In this study, we developed LPBE to measure the level of antibodies against FMDV A/Yeoncheon/SKR/2017 (A/Asia/Sea-97/G2 lineage) and validate its efficacy using an extensive range of sera obtained from pigs.

Materials and methods
The 146S particles of the inactivated FMDV A Yeoncheon (A-YC) were purified by sucrose gradient ultra-centrifugation and then used for an ELISA antigen. Two polyclonal hyper immune sera against A-YC, one for capture (rabbit), and the other for the detector (guinea pig) were prepared and optimized for ELISA reaction. After optimization of the reaction, the developed LPBE was applied to the quantitative estimation of antibodies titers against A-YC from using the field-collected pig sera.

Results
To evaluate the diagnostic performance of the developed LPBE, a total of 133 sera from pigs vaccinated with serotype A monovalent vaccine (experimental vaccine incorporated FMDV A-YC) were screened in parallel by the VNT. When test sera at a 1:10 dilution with a cut-off point of 50% inhibition of reaction, LPBE exhibited the best performance with high diagnostic sensitivity (92.1%) and specificity (88.6%) in comparison with the VNT. The developed LPBE has a correlation with the VNT (r^2 = 0.7247).

Discussion
The LPBE developed in this study is a suitable diagnostic tool for the rapid detection of antibody raised against FMDV A/Asia/Sea-97/G2 lineage.

DEVELOPMENT OF SOLID-PHASE COMPETITION ELISA FOR DETECTION OF TYPE-A FOOT-AND-MOUTH DISEASE VIRUS ANTIBODIES

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Introduction

Foot-and-mouth disease (FMD) has been mainly controlled by prophylactic vaccination and sero-surveillance after vaccination in Korea. Serological tests for detection of antibodies against virus structural proteins (SPs) are suited to determine protective antibody responses induced by vaccination. The Virus Neutralization Test (VNT) is recognized as the golden standard method for detecting SP antibodies to FMDV. However, it is not appropriate for massive serological test because it requires live virus, laborious procedure, time-consuming and training and experience to produce reproducible results. Therefore, a recombinant-protein based ELISA has been developed for the detection of antibodies to FMDV type A and has been validated using a wide range of sera from cattle and pigs.

Materials and methods

The recombinant protein (rP13C) was derived from the P1 precursor and 3C protease genes using a baculovirus-expressed system, the competitor monoclonal antibody (Mab) for the ELISA was generated by immunizing a VP1 peptide corresponding to the GH loop for high correlation of FMDV neutralizing antibodies. When test sera at a 1:4 dilution with a cut-off point of 50% inhibition of reaction, the performance of solid-phase competition ELISA showed the highest concordance rate with that of VNT for serum panel obtained from infected or vaccinated animals. SPCE assay had lower limit of detection than the virus neutralization test. The specificity of the solid- phase ELISA was considerably higher than that of the liquid-phase blocking ELISA and almost equivalent to that of the virus neutralization test. The assay thus retains the sensitivity of the liquid-phase blocking ELISA whilst being easier to use, more robust and specific, and therefore offers an improvement for FMD virus antibody detection.

Results

Thus, this SPCE is an alternative method for post-immunization detection of antibodies against FMDV serotype A, with high specificity and sensitivity.

Discussion

The use of VLPs in the SPCE assay as a replacement for inactivated FMDV provides a high level of biosafety. The SPCE showed high concordance rates when compared with the virus neutralization test and liquid-phase blocking ELISA for testing clinical serum samples and successive serological monitoring (kappa = 0.925). Thus, this SPCE is an alternative method for post-immunization detection of antibodies against FMDV serotype A, with high specificity and sensitivity.

DURATION OF IMMUNITY IN CATTLE AND PIGS UNDER NATIONAL VACCINATION PROGRAMME AGAINST FOOT-AND-MOUTH DISEASE VIRUS

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The ideal vaccine for the control and prevention of Foot-and-Mouth-Disease (FMD) should be able to induce broader protection and longer duration of immunity. Particularly, it is the important feature for the effectiveness of a vaccine to estimate the duration of immunity when the vaccines licensed for regular use are performed in field trials. In this study, the FMD antibody response profiles in cattle and pigs were observed for a certain period following the boosting vaccination in accordance with the recommended schedules.

Three FMD vaccines approved for routine use in cattle and pigs were used. They are bivalent or trivalent formulations containing either O_1-manisa+O3039+A_{22}-Iraq (Merial Animal Health Ltd.), O_1-primorskiy+A-Zabaikalskiy (FGBI ARRIAH, Russia) as double oil(W/O/W) emulsions or O_1-Campos+A_{24}-Cruzeiro+A_{2000}Argentine (Biogenesis Bago SA) as water in oil(W/O) emulsions. Each vaccine was respectively administered to 5 cattle and 104 pigs following vaccination schedules. Serum samples were collected regularly for up to 28 weeks (cattle) and 14 weeks (pigs) post-vaccination. Antibody titers were measured by virus neutralization test.

For both of animals, the antibody titers increased following primo-vaccination and remained stable or tend to increase after the administration of second dose. However, antibody responses for the vaccine containing O_1-manisa+O3039+A_{22}-Iraq demonstrated a gradual decrease from peak antibody titers which levelled off after 2 weeks for most pigs. Nevertheless, all vaccines generated a sufficient antibody response (VNT, ≥1.5 log10) in most cattle and pigs for the duration of the trial.

Recently revised vaccination program in Korea has proposed secondary administration for pigs to maintain protective levels of immunity up to 24 weeks age, which are typically slaughtered in fattening pigs. It is also suggested that in case of ruminants, further revaccinations at approximately 6 months intervals after the initial course is required to last high levels of antibodies. This study demonstrated the three routine vaccines adopted by the Korean-Expert-Committee for FMD vaccines confer enough long-term immunity for protective capability against FMDV when properly applied for the recommended vaccination regimes.

EXPERIMENTAL EVALUATION OF FOOT-AND-MOUTH DISEASE O SKR VACCINE: PROTECTIVE EFFICACY AND SEROLOGICAL PERFORMANCE IN PIGS

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Introduction

In this study, the commercial O SKR (O SKR 7/10) vaccine originated from FMDV O/SEA/Mya-98 lineages that occurred in Korea 2010 was tested for the evaluation of its protective efficacy and serological performance in pig farms.

Materials and methods

The O SKR vaccine efficacy was assessed by the post-vaccination challenge study in 8 weeks old specific pathogen-free (SPF) pigs. In the field trials, the serological performance of the vaccine was evaluated.

Results

Our results demonstrated that the O SKR vaccine can confer complete protection in SPF pigs against challenge with FMDV O/SKR/Jincheon/2014 strain (O/SEA/Mya-98 lineages). The serologic test results indicated that the vaccine developed vigorous antibody responses at 7 days post-vaccination (dpv). However, in the field trial, the vaccine did not elicit a satisfactory immunity in the vaccinated pig; a rapid decrease of antibody level in pig after the first vaccination. This result may be due to the inhibitory antibody response caused by the pre-existing FMD antibody level (SP-antibody level at 0 dpv) from the maternal transmission (MDA).

Discussions

According to the efficacy result, the FMDV strain contained the O SKR vaccine seems to be proper for the usage of a prophylactic measure against the FMD outbreak caused by FMDV O/SEA/Mya-98 lineages. However, in field, high level of FMD MDA generated by the mandatory FMD vaccination measure had an inhibitory effect on immunogenicity of O SKR vaccine. It is thus thought to be that the antigen payload of the vaccine may not enough to overcome the interference effect of MDA.

EXPLORING FOOT-AND-MOUTH DISEASE VIRUS ANTIBODY AFFINITY USING BIOLAYER INTERFEROMETRY

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Introduction

Foot-and-mouth disease virus (FMDV) vaccines protect animals from infection by inducing antibodies. In general, the level of FMDV-specific antibodies as measured by a virus neutralization test positively correlates with the level of protection afforded against subsequent challenge. As well as overall titre, antibody avidity represents a crucial metric with regards to the protection afforded by an antisera and can be quantified using bio layer interferometry (BLI), a label-free method commonly used to evaluate the binding affinity of antibodies. Here we describe the use of BLI to characterize the strength of interactions between FMDV antibodies and antigenic site 1 on the GH loop of the FMDV particle.

Material and methods

BLI experiments were performed on the Octet RED96 system. A biotinylated peptide representing the GH loop of FMDV was synthesized commercially and loaded onto streptavidin sensors at an optimal concentration. Total immunoglobulin G (IgG) was isolated using protein A/G columns (Pierce) from the sera of cattle vaccinated with O1 Manisa. To evaluate avidity, loaded sensors were dipped into a 2-fold dilution series of purified polyclonal serum and the outputs modelled using the Octet software.

Results

Using a surrogate of the FMDV GH loop we were able to define the extent and strength of interactions of antibodies present in FMDV positive serum. The sera from different animals varied in its reactivity, highlighting that quantitative differences in avidity exist between individual animals in response to FMDV vaccines.

Discussion

Unlike a conventional ELISA, BLI is able to quantify the avidity of antibodies to the target epitope(s). In turn, the ability to accurately measure the strength of antibody interactions will allow the impact of antibody avidity in protection from FMD to be quantified. Future directions include using BLI to assess the overall avidity of polyclonal serum against the antigenic landscape of the FMDV particle.

FIELD TRIAL TO ESTIMATE EFFECTIVENESS OF VACCINATION PROGRAM AGAINST FOOT-AND-MOUTH DISEASE IN TRANSCAUCASIAN COUNTRIES – GEORGIA AND ARMENIA

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Introduction
In countries endemic for Foot-and-mouth disease (FMD), routine or emergency vaccinations are strategic tools to control infection; according to OIE/FAO guidelines, a prior estimation of vaccine effectiveness is recommendable to optimize control programs. This study reports the results of small-scale vaccination trials performed in Trans-Caucasus region.

Materials and Methods
Polyvalent vaccines including serotypes O, A (two topotypes) and Asia1 from two different manufacturers were evaluated in Georgia and Armenia. Naïve large and small ruminants (20 each) were vaccinated once and a sub-group received a second dose 90 Days-Post-Vaccination (DPV). Antibody (Ab) titres were determined through Virus Neutralization test versus homologous strains in sera collected sequentially up to 180 DPV.

Results
The vaccine evaluated in Georgia induced a poor immune-response in calves after a single vaccination, with seroconversion rate reaching 70% only against A-GVII and Asia1 strains, followed by a rapid decay of Ab (almost all animals negative 90 DPV). In contrast, seroconversion and neutralizing titres suggestive of protection were observed 14 DPV in a high proportion of small ruminants (80-90%) for all four vaccine strains, but Ab decreased fast. With the booster vaccination, both large and small ruminants, tested one month later, showed a significant enhancement of Ab titres, which largely overcame the putative protection threshold of 1/100; again, Ab titres declined fast so that only 50% animals still showed protective Ab levels 90 days after the second vaccination.
In Armenia, where only calves were analyzed, early (14 DPV) seroconversion approached 100% for type O (94%) and for the type A Iran-05 vaccine strain (88%), with VNT protective levels in most animals. Differently, it was not higher than 67% for the other two strains, with low neutralizing titres. Ab titres dropped rapidly for all the four vaccine strains. The booster effect was still perceivable in the sampling obtained 90 days after re-vaccination, but a proportion of animals of 25% for type O, 37% for type A and 62% for type Asia1 was already declined to negative, suggesting a short duration of immunity.

Discussion
Taken together, the results lead to estimate that both the vaccines evaluated are not expected to induce a protective and long-lasting population immunity, even after a second vaccination. Insufficient virus payload combined with rapid decay of antibodies could be the main issue for the modest performance of the evaluated vaccines.

FILTRATION ASSISTED LUMINOMETRIC ELISA (FAL-ELISA) APPLIED TO THE DETECTION OF FOOT-AND-MOUTH DISEASE VIRUS NON-STRUCTURAL PROTEINS IN FORMULATED VACCINES

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Introduction
Foot-and-Mouth disease virus (FMDV) vaccines are required not to produce antibodies against viral non-structural proteins (usually 3ABC) aimed to enable the discrimination between infected and vaccinated animals. This requirement is currently assessed by vaccinating cattle, following an expensive, time-consuming protocol. Alternative in-vitro assays have been developed to quantify 3ABC in antigen preparations before formulation but not in ready-to-use vaccines. In this study, we assessed the feasibility of detecting NCP in oil-adjuvant vaccines using a commercial FAL-ELISA.

Methods
An aqueous-phase vaccine antigen batch "VAB" free of 3ABC (100X concentrated, FMDV A/Arg/01 strain) was provided by a local manufacturer. This VAB was diluted in PBS 1X, aliquoted in different fractions and spiked with 0, 50 and 10 ng of recombinant 3ABC per +vaccine dose and formulated with an oil adjuvant (W/O emulsion). A protein-extraction protocol was set up using the formulated vaccines. The extracted fraction was tested in a western-blot and in the PrioCHECK®FMD IPC-3ABC kit (FAL-ELISA) following the manufacturer's instructions**.**

Results
The analytical sensitivity was evaluated by extracting the aqueous phase of 3ABC-spiked oil vaccines. We verified that oil-adjuvanted vaccines should be processed by adding to 1 volume of the vaccine dose, 1 volume of PBS and 2 vol of chloroform and mixed for at least 4h at 4ºC. Longer incubation times did not increase the recovery of 3ABC. Under optimized conditions, vaccines that yielded a positive result had at least 10ng of 3ABC/ml estimated by the FAL-ELISA**.**

Conclusion
FAL-ELISA can be used for the detection of FMDV non-structural proteins in formulated vaccines. FAL-ELISA is a promising candidate for replacing the use of animals for the control of FMD-vaccine purity that can be particularly useful for vaccine banks and regulatory bodies.

FMD RISK REDUCTION IN TRANSCAUCASIA AND NEIGHBOURING COUNTRIES – AN EXAMPLE OF SUCCESSFUL REGIONAL COOPERATION

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Introduction

Foot-and-Mouth Disease (FMD) circulates in the European neighborhood and in more than 100 countries in Africa, the Middle-East, and large parts of the Eurasian landmass. The European Commission for the Control of Foot-and-Mouth Disease (EuFMD) has recently adopted a strategy which extends the scope of preparedness and risk reduction activities to FMD and similar transboundary (FAST) animal diseases.

Results

In 2016, under the Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TADs), a Statement of Intentions (SOI) was established between the veterinary services of Armenia, Azerbaijan, Georgia, Iran, Turkey and the Russian Federation for an intensified collaboration in the prevention and control of FAST diseases. EuFMD assists the implementation of the Statement of Intention activities through its work plan. The countries agreed on cooperation in a series of actions aimed at improving the confidence in the effectiveness of control programmes and at reducing the risk of introduction and spread of FAST diseases in the region such as:

- Sharing of information on FMD outbreaks and vaccination to monitor vaccination progress, and outbreaks in nearly real time,
- Testing of emergency preparedness through joint FMD simulation exercises
- FMD post vaccination monitoring (PVM) to better assess the quality of vaccines and effectiveness of vaccination programmes
- Improvements of epidemiology and laboratory networks in the West Eurasia region
- Risk based surveillance for FMD and other TADs to improve early warning

It has been agreed to extend risk information sharing to the mapping of animal movements, to include results of surveillance and PVM studies, and other TADs in the reporting system.

Discussion

This cooperation agreement can be a model for other regions to enhance early warning, build confidence in the effectiveness of control programmes and reduce the risks of FAST diseases.

FMD SEROLOGICAL BLOCKING ELISA BASED ON VHH FOR POST-VACCINATION MONITORING

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Introduction

Currently, antibodies to Foot-and-Mouth Disease Virus ("FMDV") FMDV are detected in animals using the virus neutralization test (VNT). While VNT is recognized as correlated to protection, the method is laborious, time consuming and reliant on live virus and cell cultures. Due to these constraints, alternative methods are being investigated by different labs. We have chosen an approach using VHH specific of 146S particles (or nanobodies) to set up a blocking enzyme-linked immunosorbent assays (ELISA) for the detection of specific antibodies against O1 Manisa and Asia 1 Shamir in swine and cattle sera.

Materials and methods

First, dilutions of serum are mixed with a defined quantity of FMD antigen (concentrated and inactivated) and then added on a plate coated with FMDV serotype specific VHH. The non-binded antigen present in the mix is captured by the coated VHH, and detected by a homologous biotinylated-VHH. Titer of 146S specific antibodies is expressed as log10 OD50.

Results

Preliminary results with O1 Manisa showed low variability (standard deviation below 0.1). Serotype specificity was also confirmed. Using 1500 sera from pigs and cattle vaccinated with either a monovalent or a multivalent vaccine (AFTOPOR®, AFTOVAXPUR® or experimental vaccines), we demonstrated a good correlation of the ELISA titers with the VNT titers.

Discussion

ELISA provides more reproducible results compared to VNT and has the advantage to be performed in non –BSL3 environment. Next step will be to confirm those results on other serotypes. In conclusion, the developed serological blocking ELISAs, using serotype specific VHH targeting 146S FMDV particles, can be considered, based on these studies, as an interesting alternative to VNT to evaluate vaccine immunogenicity and performance.

INDIRECT ELISAS BASED ON PURIFIED VIRAL PARTICLES THAT MEASURE DIFFERENT ASPECTS OF THE ANTIBODY RESPONSE AS ALTERNATIVES TO THE CURRENTLY USED SEROLOGICAL METHODS

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Introduction
We recently demonstrated that indirect ELISAs using whole 146S-viral particles (146S-ELISAs) detect antibodies against exposed epitopes, arising as a better alternative to the virus neutralization test (VNT) than currently-used Liquid-Phase Blocking ELISA (LBPE). Here we evaluated the application of 146S-ELISAs that measure IgG-subtypes and avidity (Avidity-ELISA, "AE") of vaccine-induced antibodies as surrogates of the VNT in pigs, buffaloes, and cattle.

Methods
The study included 530 serum samples from primo and re-vaccinated buffaloes, 58 from primo-vaccinated pigs (immunized with a commercial tetravalent vaccine), and 108 from primo-vaccinated cattle (monovalent vaccines) which were challenged with the vaccine virus. VNT was considered the gold-standard for *in vitro* assays. Pairwise-level of agreement between ELISAs and VNT results were computed by Pearson´s correlation and linear regression analyses. Concordance was assessed by Kappa value (K).

Results
Buffalo samples yielded moderate concordance between VNT and LPBE (K=0.56), with low specificity (48%) and good sensitivity (85%). Concordance was higher for AE (K=0.76), yielding excellent specificity (93.8%) and sensitivity (90%). In pigs, concordance with VNT was moderate (K=0.61) for LPBE and excellent for AE (K=0.93). IgG1 and IgG2 ELISAs correlated with the VNT (Pearson's-R=0,93 and 0,84, respectively). Finally, LPBE and VNT titers had a moderate concordance (K=0.66) in cattle, similar sensitivity (93%) but lower specificity (71%); while AE yielded high sensitivity (83%) and specificity (100%). Using the current cut-off values (EPP75), concordance with challenge outcome was moderate for VNT (K=0.6) and low for LBPE (K=0,42). Sensitivity was similar (82-83%) for both assays and specificity was lower for LPBE (78%).

Conclusions
Avidity-ELISA can replace VNT for all three species, while using other assay that do not restrict the binding of antibodies against exposed epitopes is not recommended. Indirect prediction of protection using serology may require combining at least two assays as they can bring complementary information regarding the induced antibody response.

MATERNALLY DERIVED ANTIBODIES TO FMD IN CATTLE: IS INTERFERENCE ON FMD VACCINATION APPROPRIATELY CONSIDERED?

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Introduction

Little data are available on how Maternally Derived Antibodies (MDAs) interfere with FMD vaccination in susceptible species and the potential interference of MDAs on FMD vaccine uptake is largely underestimated. This is particularly true when intensive FMD vaccination programs are in place for adults, resulting in high levels of MDAs in the young stock.

We report here the results of a PVM study conducted in a large dairy herd located in an endemic country.

Materials and methods

The study was conducted in a dairy farm with "state of the art" practices. The farm is located in an FMD endemic country with high infection pressure. Adults are vaccinated 4 times per year with Aftovaxpur. Calves are fed with high quality colostrum

MDA levels were measured in 3 groups of calves before vaccination. We then compared the current vaccination to an earlier and to a later program. Comparisons were based on VNT against O-Manisa.

Results

The average VNTs at 2.5 months of age, before any vaccination, was 1.73 Log10. Despite the care taken to colostrum administration, there was 10-fold difference (1.24 Log10-2.29 Log10) between extremes.

Among the tested vaccination programs, the one currently in place looked appropriate. There was no benefit to add an earlier vaccination. Delaying the vaccination program by a month resulted in a period with significantly lower VNTs with a risk of increased susceptibility to infection.

Discussion

The impact of MDA on vaccine uptake is largely underestimated. MDAs are frequently seen as a homogeneous parameter that can be managed base on average antibody levels over time. This study shows that in a perfectly managed dairy herd, there can be huge differences in MDA levels. Receptivity of the calves to vaccination (and susceptibility to infection) vary accordingly. Therefore, adjusting the vaccination strategy of the calf category, so that most calves are actively immunized is critical. This is not only to protect calves from disease, but also to prevent that calves become a hotspot of dissemination for the production herd.

Similar results were obtained in other large dairy herds. Such herds have some specificities, among which "optimal colostrum distribution". Heterogeneity of the colostrum antibody levels would be even higher in beef cattle, resulting in a higher disparity of FMD vaccine uptake.

NEUTRALISING ANTIBODY RESPONSE POOR PREDICTOR OF HETEROLOGOUS PROTECTION

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Introduction

To study heterologous protection against FMDV SAT2 we performed 2 potency tests with SAT2/SAU/2000 as vaccine strain and SAT2/BOT/18/09 or SAT2/LIB/40/2012 as challenge strain. However, the results of such studies are influenced by both the vaccine match and the vaccine potency. To estimate the vaccine match as well as the homologous potency we tested the sera of these 2 potency tests in VNTs against both the vaccine and challenge virus, as well as serum samples from 3 homologous potency tests with SAT2/SAU/2000. The objective of the study was to investigate if the heterologous potency divided by the homologous potency is similar to the r_1-value

Materials and methods

Virus neutralization test were performed using 100 $TCID_{50}$/well of the VNT virus and duplicates of 2-fold dilutions series of the sera. With the results of the homologous and heterologous VNTs, r_1-values were calculated. The relation between SAT/2/SAU/200 neutralizing antibody titres and dose (and other possible explanatory variables) was analyzed by normal linear regression. The relation between neutralizing antibody titres and protection (and other possible explanatory variables) was analyzed in a generalized linear model using the logit link function. Similarly, the relation between dose and protection was analyzed to determine the potency against heterologous challenge. All statistical analyses were performed in R.

Results

The geometric mean r_1-value SAT2/SAU/2000 vaccinated cattle for SAT2/BOT/18/09 was 0.05 <0.04, 0.06>. The geometric mean r_1-value SAT2/SAU/2000 vaccinated cattle for SAT2/LIB/40/2012 was 0.1 <0.09, 0.12>. There was a good correlation between vaccine dose and neutralizing antibody response 21 days post-vaccination (n=80). Also, in both the homologous and heterologous challenged cattle, a higher neutralizing antibody titre correlated with a higher probability of protection. However, the relation between VNT titre and protection was different in cattle challenged with the homologous virus compared to the cattle challenged with the heterologous virus. The potency ratio of SAT2/SAU/2000 vaccine with SAT2/BOT/18/09 challenge was 0.004 and for SAT2/LIB/40/2012 challenge 0.06 which lower than the r_1-value.

Conclusion

The potency ratio in both experiments is lower than the r_1-value determined using the sera collected in the same experiments. The estimated titre needed for 50% homologous protection was relatively low compared to the titres found in the experiments, hence resulting in a high estimate of the homologous potency. The difference in the relationship between antibody response and protection when using homologous challenge or heterologous challenge was striking. Further analysis by liquid phase blocking ELISA will be necessary.

OCULUS QUEST VIRTUAL REALITY DEMONSTRATION TO SUPPORT FMD TRAINING

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Introduction
Training is one of the strongest areas of growth in the Virtual Reality (VR) industry. Standalone headsets such as the Oculus Quest are declining cost in cost and increasing in capability. This means that headsets can now be distributed to train users on a large scale. A pilot VR experience was developed to determine how it could be used to train animal disease preparedness.

Materials and methods
Novus Res developed the VR application using the Unity game engine to operate on the Oculus Quest. The content was based on EuFMD training courses. The Quest was chosen because it is a standalone system with full head and hand tracking, making it ideal for training.

Results
Users walk around and use their hands to perform a training tasks while on a virtual representation of a farm. The modules covered in the demonstration application include establishing biosecurity control points, examination of livestock, taking laboratory samples from livestock, and interviewing landowners.

Discussion
The pilot demonstration will be trialed from November 2020 with a group of users. Feedback on the demonstration will be collected. This feedback includes information on how effective the user felt the technology was in improving their knowledge and possible improvements that could be made for future experiences.

Feedback on the pilot will help guide the development of further VR training experiences. Additionally, a report is near publication that examines in more detail the use of VR to support FMD preparedness training.

A *PAN*-SEROTYPE SOLID PHASE BLOCKING ELISA PROTOTYPE FOR DETECTION OF STRUCTURAL PROTEIN ANTIBODIES: A SOLUTION FOR EMERGENCY SUPPLY OF FMD SP DIAGNOSTIC KITS?

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FMD significantly limits trade in animals and animal products; FMD-free countries invest important resources to prevent and prepare for possible incursions. If vaccine banks enable rapid implementation of emergency vaccination, availability of diagnostics is also crucial, either to monitor virus spread with non-structural protein (NSP) or capsid structural protein (SP)-based tests, or to perform post-vaccination monitoring with SP ELISAs.

In a context of an emergency outbreak management in non-vaccinated areas, SP serology may be preferred, implying the use of Solid Phase Blocking ELISAs (SPBE) ELISAs related to the serotype causing the outbreak. Even though many research is being done to predict the patterns of viral emergence, the risk of an unexpected serotype cannot be excluded.

In this context, appropriate SP diagnostic kit availability could be an issue: diagnostic banks preparation may be complicated and costly, and inappropriate SP kit stocks could make it ineffective. A SP-*pan*serotype SPBE could potentially solve these problems.

Different SP-*pan*serotype SPBE prototypes were developed, using different *pan*serotype monoclonal antibodies as conjugate. For the best one, the specificity was evaluated by the analysis of 80 cattle and 80 swine samples from a non-endemic and unvaccinated area. Measured specificity: 99,4% (IC95% [96,6 – 99,9].

Inclusivity was assessed by testing sera from infected cattle (IAEA), including sera against the 6 FMDV serotypes (A, O, Asia 1, SAT 1, SAT 2 and SAT 3). All samples were found positive, showing the capacity of the test to detect SP antibodies, regardless of the infective FMD serotype.

Analytical sensitivity was assessed by comparing the last positive dilution for 21 samples with the homologous ID Screen® SP-SPBE. Results indicated comparable analytical sensitivity, regardless of the serotype tested.

Preliminary results indicate the possible use of a *pan*serotype SPBE kit for the specific detection of SP antibodies, regardless of the infective FMDV serotype.

SWINE PROTECTION IN THE EARLY STAGE WITH INTRADERMAL VACCINE AGAINST TYPE A FOOT-AND-MOUTH DISEASE VIRUS ISOLATED IN KOREA, 2018

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Introduction

Foot-and-mouth disease (FMD) is a highly contagious disease that causes serious economic losses in terms of animal products as well as controlling disease prevention. In Korea, the outbreak of FMD in 2010 caused great damage to the livestock industry. Due to these FMD circumstances, the FMD vaccine used to control a large scale outbreak in FMD endemic or sporadic countries. Since 2010, vaccination against FMD has been carried out nationwide. In addition, the importance of new conceptual polyvalent vaccine development for the prevention of virus transmission in the early infection stage was recognized from the outbreaks of both O and A serotypes that simultaneously occurred in 2017-2019.

Materials and methods

In this study, we compared with experimental intradermal (ID) vaccine and the intramuscular (IM) vaccines used in Korea for the early protection from FMD. And we investigated the prevention and specific antibody after ID or IM vaccination. Also, we challenged the pigs with type A virus isolated in Korea, 2018 after 3-week immunization.

Results

Through serological analysis, changes in two antibodies, IgG and IgE, were confirmed, and changes in TNF-α and IL-4 have also confirmed changes in the cytokines. As a result of IL-4, it was found that the ID vaccine may also help provide early protection from FMD. Also, the swine protection in early stage 3 weeks after vaccination with the ID vaccine was confirmed by a challenge of A/GP/SKR/2018 isolated in Korea, 2018.

Discussion

We concluded that the ID vaccine can also provide early protection against the recent FMD virus, and that ID vaccination has the advantages of being efficient.

Session IV

EMPOWERING VETERINARY PARAPROFESSIONALS IN AFRICA FOR BETTER CONTROL OF TADS

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Veterinary paraprofessionals (VPPs), often referred to as *paravets*, collectively represent a spectrum of workers in the field of animal health who may be trained from a few weeks (community-based animal health workers) to several years (Bachelor's degree), but are not regarded as veterinarians and cannot be qualified as such, which limits their relative scope of activities. VPPs encompass a wide range of categories, e.g., vaccinators, field animal health assistants, laboratory bench workers, meat inspectors and veterinary nurses, to name a few. These professionals work either in the private or public sector as part of a veterinary team, under the direction of a qualified, certified, veterinarian.

In Africa, veterinary paraprofessionals have been active for decades greatly outnumbering veterinarians, particularly in remote areas, and have been successfully deployed in a variety of tasks and campaigns, such as the eradication of rinderpest. VPPs in Africa still frequently play a critical role in delivery of preventative and associated services in animal health. Since the adoption of the global programme to eradicate *peste des petits ruminants* (PPR), there is renewed interest in supporting this cadre of veterinary staff and identifying how the recently adopted OIE Competency and Curricula Guidelines for VPPs could be used to improve their training and promote standard setting, recognition and licensing of VPPs by veterinary statutory bodies.

Several initiatives, led by the OIE and EuFMD, are currently underway to strengthen the competency acquisition and recognition mechanisms and establish models for sustainable practices providing high quality delivery of "last mile" VPP services. These models will enhance preventative approaches against PPR, FMD and other *transboundary animal diseases* (TADs) and identify levers to amplify the impact that several categories of VPPs might have on attaining the objective of eradicating PPR by 2030. These include legislative reform or adaptation of regulations, curriculum development, board certification or -at least – licensing and *continuous professional development* (CPD). These initiatives are supported by the donor community (AFD, BMZ, DTRA, BMGF) with beneficiary countries to be identified shortly in West, Southern and Eastern Africa.

HOW DO YOU DEFINE A FOOT-AND-MOUTH DISEASE OUTBREAK IN AN ENDEMIC CONTEXT? A CASE STUDY FROM NAKURU COUNTY, KENYA

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Introduction
Endemic disease can be defined as continually persisting within a local population, with outbreaks at a consistent frequency unless large-scale changes to disease control or epidemiology occur. The OIE terrestrial code defines an outbreak as the occurrence of one-or-more cases in an epidemiological unit; however, this can be difficult to use in endemic situations. Foot-and-mouth disease (FMD) is considered endemic in Kenya. Government veterinary services are responsible for monitoring and responding to outbreaks. This study aimed to identify the number of FMD outbreaks in Nakuru County, Kenya in 2019 and understand the working definition of an FMD outbreak.

Methods
A workshop was held in Nakuru County with 11 sub-county veterinary officers (SCVOs), three veterinary officials based at County headquarters and one national para-veterinarian. Outbreak data were collected from county and national government veterinary departments.

Results
Participants defined an FMD outbreak as a farmer-reported index case, usually with samples taken for laboratory confirmation, plus subsequent cases on neighboring farms. Some outbreaks were described as discrete events, well controlled with vaccination and quarantine, and others as longer, less well-defined events described as “persistent” or “un-controlled” that would show geographical spread. These “persistent” outbreaks were portrayed as complicated due to incomplete or delayed ring vaccination and resultant outbreak spread, and treatment of FMD lesions prior to laboratory investigation preventing accurate serotyping.

In 2019, four serotypes were identified in Nakuru: A, 0, SAT-1 and SAT-2. Nakuru’s veterinary department reported a different number of outbreaks to the government FMD laboratory, Nairobi, due to discrepancies in categorization based on sample serotyping.

Conclusions
A clear, standardized outbreak definition was not used in this context. An agreed outbreak definition would support Kenya’s progression through the Progressive Control Pathway for FMD, enhancing reports of disease frequency based on passive surveillance and allowing development of robust, responsive mitigation measures.

SPREAD: DECIPHERING FARM-TO-FARM FMD TRANSMISSION THROUGH A BIG DATA DECISION SUPPORT SYSTEM

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Introduction
In controlling FMD epidemics, an important tool is the epidemiological investigation that seeks to determine the source of the farm-level outbreak. Traditionally this has been undertaken by applying questionnaires during farm visits, but results are often inconclusive. To address this, we have developed a web-based application called *SPREAD* – System for Preparedness and Response to Emergency Animal Diseases - that will allow veterinarians to access relevant data to inform their investigations. However, to be truly useful, this "decision support system" requires the processing of large amounts of data and in near real-time.

Materials and methods
SPREAD uses a "loosely coupled" architecture wherein end-user access is via the web, but any requests for undertaking data analyses and modelling are handled by intermediate "Application Programming Interface". The API then passes the request onto a high-performance computer, which following the processing of the data and the running of models, returns results back to the API, and then back the user.

Results
SPREAD is complex software, and accordingly is being built in phases. Stage 1, which is substantially complete, enables the visualization of epidemics, wind-borne dispersion risk assessments and the construction of FMDV genomic networks. Datasets from historical FMD outbreaks in Europe have been collated for validation exercises as well as providing new insight into underlying meteorological processes driving these.

Discussion
The concept of integrating whole-genomic sequencing data with wind dispersion modelling was developed from the experience of the 2007 UK FMD outbreak. However, this pioneering work was undertaken retrospectively, and to date no system has been developed that will enable transmission pathways to be determined in near real-time. Whilst the *SPREAD* application will address this for Australia, it is being built so as to be run for FMD epidemics in any country, thus encouraging international collaborative partnerships to ensure ongoing funding for maintenance and enhancements.

Session V: General/Diagnosis and Viral Characterization

ASSESSMENT OF POTENCY AND EFFECTIVENESS OF HEPTA-VALENT FMD VACCINE OILADJUVANTED (ISA 206) IN EGYPT

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Introduction
Foot-and-Mouth disease (FMD) is a terrible highly contagious viral disease affecting most domestic animals, leading to severe economic impacts. Vaccination is the most effective strategy for controlling the infection.

Material and methods
An inactivated hepta-valent FMD oil adjuvanted vaccine was prepared from the following virus strains: A-Iran 05, A-Africa (GIV), O-PanAsia2, O- Manisa69, OEA-3, SAT-2 Gharbia 12, and SAT-2 Libya 18. The vaccine potency was evaluated in three groups (five calves each) of 6-8-month-old, and 50 adult dairy cattle under field conditions. All were vaccinated with 3 ml of the prepared vaccine and groups of the young calves were challenged after 28 days by the inoculation of 10^4 MLD50 of one of the wild-type viruses of serotypes A, O, or SAT-2 strains via the intra-dermo-lingual route. Mock groups (two calves each) served as negative non-vaccinated controls during the challenge test Adult dairy cattle were assessed for seroconversion using the virus neutralization test (VNT) after 30 days.

Results
All calves displayed complete protection against the challenge with the different serotypes of FMD virus (FMDV) as compared to the control groups. Serum samples collected after the primary and booster immunizations at 0 and 30 days showed protective levels of antibodies at 30 days post vaccination [VNT: 1.57±0.16, 1.60±0.2, and 1.52±0.17 against serotypes A, O, and SAT-2, respectively]. Antibodies persisted till the end of the experiment, with a peak value around 60 days post vaccination [VNT: 1.75±0.18, 1.78±0.17, and 1.76±0.21 for serotypes A, O, and SAT-2, respectively].

Discussion
The prepared heptavalent FMD vaccine is potent and capable to provide a protective immune response in both experimental and field conditions.

BIOLOGICAL VARIANCE OF SAT2 FOOT-AND-MOUTH DISEASE VIRUSES.

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Introduction
In Africa, some SAT foot-and-mouth disease viruses have been reported to cause mild or subclinical infections that may go undiagnosed in field conditions and are likely to be more common than previously expected. Animals may become infected and excrete the virus despite not developing clinical signs of the disease. This is a major concern for control strategies and for the effective control of SAT2 viruses one needs to consider variance in biological phenotypes attributed to survival and increased spread. The studies presented here demonstrates that not all SAT2 viruses are equally virulent in cattle or in cultured cells.

Material and methods
We investigated the pathogenesis, relative infectivity, genetic variability, virus fitness and biophysical stability of SAT2 viruses. To this end, two related (SAT2/ZIM/5/83 and SAT2/ZIM/7/83) and two incongruent and virulent (SAT2/ZIM/14/90 and chimeric SAT2/EGY/9/12) SAT2 viruses were used. This study is a consolidated view of the key findings of SAT2 viruses studied over a 14-year period.

Results
The results indicated that SAT2 viruses have a wide range of lability at low pH or high temperatures; replication dynamics and fitness in cultured cells related to the number of passages; and cause mild to severe clinical or subclinical signs in cattle. The variance in pathogenesis of SAT2 viruses did not correlate with cell lysis in cultured cells or viral fitness during co-infection of cultured cells.

Discussion
The genetic variability and adaptive potential of RNA viruses' quasi-species genomes enable RNA viruses to adapt rapidly to changing environments and to advance in fitness or virulence *in situ* or *in vivo*. This emphasize the need of heightened surveillance in regions where SAT2 infections are prevalent. The variance in pathogenesis of SAT2 viruses did not correlate with virulence in cultured cells or viral fitness during co-infection of cultured cells. The biophysical stability of SAT2 viruses revealed that SAT2 viruses have a wide range of lability at low pH or high temperatures with no direct correlation with pathogenesis. This has implications for the emergence of new viruses in nature and therefore the effective control of SAT2 viruses needs to consider the variance in biological phenotypes attributed to survival and increased spread.

CHARACTERISING FOOT-AND-MOUTH DISEASE VIRUS IN CLINICAL SAMPLES USING NANOPORESEQUENCING

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Introduction

Viral sequence data provides crucial insights into the epidemiology of infectious diseases such as foot-and-mouth disease virus (FMDV). Oxford Nanopore Technologies' MinION portable sequencer is able to generate long reads and produce real time data which can be used for strain identification, outbreak tracing and vaccine selection. The cost and size of the sequencer lends itself to use in well-resourced laboratories and has been used during outbreaks of viral diseases such as Ebola, Zika and the ongoing COVID-19 pandemic. In this study, we investigated the suitability of the MinION to characterize FMDV in clinical samples.

Materials and methods

A single, two-step FMDV universal PCR was used to amplify the capsid-encoding region of three FMDV serotypes (A, O and Asia 1) from cell culture supernatants (n=3) and clinical samples (tongue epithelium (n=5) and oral swabs (n=12)). Following sequencing, the data were analyzed using the current Medaka pipeline to generate consensus sequences at various time intervals throughout the sequencing run. Reference sequences for each sample were produced using conventional Illumina sequencing and were used to determine consensus accuracy.

Results

Sufficient DNA for MinION sequencing was achieved from all cell culture adapted viruses, all epithelium and 50% of oral swabs tested. A consensus accuracy of 100% was achieved for all cell culture supernatants after ten minutes of sequencing. This was also achieved for epithelium samples from type O and Asia 1 after two minutes of sequencing and up to 30 minutes for type A. Oral swabs required up to 2.5 hours of sequencing to achieve 100% consensus accuracy.

Discussion

This preliminary study provides information useful to assess nanopore sequencing as a tool for use with clinical samples. Future research could investigate the use of the MinION as part of a low-cost and non-invasive sample-processing pipeline to generate quality sequence data in low resource settings.

COMPARISON OF USE OF PRIMARY CELLS AND CELL LINES FOR VIRUS ISOLATION ASSAYS FOR FMDV

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Introduction

For virus isolation (VI) of FMDV primary kidney cells (ovine or porcine) are used at WBVR. Stocks of these cells are prepared from kidneys obtained from 6-8 week old lambs or piglets and stored in liquid nitrogen until use. We investigated if replacement of the primary cells by cell lines in our VI assay is possible. First, we compared the sensitivity of the primary cells with that of two cell lines (BHK-21, ZZ-R). Further, we compared the sensitivity of primary lamb kidney cells with that of cell lines IBRS-2 and LFBK.

Materials and methods

Cells were grown in 6-well tissue culture plates before they were incubated for 1 hour with ten-fold dilution series of various FMD viruses. For the comparison of lamb kidney, porcine kidney, BHK-21 and ZZ-R cells we used cell adapted strains (A_{22} Iraq, O Manisa, O NET01, C_1 Detmold, Asia-1 Shamir, SAT-1, SAT-2, and SAT-3). Further, we compared the sensitivity of primary lamb kidney cells with the sensitivity of cell lines IBRS-2 and LFBK using 10 cattle passaged challenge viruses.

Results

The titres of cell adapted viruses were almost equal in primary lamb and porcine kidney cells as well as in ZZ-R cells. The titres on BHK-21 cells were slightly lower, although there was variation between the strains. The cattle passaged cattle challenge viruses scored consistently the highest titre on LFBK cells.

Discussion

The ZZ-R cells had a comparable sensitivity to our primary cell lines, but are difficult to handle. The results with the LFBK cells show that these have a higher sensitivity for FMDV than our primary cells. Since they are contaminated with a pestivirus, their purpose is limited. We need further results of laboratory tests before we decide if and for which purposes we will replace our primary cells by one or more cell lines.

DEVELOPMENT OF A NEW EXPERT-CURATED FOOT-AND-MOUTH DISEASE VIRUS NUCLEOTIDE SEQUENCE DATABASE

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Introduction

The accessibility of foot-and-mouth disease virus (FMDV) genome data is either limited to personal data or data available on public repositories (i.e. GenBank, EMBL and DDBJ), with often non-existent, limited or incorrect metadata annotation. The World Reference Laboratory for FMD (WRLFMD), possesses a significant amount of unpublished sequence data, which are well-curated. Third-party annotation of sequences on public databases is problematic and inaccurate data is often not corrected which can lead to incorrect spatial or temporal phylo geographical inferences. To address these problems, we are building an FMD Network Laboratory Sequence Database, simply known as FMD base.

Materials and methods

An open-source relational database management system has been developed in MySQL. The database has been populated with FMDV sequence data retrieved from three sources: i) GenBank; ii) the WRLFMD database of published and unpublished VP1 sequences; and iii) unpublished full-genome sequences determined by WRLFMD. Data were manually checked for inconsistency, debugged and curated with all their required information.

Results

GenBank FMDV sequence data comprised 10,136 records of which 1,131 were complete or near-complete genomes. To this were added 931 unpublished WRLFMD whole genome sequences and 6,079 VP1 sequences (including some submitted by other laboratories). Therefore, the current total number of sequences added to FMD base was 17,146 of which 2,062 were complete or near-complete genome sequences.

Discussion

The release of the database for external access is expected by the end of 2020. The accessibility of the system to researchers will initially be via a web portal and based on a three-tier security structure, allowing different users access and retrieve data. Further developments of online applications for dynamic data query and visualizations of a comprehensive and harmonized repository of FMDV genetic and epidemiological data are planned.

DEVELOPMENT OF LINEAGE-SPECIFIC REAL-TIME RT-PCR FOR THE RECENT FMDV, ASIA/SEA-97 IN SOUTH KOREA

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Introduction

Foot-and-Mouth disease (FMD) are highly contagious in cloven hood animals, causing serious economic losses. From the first outbreak in Republic of Korea, there have been enormous endeavors to prevent FMD outbreak, along with reinforcement of border quarantine to deter introduction of FMD virus (FMDV) from foreign countries. Accurate and fast diagnostic tools are highly for identification and prompt control of FMD in FMD outbreak emergency to minimize economic losses.

Materials and methods

In this study, we developed lineage-specific real-time RT (reverse-transcriptase)-PCR for FMDVA/ASIA/Sea-97 as the causative FMDV genotype of FMD outbreaks in Republic of Korea in 2017-2018. For the evaluation of the method, FMDV viruses isolated from Vietnam, Laos, Myanmar, and Cambodia, which belongs to POOL 1 region were utilized and the real time RT-PCR newly developed from our laboratory was compared with that from WRFMD (Pirbright).

Results

In results, our newly developed real time RT-PCR kit did not have cross-reactive reaction to other genotypes lineages, while WRFMD real time RT-PCR method had.

Discussion

Thus, this study suggested that the newly developed real time RT-PCR method should be highly useful to make rapid control of FMD outbreaks by identifying the specific genotype-lineage from clinical samples. Further study will be needed for the test accuracy with larger number of samples on the purpose of global usefulness and commercialization.

DIAGNOSTIC PERFORMANCE OF FOOT-AND-MOUTH DISEASE VIRUS DETECTION AND SEROTYPING ASSAYS WITH FIELD SAMPLES FROM EAST AFRICA

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Introduction

Multiple Foot-and-Mouth Disease virus (FMDV) serotypes circulate in endemic countries and need identifying to inform control. Specific topotypes of four FMDV serotypes (Pool 4) are present in East Africa (EA). Recently, the World Reference Laboratory for Foot-and-Mouth Disease developed topotype-specific real-time RT-PCRs tailored to EA topotypes. Here, we compared these molecular assays with other tests for detection and/or serotyping on field samples collected in northern Tanzania during 2012-2018.

Materials and Methods

A total of 127 vesicular samples were analyzed using:

- FMDV monoclonal antibody-based antigen (Ag) detection and serotyping ELISA kit;
- Virus Isolation (VI) on LFBKαvβ6 cell line combined with the above Ag-ELISA kit;
- Real-time RT-PCR targeted on 3D sequence for pan-FMDV detection; and
- A panel of four topotype-specific real-time RT-PCRs for A/AFRICA/G-I, O/EA2-4, SAT1/I (NWZ), SAT2/IV.

Results

Six samples were negative in all tests. Bovine Viral Diarrhoea Virus was isolated from three of them. Topotype-specific real-time RT-PCRs identified and typed FMDV in 93% of samples (28 type O, 40 A, 31 SAT1, 15 SAT2 with five positive for two serotypes). The SAT1 real-time RT-PCR had the highest (20%) failure rate. Antigen-ELISA detected and typed FMDV in 70% of homogenates, including six SAT1 positive samples missed by the specific real-time RT-PCR. The 3D real-time RT-PCR showed the highest (98%) diagnostic sensitivity; however, due to its pan-FMDV reactivity, it lacked typing capacity and the two samples missed were detected by the type-specific real- time RT-PCRs. VI detection rate was 80%. VI and Antigen-ELISA combined increased typing efficiency to 86%, while topotype-specific PCRs and Antigen-ELISA together reached 98%.

Discussion

Topotype-specific real-time RT-PCRs had the highest serotyping capacity for EA FMDVs, although four assays are required, of which the SAT1-specific one needs improvement. The antigen-ELISA kit was less sensitive, but more user-friendly, hence suitable for any laboratory level. When these tests were used in combination, the diagnostic and serotyping performance approached 100%.

ELISA TECHNIQUES FOR FMD

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Introduction

ELISA test based on the distinct format, antigen type and specific antibody reinforce its predominance in different research areas of FMD, and this may replace the traditional methods in the near future. This review gives comprehensive insight on ELISA currently available for typing, antigenic analysis, vaccination status differentiation and surveillance vaccine purity and content at all stages of manufacture in FMDV. Besides, some viewpoint about the recent advances and trends of ELISA reagent for FMD are described here.

Material & methods

More than 100 studies regarding ELISA method available for FMD diagnosis, antigenic analysis and monitor were thoroughly reviewed. We investigated previous sagacious results of these tests on their sensitivity, specificity.

Results

We found that in all ELISA formats for FMD, antibody-trapping and competitive ELISAS have high specificity and RT-PCR (oligoprobing) ELISA has extra sensitivity. A panel of monoclonal antibodies to different sites or monoclonal antibody in combination of antiserum is the most suitable combination of antibodies in ELISA for FMD. Even though from its beginning, 3ABC is proven to be best performance in many studies, no single NSP can differentiate infected from vaccinated animals with complete confidence. Meanwhile, recombinant antigens and peptide derived from FMDV NPs, and NSPS have been developed for use as an alternative to the inactivated virus antigen for security.

Conclusions

There is a need of target protein, which accurately determines the susceptible animal status based on the simple, fast and reliable routine laboratory test. A further alternative based on virus-like particle (VLP, also called empty capsids) in combination of high throughout antibody technique (Phage antibody library/antibody microarray) may be the powerful ELISA diagnostic reagents in future.

ENHANCED COMPLETE GENOME SEQUENCING OF FOOT-AND-MOUTH DISEASE VIRUS USING PROBE ENRICHMENT

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Introduction

The resolution and insights achievable by molecular epidemiology is directly influenced by the ability to sequence viral genomes. Next generation sequencing (NGS) approaches have been developed for foot-and-mouth disease virus (FMDV) which allow the sequencing of complete genomes. However, the sensitivity of NGS for FMDV is limited to good quality samples with strong Ct values. Here, we describe the development of a probe enrichment process to increase the sequencing capacity for FMDV.

Material and methods

Complete FMDV genome sequences (n=622) encompassing the seven serotypes were downloaded from GenBank and subjected to an automated pipeline to generate overlapping oligonucleotide probes. Further filtering of the probes resulted in a total of 26,275 FMDV-specific probes. Imitation clinical samples were prepared in duplicate by diluting FMDV O1 Manisa into a suspension of bovine epithelium. One set of dilutions was heated to mimic poor quality samples. Illumina libraries were prepared in duplicate, with one replicate of each pair subjected to probe enrichment using Illumina reagents. Additional samples subjected to enrichment included RNA extracted from an environmental swab.

Results

Reference assemblies of the resulting data revealed an increase of up to 93-fold in the depth across the entire genome for good quality samples. Probe enrichment was shown to increase the sensitivity of complete genome sequencing such that near complete genomes can be sequenced using clinical samples with a 100-fold less virus. De novo assembly followed by reference assembly allowed the assembly of an almost complete genome from the environmental swab sample.

Discussion

Genomic sequencing has become a cornerstone of FMDV surveillance and outbreak management. The probe enrichment methodology described here stretches the limits of what is possible regarding FMDV sequencing, notably in terms of virus titre, RNA quality and sample matrix. In turn, the variety of questions that can be addressed will be dramatically enhanced.

ENHANCED DIAGNOSIS EFFICACY OF A NEWLY DEVELOPED ELISA KIT FOR FMDV IN POOL 1 REGION

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Introduction
Foot-and-mouth disease (FMD) is the most important disease of livestock, causing huge economic impact on worldwide. FMDV has been highly prevalent in most of Southeast Asia countries including Vietnam, Laos, Myanmar and Cambodia of POOL 1 region, which Republic of Korea belongs. As FMD outbreaks caused by FMDV virus serotype O and A occurred throughout POOL1 region

Materials and methods
In this study, FMDVs were isolated from clinical samples of FMD outbreaks in 2016-2018 of Vietnam (n=31), Laos (n=11), Myanmar (n=1), and Cambodia (n=8) through the international collaborative research projects and subjected to performance comparison between OIE reference ELISA kit (Pirbright kit) and APQA ELISA kit newly developed from our laboratory.

Results
In results, the APQA ELISA kit had better sensitivity and specificity than Pirbright ELISA kit. Besides, the APQA ELISA kit is quick and simple by saving approximately 2hrs, being compared with the Pirbright ELISA kit.

Discussion
Conclusively, the APQA ELISA kit is expected to make a significant contribution to control and prevention of FMD in POOL 1 region.

ESTABLISHMENT SECONDARY STANDARDS FOR FMD SEROTYPE O SP ANTIBODY ELISAS

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South Korean government has been executed sero-surveillance to monitor the population immunity since FMD routine vaccination was adopted. Merial Animal Health Ltd. was the only vaccine provider and PrioCHECK FMDV Type O Antibody ELISA was sufficient to examine the O_1 Manisa vaccine induced antibodies until 2016. However, FMD vaccines from FGBI ARRIAH (Russia) and Biogenesis Bago SA (Argentina) were introduced for emergency use at the end of 2016 and now there are three FMD vaccines of different strains in Korean market.

Diversification of vaccines raised an important question of whether using a single SP O antibody ELISA is adequate to detect antibodies induced by various serotype O vaccine strains; O_1 Manisa, O3039 (Merial Animal Health Ltd.), O Primorskiy (FGBI ARRIAH, Russia), and O_1 Campos (Biogenesis Bago SA). To accommodate such changes in FMD vaccine market, two more SP O ELISAs, produced by Median Diagnostics Inc. and Bionote Co., LTD, were put to use by 46 regional veterinary laboratories.

OIE highlighted the importance of reference samples and panels for many purposes. However, internationally approved primary reference standards are not suitable for daily use due to its own nature of finity and scarcity. Thus, it is recommended to produce secondary standards (working standards), calibrated to primary standards, for diagnostic routine.

Previously, we have established serum bank to support FMD diagnostic research. Here, we demonstrated selection of the candidates from the bank, calibration of these candidates to primary standards, and finally their application in two SP O ELISAs introduced lately.

GENETIC ANALYSIS OF THE 2013/14 SAT2 FOOT-AND-MOUTH DISEASE (FMD) OUTBREAK IN MPUMALANGA PROVINCE, SOUTH AFRICA

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Introduction
The epidemiology of Southern African Territories (SAT) serotypes of foot-and-mouth disease (FMD) is unique because of the presence of wildlife reservoirs. The African buffalo (*Syncerus caffer*) is susceptible to infection with all three SAT serotypes and can remain infected for several years while rarely developing clinical signs. There are few data on the evolution of FMD virus SAT2 serotypes once it has entered a host. Isolates from a 2013/14 SAT2 FMD outbreak in South Africa underwent next-generation sequencing (NGS) to study the molecular epidemiology including viral evolution and phylogenetic relationships.

Materials and Methods
Samples were prepared by extracting RNA and performing reverse-transcription PCR (RT-PCR) to generate full open reading frames (ORFs) for 10 SAT2 isolates obtained from different time points of the outbreak. Consensus sequences were aligned and compared to identify genome regions undergoing the greatest amount of change and to define phylogenetic relationships.

Results
The most variable were the Leader (1.17% non-synonymous single nucleotide polymorphisms per base pair length) and VP1 (0.93%) regions, and the most conserved were the VP4, 2A, 3B and 3C regions with no non-synonymous changes. Four previously unpublished and therefore unique substitution sites were identified with two in the Leader, one in VP2 and one in 3D. Phylogenetic analysis of the ORF sequences grouped the outbreak isolates into three clusters corresponding to the time period of the outbreak.

Discussion
The highly variable regions were those coding for proteins that repress innate host immunity and responsible for viral antigenicity. The highly conserved regions were those that play a role in capsid stability and assembly, viral replication efficiency, and suppression of host cellular immune responses. Structural proteins are variable over time, which will influence immune system responses to field viruses after being primed by vaccination.

GENETIC CHARACTERIZATION OF SEROTYPE AND GENETIC RELATEDNESS OF FOOT-AND-MOUTH DISEASE VIRUSES IN SOUTH EAST ASIA.

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Introduction

Foot-and-Mouth disease (FMD) is a highly contagious viral disease in the cloven-hoofed animals such as pig and cattle. The causative agent, FMD virus (FMDV), is divided into seven Serotype categories: A, O, C, Asia1, SAT1, SAT2 and SAT3 based on VP1 sequence. All of FMD outbreaks from 2000 in Korea are investigated to be introduced from foreign countries in the Pool 1 region. Therefore, genetic characterization of FMDV currently prevalent in the Pool 1 region will help us prepare control measures (diagnostics and vaccines, etc.) against introduction of FMDVs from the Pool 1 region in the future.

Materials and methods

In this study, 95 clinical samples were obtained from FMD-affected regions of three countries, Vietnam, Laos and Cambodia from 2018 and subjected to VP1 sequencing.

Results

In results, FMDVs in Vietnam and Laos belonged to Serotype O and classified into O/Me-SA/Panasia and O/SEA/Mya-98 genotypes. FMDVs in Cambodia belonged to Serotype O and A, being classified into O/ME-SA/Panasia genotype.

Discussion

The further study may require investigation of antigenic relatedness of the field FMDVs to strains of commercial FMD vaccines.

A MULTIPLEX LATERAL FLOW DEVICE FOR ON-FIELD IDENTIFICATION AND SEROTYPING OF FOOT-AND-MOUTH DISEASE VIRUS

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Introduction

In foot-and-mouth disease (FMD) endemic regions, which often lack adequate transport systems and equipped laboratories, Lateral Flow Devices (LFD) represent the simplest tool for rapid on-site diagnosis. A commercially available pan-serotype LFD offers a user-friendly disease confirmation tool, but lacks serotyping capacity, whilst serotype identification is crucial to identify regional transmission patterns and to ensure appropriate vaccines selection in countries where multiple serotypes co-circulate. This study describes the development of a multiplex LFD, based on well characterized monoclonal antibodies (MAbs), for FMD diagnosis and simultaneous serotyping of FMDV O, A and Asia 1 in a single strip.

Materials and methods

The assay, based on the lateral flow immunoassay technique, exploits serotype-selective capturing MAbs and a pan-FMDV MAb linked to gold nanoparticle as signal reporter enabling naked-eye detection after 15 minutes. The same set of MAbs validated for the FMD Antigen-ELISA kit has been employed. In a single strip, five reactive lines reveal respectively: pan-FMDV positivity (test line 1), positivity to type O, A or Asia1 virus (test lines 2, 3 and 4), and test validity (control line). An appropriate running buffer was also formulated.
FMDV reference strains and known epithelium homogenates from outbreaks occurred in Tanzania were used for an initial evaluation of the novel multiplex LFD and for comparative analysis with Antigen-ELISA and real-time RT-PCRs.

Results

The reference strains were correctly classified with analytical sensitivity similar to that shown by the Antigen-ELISA (detection limit of $10^{2.2}$, $10^{2.7}$ and $10^{4.2}$ $TCID_{50}$ for types A, O and Asia1 respectively, and absence of cross-reactivity between serotypes. The pan-FMDV test line was clearly visible, irrespective the serotype analyzed.
Five field samples positive for type O and nine positive for type A also produced an evident pan-FMDV reaction combined with the type-specific detection.

Discussion

The performance of the Antigen-ELISA and the multiplex LFD was comparable as the same catching and detector monoclonal antibodies are used in both kits. Thanks to its multiplexing capability and maximum simplicity, the device is suited for timely on-site FMD diagnosis with simultaneous identification of three serotypes within minutes and without requiring complicated or costly equipment.
Additional validation of the technology in endemic areas is needed, as well as further research to cover also SAT serotypes detection using the same technology.

Acknowledgment

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A NEW FMDV ANTIGEN ELISA USING MULTISEROTYPE-REACTIVE MONOCLONAL ANTIBODIES

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The wide range of hosts, rapid replication, high levels of viral excretion and multiple forms of transmission make FMD difficult to control and eradicate. As FMD can spread fast, rapid and specific identification of the agent is required, as FMD is clinically indistinguishable from other vesicular diseases such as vesicular stomatitis (VS) and swine vesicular disease (SVD).

In this study, we describe the preliminary performance evaluation of a Double Antibody Sandwich (DAS) ELISA for FMDV detection.

Reactivity profile of different *pan*FMD Mabs was investigated by indirect ELISAs. The Mabs that showed the wider spectrum of recognition were selected and submitted to further testing for their ability to capture and reveal the different virus strains in DAS ELISA format.

Inclusivity was assessed by testing different serotypes including O, A, Asia1, SAT1 and SAT2. The analytical sensitivity was evaluated by testing serial dilutions of these viruses. Results obtained with the new *pan*FMDV DAS ELISA were compared to commercially available techniques: a Mab –based ELISA kit produced by reference laboratories and a lateral flow device test based on the well described 1F10 Mab.

The new *pan*FMDV DAS ELISA was able to detect all strains tested. SVD virus was not detected. Interestingly, SAT1 and SAT2 strains were very well detected, whereas a very low signal was observed with the other DAS ELISA. The new *pan*FMDV DAS ELISA showed an improvement in analytical sensitivity (up to 10-fold) compared to the other techniques, and seemed to have a wider spectrum of detection.

Further testing on more strains is ongoing to better characterize the Mabs recognition pattern and the usefulness of their use in viral detection tests. This new *pan*FMD DAS ELISA allows for rapid and specific FMDV detection. It could be a useful tool for detecting and controlling FMDV outbreaks.

PROVEN PERFORMANCES FOR FMDV NSP ANTIBODY DETECTION WITH THE ID SCREEN® FMD NSP COMPETITIVE ELISA

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Only assays that measure levels of antibodies against non- structural protein (NSP) can differentiate infected and vaccinated animals (DIVA). We make a review of the ID Screen® FMD NSP competitive ELISA designed to detect anti FMDV NSP specific antibodies. This test offers an overnight protocol as well as a short protocol for same-day results.

Test specificity was assessed for both protocols by testing 2009 sera from non-endemic and non-vaccinated areas. The global specificity was high 99.7%, regardless of the species tested.

Sensitivity was evaluated using the Pirbright Institute International reference panel of NSP sera, composed of 36 sera derived from vaccinated / challenged or unvaccinated / infected animals (Parida et al., 2007). The ID Screen® sensitivity was equivalent or highly superior to the best ELISAs evaluated in the study.

DIVA aspect was evaluated by testing 28 animals vaccinated with O monovalent highly purified vaccine at 0 and 50 day post vaccination (dpv). Whereas the animals seroconverted to FMDV (positive on a type O serotype-specific Solid Phase Blocking ELISA), all vaccinated samples were found negative at 0 and 50dpv.

A real-time stability study showed that the kit was still working with satisfactory results after storage for 18 months at 21°C, indicating a very high stability of the kit.

The Pirbright Institute validated the ID Screen® ELISA and “shown that both the formats of this test have equivalent specificity and sensitivity with the established Prionics PrioCHECK® FMDV NS 3ABC test” (EVIDENCE Project final report, available online).

In an “Inter Laboratory exercise to evaluate NSP kits”, comparing the Priocheck® and the IDvet NSP ELISA, the World Reference Laboratory concluded that both kits “have equivalent performance” (EuFMD Open session, Italy, 2018).

The ID Screen® ELISA demonstrates high specificity, excellent performance on reference panels and correctly identified all strains tested and efficiently detected carrier animals.

READY-TO-USE SOLID PHASE BLOCKING ELISA KITS FOR DETECTION OF SPECIFIC ANTIBODIES TO FMDV SEROTYPES O, A, Asia1.

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We describe the performances of a new Solid Phase Blocking ELISA (SPBE). The ID Screen® FMD Type Asia1 Competition ELISA (cELISA) specifically detects FMDV Asia1 serotype-specific antibodies in serum or plasma from cattle, swine or any other susceptible species.

Test specificity was evaluated by testing 1672 samples coming from non-vaccinating and non-endemic areas including 352 small ruminants, 704 swine and 616 cattle. Measured specificity of the ID Screen® cELISA was 100% ($CI_{95\%}$ = 99.77 % - 100 %), regardless of the species tested.

Analytical sensitivity was assessed by comparison with two others commercially available SPBE cELISAs, by testing 7 samples from experimentally vaccinated animals and 11 samples from vaccinated animals in endemic area. Results indicated a globally comparable analytical sensitivity, regardless of the kit tested.

Exclusivity was tested with the IAEA serum panel from infected cattle (FAO/IAEA) that includes sera against the 6 FMDV serotypes. The ID Screen® cELISA correctly identified as positive only the Asia1 antiserum, whereas all the antiserum from other serotypes from this panel were found negative.

When comparing the results with other kits, the ID Screen® cELISA also showed an improved discriminatory capacity between infected/vaccinated and naïve/negative samples.

Kit stability was tested by accelerated ageing. All components were stable enough to allow shipment without room temperature control, like all other kits from the ID Screen® range.

The new ID Screen® FMD type Asia1 Competition ELISA demonstrates excellent performance. It allows for serotype-specific antibody detection to FMDV serotype Asia 1. The kit is particularly user-friendly: all reagents are ready-to-use and very stable. Results are obtained in 2h15. With the ID Screen® FMD Type O, type A and Type Asia 1 Competition ELISAs, IDvet now offers a complete and full range for the serotype-specific antibody detection of FMDV serotype O, A and Asia 1 respectively.

A REVIEW OF THE WRLFMD'S PROFICIENCY TESTING SCHEME

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Introduction

This presentation will highlight the latest findings for two proficiency testing schemes (PTS) carried out by the World Reference Laboratory for foot-and-mouth disease (WRLFMD): Phase XXXI (2018) and Phase XXXII (2019). The most recent scheme has provided common sample panels that can be used to assess the different levels of laboratory performance that is required to support FMD control along the Progressive Control Pathway (PCP).

Materials and Methods

For Phase XXXI, virological ("live" and inactivated FMDV) and serological panels were sent to 70 laboratories around the world. The diagnostic methods used were not specified and needed to be determined by each laboratory based on the description sent with the panels. In addition to testing and characterizing samples, laboratories were asked to provide overall case interpretations. Phase XXXII had a similar format and used the PCP status of the country to define the minimum expected capability of the participating laboratories.

These data were included with retrospective data from the last 10 years to assess whether there is an association between a laboratory's PTS performance and the host country-level status on the PCP.

Results

The overall ability to identify samples as positive for FMDV antibodies improves year upon year; however, there are still difficulties in identifying the serotype that is present in the sample. The virological panels of phase XXXI had an increase in the number of false positives observed on both the rRT-PCR and the antigen ELISA. Data analysis for Phase XXXII is ongoing.

Results and implication for surveillance and progress through the PCP will be discussed in relation to their PTS performance.

Discussion

The results for Phase XXXII will be distributed to each laboratory early 2021 and it is planned that a new PTS, Phase XXXIII will be initiated in mid-2021.

SEROLOGICAL ELISAs BASED ON MONOCLONAL ANTIBODIES AS DIAGNOSTIC TOOLS FOR LUMPY SKIN DISEASE

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Introduction

Lumpy skin disease (LSD) is an OIE notifiable transboundary disease of cattle, caused by LSD virus (LSDV), genus *Capripoxvirus*, family Poxviridae. In 2015, LSD emerged in the EU causing outbreaks in Greece and then, throughout 2016, in several Balkan countries. Due to the lack of reliable and practical diagnostic tools for serological surveillance, the aim of this study was to develop ELISA assays based on monoclonal antibodies (MAbs) for the serological detection of LSD.

Materials and Methods

From 75 MAbs produced against LSDV, four were selected among 18 recognizing a 35kDa viral protein, known to be one of the most immunogenic proteins of poxviruses. These four MAbs were able to trap and detect the virus when used as catching and conjugated MAbs in a sandwich ELISA.

A total of 70 sera from 14 cattle and 28 sera from 8 goats, collected weekly up to 28 days after experimental infection with LSDV-Neethling vaccine strain or an LSDV field isolate and a goat poxvirus (GPV) respectively, were used to evaluate two developed assays, one indirect and one competitive ELISA. The cut-off of the tests was evaluated by testing 170 field negative sera from livestock in northern Italy.

Results

In both indirect and competitive ELISA, inactivated LSD virus was trapped onto the solid phase by MAb 2F10; then in the former ELISA serum antibodies were detected with an anti-ruminant IgG MAb, peroxidase conjugated, while in the competitive ELISA the conjugated MAbs 2C6 or 3H5 were selected to measure serum competition.

Both ELISAs consistently detected seroconversion in all cattle 14 days post infection, with specificity of 100% considering results with the negative field samples. In infected goats, indirect ELISA clearly detected seroconversion in only three animals during the observation period, resulting less sensitive or more specific than the competitive test that revealed antibodies in all goat.

Discussion

The assays developed are promising tools for the control of LSD diffusion, despite cross-reactivity due to common epitopes between LSDV and GPV; moreover, the availability of a panel of characterized MAbs may provide strategic resources for further diagnostic tests and for improving knowledge on C*apripoxviruses* antigenicity.

Acknowledgments

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VALIDATION OF RECOMBINANT PROTEIN-BASED ELISA FOR DETECTION OF ANTIBODIES TO FOOT-AND-MOUTH DISEASE VIRUS TYPE-O

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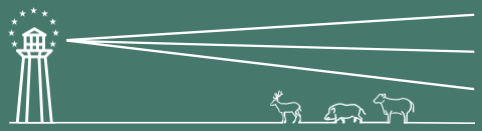
Serological tests for detecting antibodies to structural proteins of Foot-and-Mouth disease virus (FMDv) are required to support assessment of vaccination effectiveness and contribute to estimating the population immunity level for post-vaccination monitoring. Although Virus Neutralization Test (VNT) is prescribed in the OIE-Manual as the golden standard method for determining SP antibodies to FMDV, there may be disadvantages in terms of ease of use (high-level biocontainment facilities, trained personnel, time-consuming, labor etc.) for massive screening samples. Therefore, we have developed a new recombinant protein-based solid-phase competitive ELISA(r-SPCE) with monoclonal antibody (Mab) for detection of antibodies to FMDV type-O. This study describes the validation process in cattle and pigs for this kit.

The ELISA (r-SPCE) was validated with field sera collected from either vaccinated or non-vaccinated from non-infected cattle and pig farms, international reference sera obtained from WRLFMD, Pirbright and sera from experimentally challenged animals. The overall diagnostic specificity of 99.9% with a threshold of 50% inhibition was identified by analyzing 1,070 cattle and 730 pigs from FMD-free and non-vaccinated country (Canada, USA). Diagnostic sensitivity estimated using 475 known positive animal sera result of 95.2%. International reference sera were correctly detected. A high level of serotype-specificity was demonstrated testing IAEA/FAO standard sera strongly positive against other FMDV serotypes. Also, the CV obtained for evaluating reproducibility and repeatability estimated ≤5%, demonstrating the excellent stability of the ELISA (r-SPCE).

Establishing fully validated and reproducible methods for serological assessment of detecting vaccine-induced antibodies needs considerable effort, particularly if a several of vaccine and field strains are involved as in the case of Korea. The recombinant protein-based SPCE developed for the detection of antibodies to FMDV type-O demonstrated high specificity and sensitivity. In addition, this assay offers advantages in terms of repeatability and broader cross-specificity, but also is easy-to use and applicable to multiple species.

Funded by the European Union



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