OIE/FAO Foot-and-Mouth Disease Reference Laboratory Network

Annual Report 2020

Editors:

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Contents

1 OIE/FAO FMD Reference Laboratory Network

1.1 Principle Goals

The Network of OIE/FAO FMD Reference Laboratories has been established with two principal goals:

1) To understand global virus distribution patterns and use these data to inform vaccine recommendations

and

2) To harmonise and improve the quality of laboratory testing carried out by international and national reference laboratories.

These activities require sharing and joint evaluation of surveillance information from laboratory diagnosis, serotyping, genetic characterisation and vaccine matching tests and harmonisation of standards for diagnostic procedures.

This report is divided into two parts providing an update on progress towards each of these goals.

1.2 Reporting Period

1st January 2020 - 31st December 2020

1.3 Collated input from

OIE Reference Laboratory for Foot and Mouth Disease, Dirección de Laboratorio Animal

SENASA, Argentina

OIE Regional Reference Laboratory for Sub-Saharan Africa (RRLSSA)

BVI, Gaborone, Botswana

FAO FMD Reference Laboratory

National Centre for Foreign Animal Disease National Centres for Animal Disease, Canadian Food Inspection Agency, Winnipeg, Manitoba, Canada

OIE FMD Reference Laboratory

French Agency for Food and, Environmental and Occupational Health & Safety (ANSES), Maisons-Alfort, Paris, France

OIE collaborating centre for validation, quality assessment and quality control of diagnostic assays and vaccine testing for vesicular diseases in Europe, and FAO Reference Centre for vesicular Diseases

Sciensano, Ukkel, Belgium

Centro Panamericano de Fiebre Aftosa (PANAFTOSA) and OIE Reference Laboratory for FMD

Rio de Janeiro, Brazil

OIE and China National FMD Reference Laboratory

Lanzhou Veterinary Research Institute (LVRI), CAAS, Gansu, People's Republic of China

FAO Reference Centre for FMD in South Asia

ICAR – Directorate of Foot-and-Mouth Disease, Indian Council for Agricultural Research, Mukteswar, Nainital (Uttarakhand), India

OIE/FAO FMD Reference Laboratory

Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna (IZSLER), Italy

FAO Reference Centre for FMD for Central Asia and West Eurasia and OIE Reference Laboratory for FMD

Federal Governmental Institute, Centre for Animal Health (FGI ARRIAH), Vladimir, Russian Federation

OIE Regional Reference Laboratory for Foot and Mouth Disease in the South East (RRLSEA)

Department of Livestock Development, Pakchong, Thailand

FAO Reference Centre for FMD and other vesicular diseases for the Americas and the Caribbean and OIE FMD Reference Laboratory

Foreign Animal Disease Diagnostic Lab, Plum Island Animal Disease Center (PIADC), Greenport, United States of America

OIE Reference laboratory for Foot and Mouth Disease

Animal and Plant Quarantine Agency (QIA), Anyang city, Gyeonggi-do, Republic of Korea

FAO Reference Laboratory for FMD in Africa and OIE FMD Reference Laboratory

Transboundary Animal Diseases Programme, ARC-Onderstepoort Veterinary Institute (ARC-OVI), South Africa

FAO World Reference Laboratory and OIE FMD Reference Laboratory

The Pirbright Institute Pirbright, Surrey, United Kingdom

Additional input kindly supplied by:

Australian Animal Health Laboratory (AAHL)

Geelong, Australia

Foot and Mouth Disease Laboratory

Embakasi, Kenya

Laboratoire National de l'Elevage et de Recherches Vétérinaires (LNERV)

Dakar, Senegal

NATIONAL Animal Health Diagnostic & Investigation Center (NAHDIC)

Sebeta, Ethiopia

National Veterinary Research Institute

Vom, Plateau State, Nigeria

Şap Institute (and WELNET FMD)

Ankara, Turkey

2 Global distribution and impact of foot-and-mouth disease

Foot-and-mouth disease (FMD) is a highly contagious viral disease that infects a wide variety of domestic and wild cloven-hooved hosts. Its presence impacts upon rural livelihoods and restricts trade opportunities for countries where the disease is endemic and poses a constant threat to those countries that are free of the disease. In endemic countries, the economic costs associated with FMD are estimated to be US$6.5–21 billion annually, with outbreaks in FMD-free countries and zones potentially causing economic losses of >$1.5 billion. FMD virus lineages are not randomly dispersed throughout the world but are associated with particular ecological niches. The distribution of these FMD virus lineages is affected by cyclical upsurges in the prevalence of particular strains that may be associated with the evolution of FMD viruses to escape protective immunity in susceptible livestock populations and/or opportunities presented by movements of animals and their products. These features can give rise to pandemic events where FMDV lineages spread widely to affect new regions.

Global surveillance for FMD is necessary to identify the current hazards and to predict heightened risk so that appropriate diagnostic tools and vaccines are available for detection and control. This requires sustained effort directed towards the monitoring of FMD outbreaks and ideally also of FMDV circulation and persistence, along with collection and characterisation of FMD viruses and integration of findings with associated epidemiological intelligence. Such an extensive effort requires a coordinated approach encompassing national and international disease laboratories of the **OIE/FAO FMD Laboratory Network** (www.foot-and-mouth.org) along with partnering laboratories, commercial vaccine and diagnostic providers. The worldwide distribution of the different serotypes and variants of FMD virus (as compiled in 2020) and the associated activities of the Network laboratories are presented in this report.

2.1 Introduction

Global surveillance undertaken by the OIE/FAO FMD Laboratory Network aims to monitor the distribution of FMD viruses to predict risk for endemic and FMD-free countries. FMDV is unevenly distributed throughout the world reflecting factors such as livestock density and species mix, patterns of husbandry, animal movement and trade, wildlife reservoirs and incentives and capacities for disease control. The virus exists as seven serotypes and multiple subtypes where cross-immunity is absent or incomplete. The situation is dynamic and complex and affected by viral evolution, waxing and waning of host immunity and changing ecosystems and trading patterns. Despite the opportunities for spread of FMDV into new regions, viruses tend to recur in the same parts of the world, presumably reflecting some degree of either ecological isolation or adaptation. On this basis, the global pool of FMD viruses can be subdivided into seven ‘regional pools’ in which genetically and antigenically distinctive virus strains tend to occur within a defined region.

The seven ‘Regional Pools’ referred to throughout this report are shown below (Figure 2.1) and represent:

Pool 1	Southeast Asia with spill over into Eastern Asia
Pool 2	Southern Asia
Pool 3	Western Asia with spill over into North Africa
Pool 4	Eastern Africa with spill over into North Africa
Pool 5	Western Africa
Pool 6	Southern Africa
Pool 7	South America

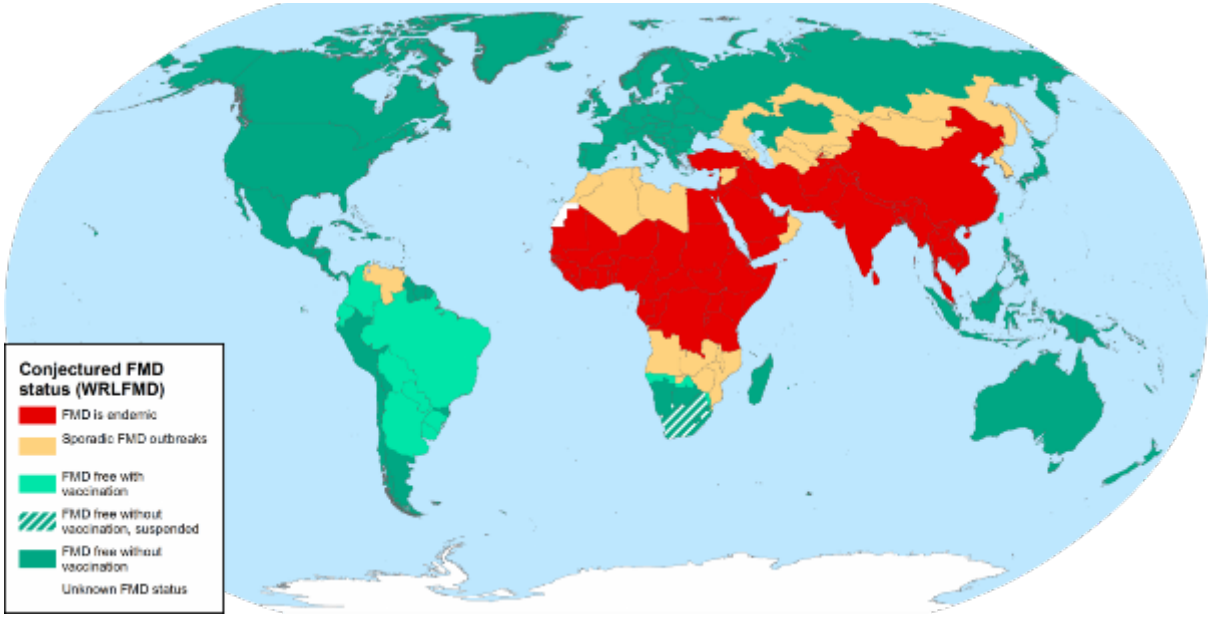


Figure 2-1: Distribution of the seven endemic pools of FMD showing conjectured status of FMD in countries during 2020. Periodically, viruses spread between pools and to free regions, and countries at the interfaces between pools (such as in North Africa and Central Asia) often experience FMD outbreaks from different regional sources. Note on Pools 4-6: In Africa there are currently three FMD virus pools loosely defined as covering East Africa (pool 4), West Africa (pool 5) and Southern Africa (pool 6). A map describing the official OIE status for these countries can be found at: https://www.oie.int/app/uploads/2021/05/fmd-world-eng.png

The clustering of FMD viruses into 7 virus pools, with 3 pools covering West Eurasia, South Asia and Southeast Asia, 3 pools covering East, West and Southern Africa and 1 pool covering the Americas, is now enabling a targeted approach to be applied to the ‘Progressive Global Control of FMD’ initiative overseen by the OIE and FAO and for which the Network laboratories will play a pivotal role.

Overview of the Global situation in 2020

It is perhaps inevitable that the activities of international FMD reference laboratories have been impacted by COVID-19. New outbreaks reported on the OIE WAHIS website for 2020 are about 1% of the annual average for the previous 15 years (see Table 2-1 and Figure 2-4 below).

Key headline events (highlighted in Figure 2-2):

- A new serotype O lineage was described for samples collected in Sri Lanka; further data provided from ICAR-DFMD India during the OIE/FAO FMD Laboratory Network meeting provided evidence that this lineage (tentatively named O/ME-SA/SA-2018) is more widely distributed in South Asian countries.
- Samples tested from Pakistan indicate that the O/ME-SA/Ind-2001e is becoming established in the country (after it was detected for the first time in 2019; see: https://mra.asm.org/content/9/18/e00165-20).
- A new introduction of the O/ME-SA/PanAsia-2^{ANT-10} lineage into Turkey has been detected (the first time this lineage has been identified in the country since 2017).
- A new genetic clade within the A/ASIA/Iran-05^{FAR-11} sub-lineage has been detected in Iran.
- Serotype SAT1 and SAT2 outbreaks have been reported in Limpopo, South Africa.
- There have been new serotype A FMD outbreaks in North Africa (Libya), from where the disease threatens the Maghreb.

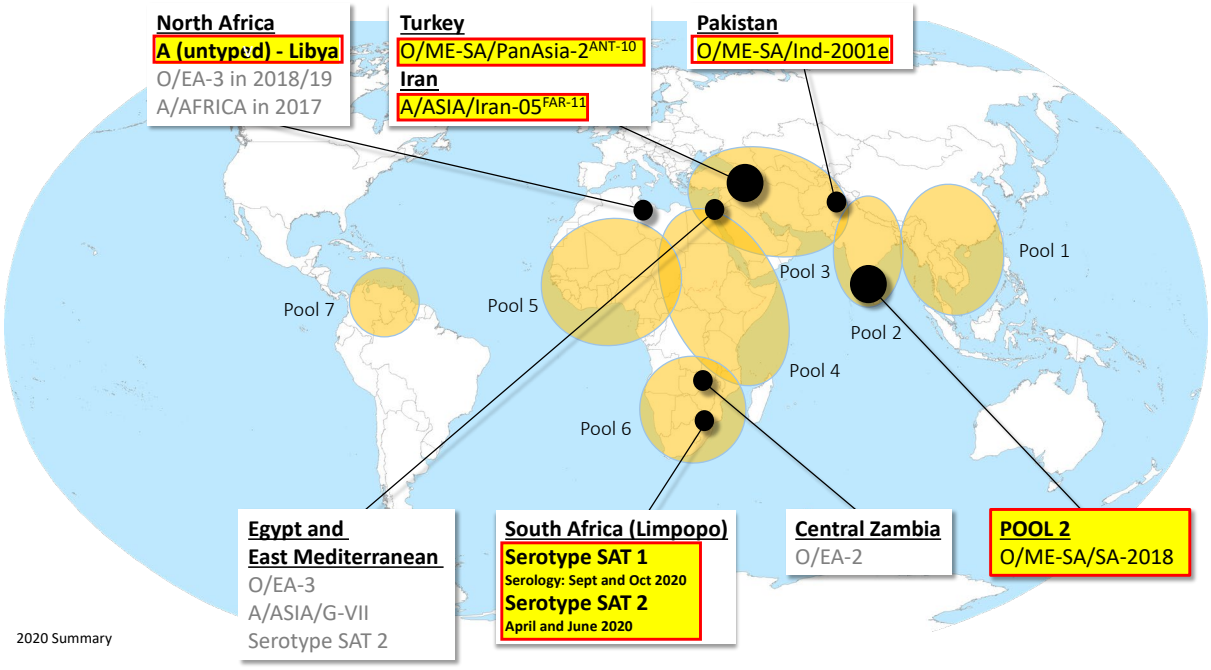


Figure 2-2: Headline FMD events for 2020 (highlighted in yellow – important epidemiological events from 2019 are also shown in grey)

Specific information regarding contemporary FMD outbreaks can be found on the World Animal Health Information Database (WAHID) located on the OIE website (https://wahis.oie.int/#/home), as well as the EMPRES Global Animal Disease Information System (http://empres-i.fao.org/) provided by FAO. Further supplementary data and updates are provided in the WRLFMD/EuFMD Quaterly Report for FMD (https://www.wrlfmd.org/ref-lab-reports).

During 2020, FMD outbreaks have continued to affect countries in the established endemic regions of the world. Particular attention has been focussed upon new FMD outbreaks and events that have occurred at the margins of these endemic regions (reported on the OIE WAHIS Interface: https://wahis.oie.int/#/home, summarised in Figure 2.1-3, Table 2-1 and

described elsewhere in this report). Further details of many of the characterisation of viruses retrieved from these outbreaks are provided later in this report.

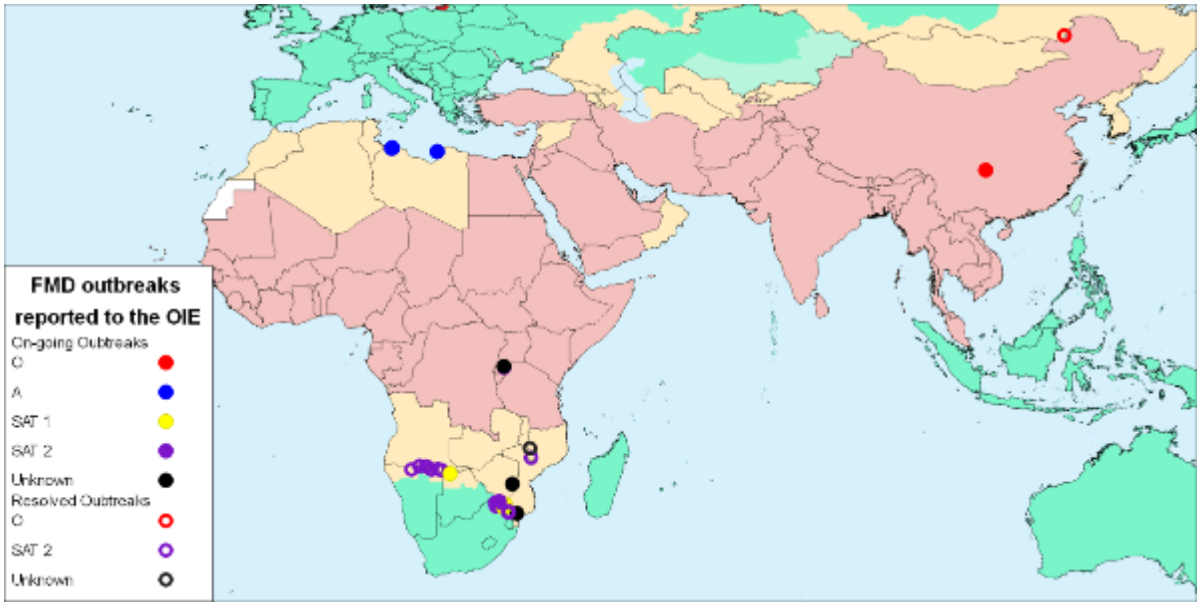


Figure 2-3: Map indicating the location of significant epidemiological events and disease outbreaks reported to OIE in immediate notifications or follow-up reports in 2020 (data, available from: https://wahis.oie.int/#/home, downloaded on 11 July 2021)

These numbers reported by the OIE most probably represent under-reporting due to the COVID-19 pandemic. Given that during 2020 only 57 new outbreaks were reported globally, compared to a global average of 5493 ± 702 over the previous 15 years (*Figure 5*).

Table 2-1: New FMD outbreaks reported to OIE (data retrieved from WAHIS on www.oie.int on 8th June 2021).

Country	Jan-Jun 2020	Jul-Dec 2020	Total
Botswana	0	1	**1**
China (People's Rep. of)	2	3	**5**
Libya	5	7	**12**
Malawi	1	1	**2**
Mozambique	0	1	**1**
Namibia	0	9	**9**
Russia	3	0	**3**
Rwanda	1	1	**2**
South Africa	16	5	**21**
Thailand	4	0	**4**
Zimbabwe	0	1	**1**
Total	**32**	**29**	**61**

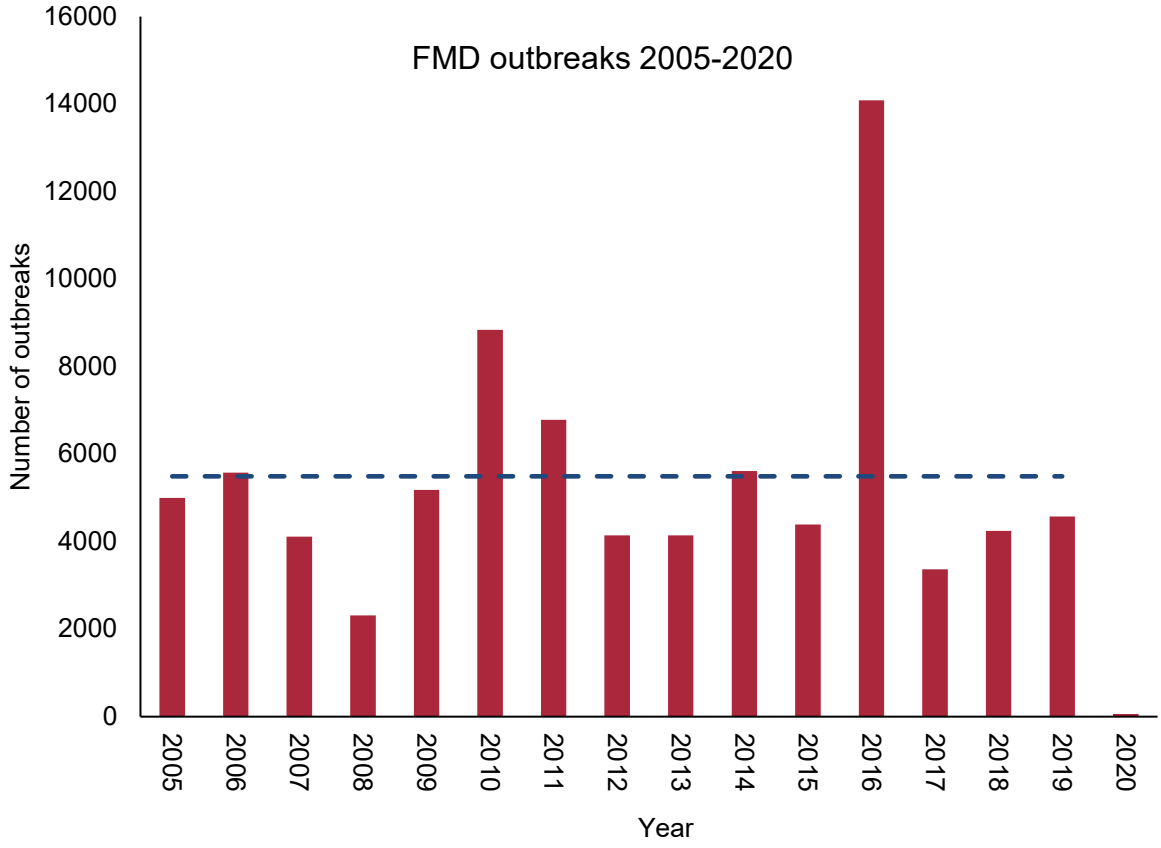


Figure 2-4: New FMD outbreaks reported to the OIE in the period 2005 to 2020 (data retrieved from WAHIS on 8th June 2021). Dotted line shows the 2005 to 2019 annual average.

2.2 Overview of the activities of the OIE/FAO FMD Laboratory Network during 2020

The OIE/FAO FMD Reference Laboratory Network provides important support to the global control of FMD and provides opportunities and expertise for developing and sustaining laboratory capacity and capability, exchange of materials and technologies, harmonising approaches to diagnosis and supporting complementary research. Laboratories within the Network regularly receive samples for FMD diagnosis from many parts of the world. The *in vitro* antigenic properties of selected isolates are assessed for vaccine matching and nucleotide sequencing allows precise characterisation of new isolates and tracing of their origin by comparison with viruses held in virus collections. This analysis assists the monitoring of the 'real time' emergence and spread of FMD virus globally.

1284 clinical samples from suspect cases of FMD were tested by laboratories in the Network (and associated laboratories) during 2020. These samples were collected from 26 countries from all seven FMD endemic pools (Figure 2.4). **However, sampling within these pools is not equivalent:** and efforts are currently underway with the Network to improve sample collection in regions where sampling is particularly under-represented.

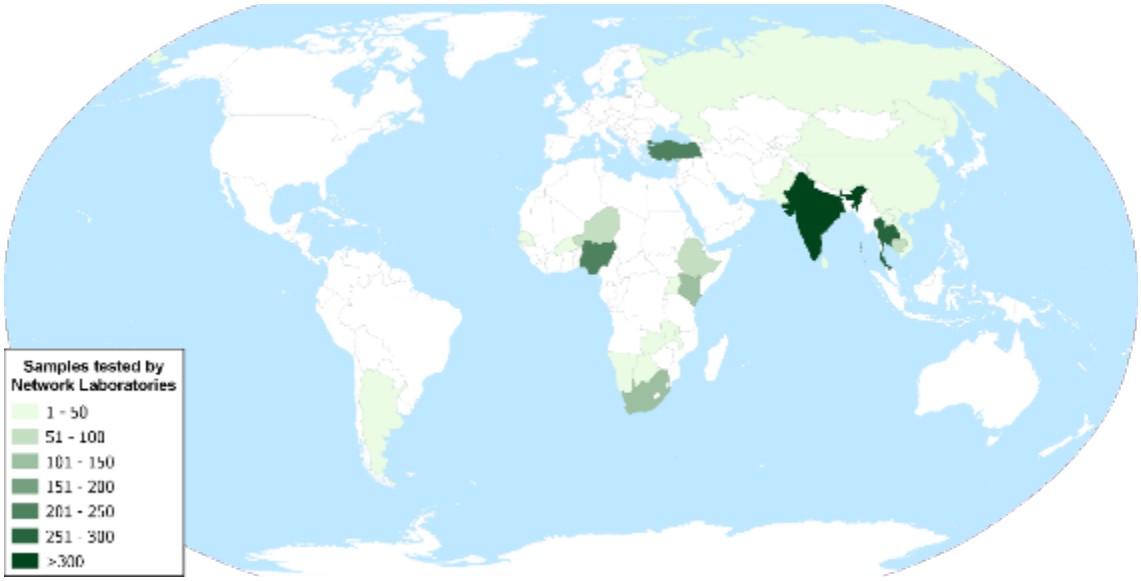


Figure 2-5: Distribution of samples collected from suspect cases of FMD and reported by the OIE/FAO FMD Laboratory network during 2020. Routine surveillance that is undertaken in countries that are FMD-free without vaccination is not shown

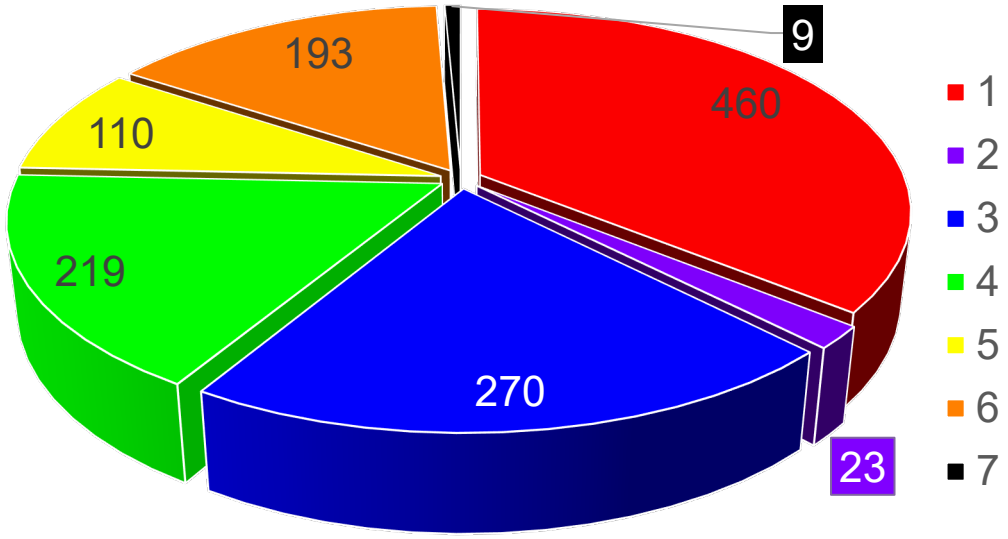


Figure 2-6: Clinical samples (n=1284) tested for FMD investigation (virology) by the OIE/FAO FMD Laboratory Network from FMD endemic countries during 2020 and their distribution across the seven FMD endemic pools (see Figure 2.1-1). NB: Pool 2 does not include data for samples tested at ICAR-DFMD.

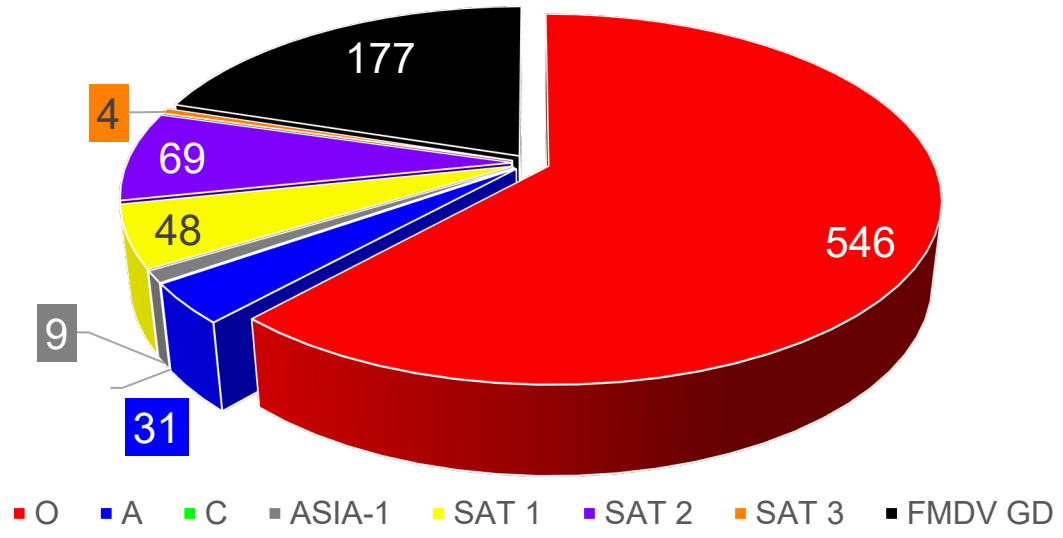


Figure 2-7: Summary of results for characterised isolates (n=1281) from FMD endemic countries were reported by the Network during 2020. FMDV GD denotes samples that were only positive using molecular (RT-PCR methods), while a further 556 samples were tested but found to be negative for FMDV using all diagnostic methods. B: Pool 2 does not include data for samples tested at ICAR-DFMD.

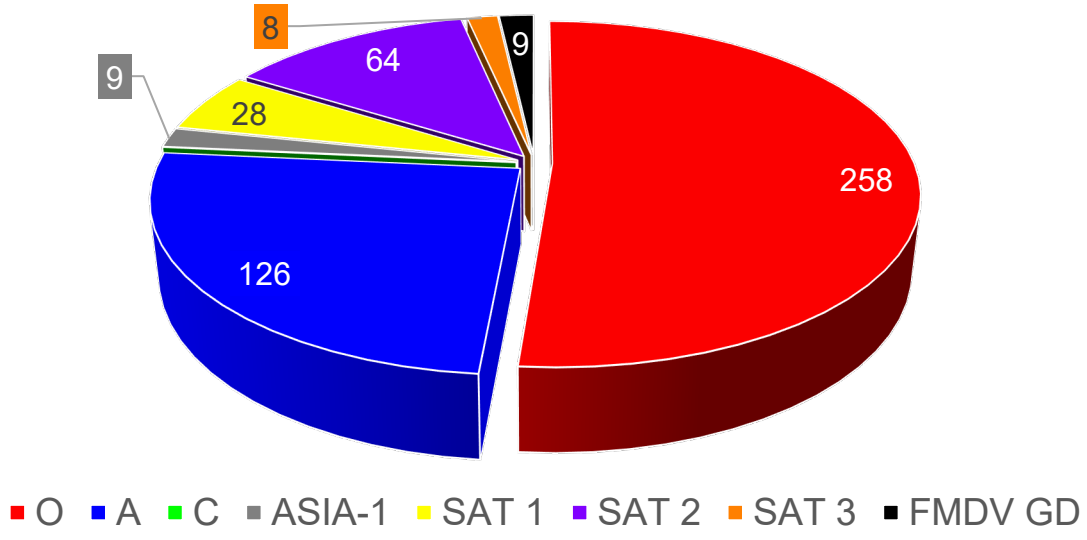


Figure 2-8: Summary of 502 samples (viruses and field isolates) that were sequenced (VP1/capsid/complete genome) during 2020 (see Appendix 3). B: Pool 2 does not include data for samples tested at ICAR-DFMD.

The results for the individual samples are reported later in this report. Characterization results obtained on samples received by WRLFMD and PANAFTOSA can also be found respectively at: http://www.wrlfmd.org/ and at: http://new.paho.org/panaftosa.

2.3 Regional distribution of different FMD viral lineages

In regions where FMD is endemic, continuous evolution of the virus generates geographically discrete lineages that are genetically distinct from FMD viruses found elsewhere. The conjectured global status for FMD (see Figure 2.1) masks the underlying complexity of FMDV virus distribution in the different pools (at serotype, topotype and lineage levels). This report showcases a new format to display how different FMD lineages ciruculate in different regions of the world. Using a new tool (called PRAGMATIST) that has been developed in partnership between WRLFMD and EuFMD, analyses accommodate the latest epidemiological data collected by the Network and presented in this report regarding FMDV lineages detected in samples to assess the relative importance of the viral strains circulating within each *source regions* (see Table below).

Table 2-2: Conjectured distribution of important FMDV lineages in different endemic regions. For each of the regions, data represent the relative importance of the different lineages [prevalence score estimated as a proportion (%) of total FMD cases that occur in domesticated host animals]. NB: Arrows highlight changes from the figures published in this table in last year's report

FMDV Lineage	West Eurasia	East Asia	North Africa	South Asia	East Africa	West & Central Africa	Southern Africa	South America
O/ME-SA/PanAsia-2	35	-	-	-	-	-	-	-
O/ME-SA/PanAsia	-	10	-	-	-	-	-	-
O/SEA/Mya-98	-	33	-	-	-	-	-	-
O/ME-SA/Ind2001	⬆ 7 (6)	20	10	80	-	-	-	-
O/EA or O/WA	3	-	55	-	55	70	-	-
O/EURO-SA	-	-	-	-	-	-	-	80
O/CATHAY	-	10.5	-	-	-	-	-	-
A/ASIA/Sea-97	-	⬆ 26 (25)	-	-	-	-	-	-
A/ASIA/Iran-05	⬆ 27 (25.5)	-	-	-	-	-	-	-
A/ASIA/G-VII	⬇ 15 (17.5)	-	-	16	-	-	-	-
A/AFRICA	-	-	25	-	22	15	-	-
A/EURO-SA	-	-	-	-	-	-	-	20
Asia-1	12.5	⬇ 0.5 (1.5)	-	4	-	-	-	-
SAT 1	-	-	-	-	8	5	27	-
SAT 2	0.5	-	10	-	14	10	57	-
SAT 3	-	-	-	-	1	-	16	-
C	-	-	-	-	-	-	-	-

Based on these data, a *prevalence score* is defined by estimating the proportion of each of the local viral strains that would be represented if 100 animals infected with FMDV were randomly selected from each source area.

In order to help visualise the changing patterns in FMDV distribution and recognise risks for the emergence of new lineages, the Network has reviewed available intelligence for epidemiologically important FMDV lineages (Table 2-2), focussing on those that have already demonstrated a potential for long-distance trans-pool spread: O/ME-SA/Ind-2001, O/ME-SA/PanAsia, O/ME-SA/PanAsia-2, O/SEA/Mya-98, O/EA-3, A/ASIA/G-VII, A/ASIA/Iran-05, A/ASIA/Sea-97 and SAT 2/VII.

The current known and conjectured distribution of these different FMD viral lineages are represented in the maps below: The extent of current distribution for each of the viral lineages is represented within the black lines, while the location of individual outbreaks (dots) and affected countries (shaded colours, according to dates) are shown. NB: Arrows are drawn to highlight the regions that are now threatened by these lineages and text boxes highlight some of the headline events and changes that have occurred during 2019-20.

FMDV O

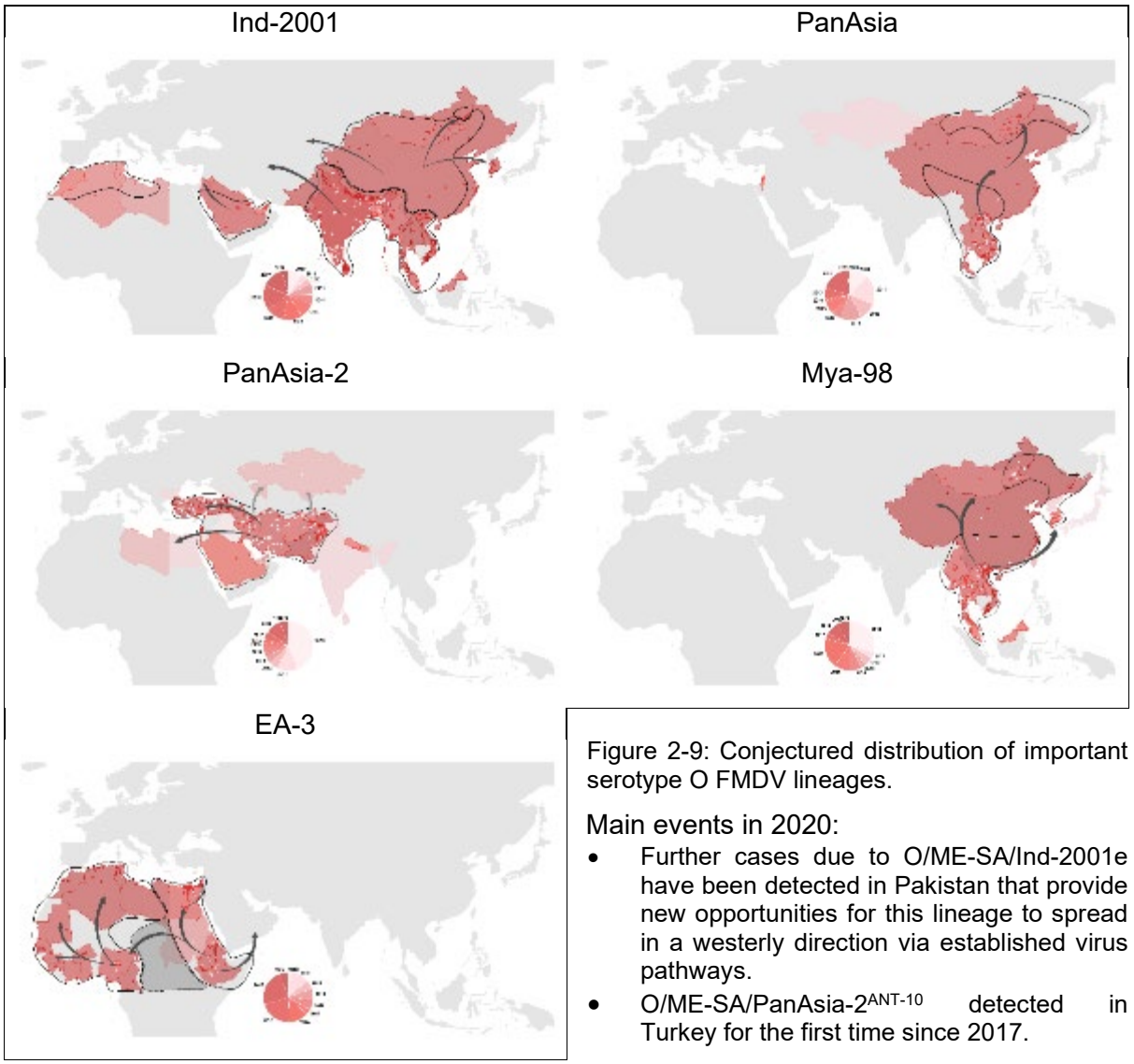


Figure 2-9: Conjectured distribution of important serotype O FMDV lineages.

Main events in 2020:

- Further cases due to O/ME-SA/Ind-2001e have been detected in Pakistan that provide new opportunities for this lineage to spread in a westerly direction via established virus pathways.
- O/ME-SA/PanAsia-2^{ANT-10} detected in Turkey for the first time since 2017.

FMDV A

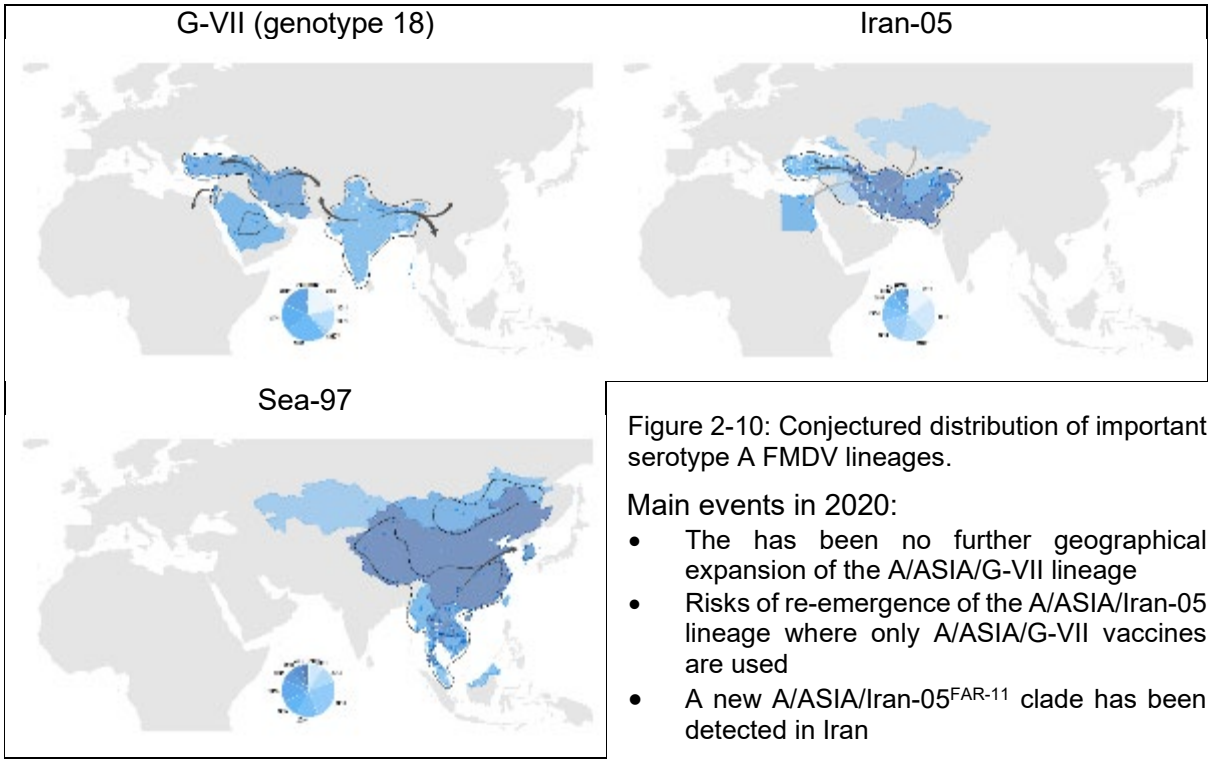


Figure 2-10: Conjectured distribution of important serotype A FMDV lineages.

Main events in 2020:

- The has been no further geographical expansion of the A/ASIA/G-VII lineage
- Risks of re-emergence of the A/ASIA/Iran-05 lineage where only A/ASIA/G-VII vaccines are used
- A new A/ASIA/Iran-05^{FAR-11} clade has been detected in Iran

FMDV Asia 1

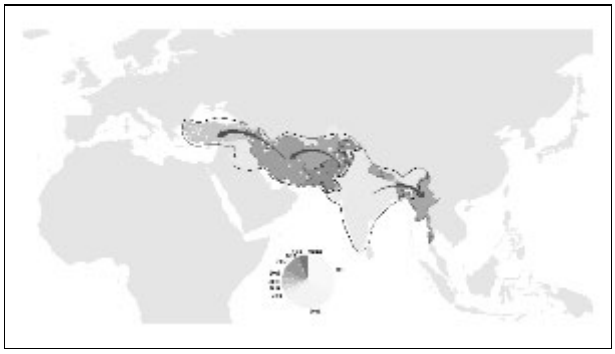


Figure 2-11: Conjectured distribution of serotype Asia 1.

Main events in 2020:

- No further spread of this serotype in Southeast Asia (beyond cases reported in 2017)

FMDV SAT 2

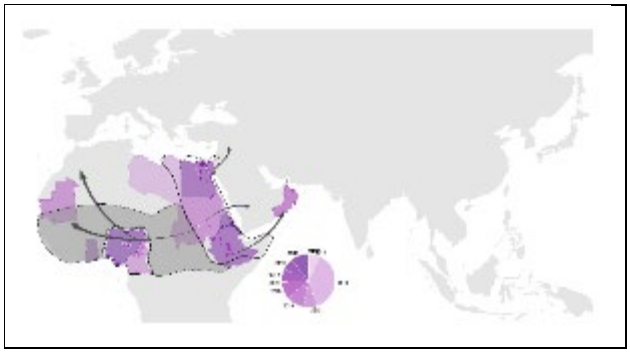


Figure 2-12: Conjectured distribution of serotype the SAT 2 (topotype VII) FMDV lineage.

Main events in 2020:

- Potential for this serotype to spread from West Africa into North Africa (paralleling the incursions of A/AFRICA/G-IV (in 2017) and O/EA-3 (in 2018/19).

2.4 Vaccine matching and recommendations

These take two forms: regional recommendations and details of locally produced vaccines for each of the FMD endemic pools are summarised later in this report, whilst the WRLFMD recommendations for FMD free countries are given in Figure 2-13 below. Details of vaccine matching work undertaken by the Network are summarised in Appendix 2.

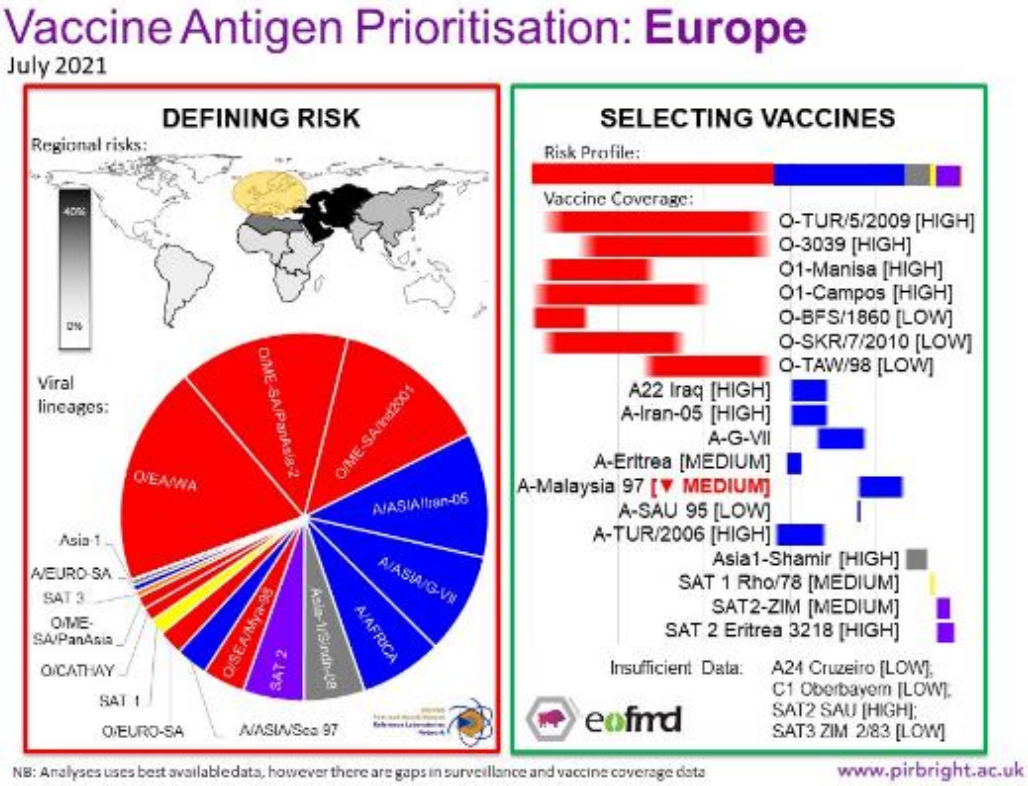


Figure 2-13: Recommendations from WRLFMD on FMD virus strains to be included in FMDV vaccine antigen bank for Europe

Outputs from WRLFMD are generated with a tool (called PRAGMATIST) that has been developed in partnership between WRLFMD and EuFMD. These analyses accommodate the latest epidemiological data collected by the Network regarding FMDV lineages that are present in different source regions (see Table 2-2 above), as well as available *in vitro*, *in vivo* and field data to score the ability of vaccines to protect against these FMDV lineages. Further

information about FMD vaccine producers is available on the Network website: https://www.foot-and-mouth.org/fmd-vaccine-producers

The figure highlights the importance of these source regions for Europe (using data collected at the EU-RL Workshop); please contact WRLFMD/EuFMD for assistance to tailor these outputs to other geographical regions. NB: Vaccine-coverage data presented is based on available data and may under-represent the true performance of individual vaccines.

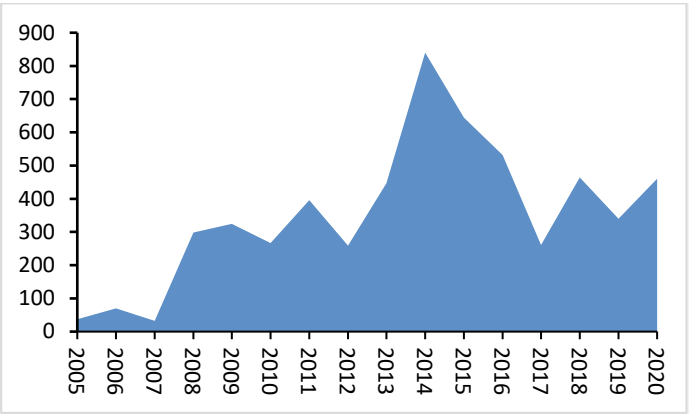
3 Overview of Network surveillance activities in each of the regional endemic pools

3.1 Pool 1 Regional synopsis

3.1.1 Conjectured circulating FMD viral lineages in Pool 1 during 2020

- Serotype O:
  - SEA/Mya-98
  - ME-SA/PanAsia
  - ME-SA/Ind2001d
  - ME-SA/Ind2001e
  - CATHAY
- Serotype A:
  - ASIA/Sea-97
- Serotype Asia-1 (no outbreaks detected since 2017, Myanmar)

Table 3-1: Overview of clinical samples collected and tested from Pool 1 in 2020 (countries highlighted in blue; graph represents clinical submissions since 2005)

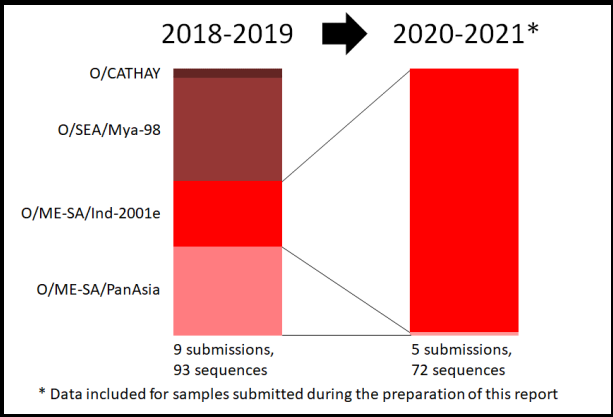


Laboratory	Countries of Origin	Number of Samples	
		Clinical Field Cases	*Surveillance Activities*
LVRI, China	China	27	5180
FGBI ARRIAH, Russia	Russia, Korea (Republic of)	6	54684 *
RRL SEA Pakchong, Thailand	Cambodia, Lao PDR, Thailand	358	5733
WRLFMD, UK	Cambodia, Lao PDR, Thailand, Vietnam	69	0

* 54684 from Russia. Some of these samples may be from Pool 3

Pool 1 headlines:

- Serotypes O & A are endemic in the Southeast Asia region. No new/unexpected lineages were identified in this region during 2020.
- During 2020, FMD outbreaks in China have been caused by O/SEA/Mya-98 (two clades), O/ME-SA/Ind-2001e and O/CATHAY (see A4.1)
- In January 2020 cases in the Russian Federation due to O/SEA/Mya-98 were reported (see A4.2)
- Three serotype O lineages were detected in samples collected during 2019-20 in Vietnam representing O/SEA/Mya-98, O/ME-SA/PanAsia and O/ME-SA/Ind-2001e (see A4.3)
- For serotype O, samples submitted to the WRLFMD during 2020 and 2021 highlight an increased dominance of the O/ME-SA/Ind-2001e lineage detected in countries in mainland Southeast Asia (Cambodia, Laos, Myanmar, Thailand and Vietnam).



- No new outbreaks due to serotype Asia1 were detected in 2020. This serotype has been absent since 1998, with the exception of outbreaks in Vietnam (2006) and Myanmar (2017).

3.1.2 Vaccine recommendations for Pool 1

- Internationally produced vaccines:
  - O: Campos, Manisa, Primosky, TUR/5/2009 & 3039
  - A: Arg2001, A24 Cruzeiro, Iran/05, A22/Iraq/64, Malaysia/97, TUR/20/06, Zabaikalsky & A22-IRQ.
  - Asia 1: Shamir
- Locally produced vaccines (at RRL SEA):
  - O: 189/87 (Udornthani/87)
  - A: Lopburi/12, Sakolnakorn/97
  - Asia1: Petchaburi/85
- Locally produced vaccines (at FGBI ARRIAH):
  - O: Ind-2001, Mya-98, PanAsia, PanAsia-2
  - A; G-VII, Iran-05, Sea-97
  - Asia1: Shamir, Sindh-08
- Locally used vaccine strains (by Chinese manufactures):
  - O/Mya-98 (O/Mya98/BY/2010 and Re-O/Mya98), O/HK99
  - Re-A/Sea-97 (Re-A/WH/09)

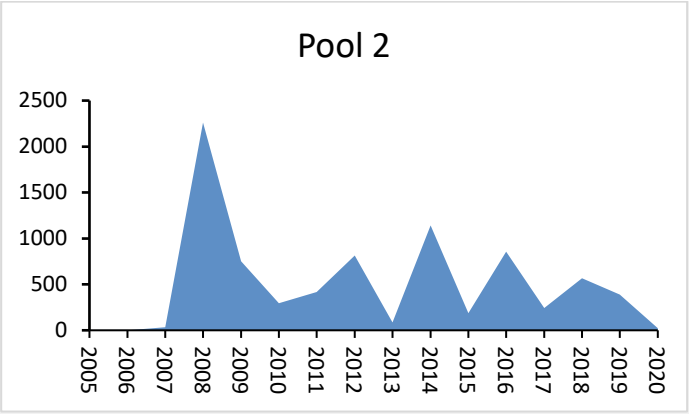
- Asia1/GV (Asia1/JSL/06).

3.2 Pool 2 Regional synopsis

3.2.1 Conjectured circulating FMD viral lineages in Pool 2 during 2020

- Serotype O:
  - ME-SA/Ind-2001
  - O/ME-SA/SA-2018 (Newly described lineage)
- Serotype A:
  - ASIA/IND (genotype VII also known as genotype 18)
- Serotype Asia-1:

Table 3-2: Overview of clinical samples collected and tested from Pool 2 in 2020 (countries highlighted in blue; graph represents clinical submissions since 2005)



Laboratory	Countries of Origin	Number of Samples	
		Clinical Field Cases	*Surveillance Activities*
ICAR-DFMD, India	~~India~~	[306]*	[30413]*
WRLFMD, UK	Sri Lanka	23	0

* Retrospective data for 2019 not included in the figures for 2020.

Pool 2 headlines:

- A new serotype O lineage was described for samples collected in Sri Lanka and new data provided from ICAR-DFMD India during the OIE/FAO FMD Laboratory Network meeting provides further evidence that this lineage (tentatively named O/ME-SA/SA-2018) is more widely distributed in South Asian countries.
  - New lineage is distinct from O/ME-SA/Ind-2001 (see A4.4 and A4.5)
  - Shares closest identity (~92% at VP1) to Indian virus collected in 2010

3.2.2 Vaccine recommendations for Pool 2

- Internationally produced vaccines:
  - O/ME-SA/PanAsia-2 (or suitable alternative). *In vitro* vaccine matching data for O/ME-SA/Ind2001 provides evidence for an antigenic match with O/TUR/09 vaccine (MSD) and O-3039 (Boehringer Ingelheim).

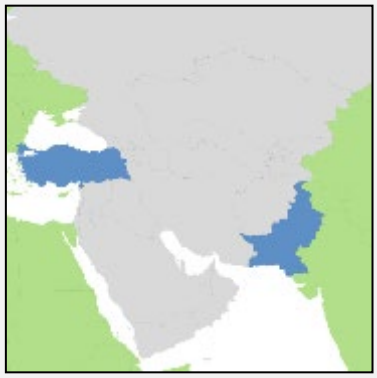
- Locally produced vaccines (by Indian suppliers):
  - O/IND/R2/1975
  - A/IND/40/2000
  - Asia1/IND/63/1972

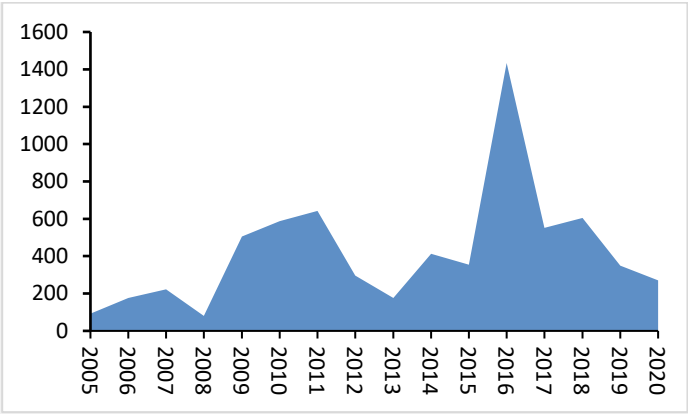
3.3 Pool 3 Regional synopsis

3.3.1 Conjectured circulating FMD viral lineages in Pool 3 during 2020

- Serotype O:
  - ME-SA/PanAsia-2 [comprising at least two viral sublineages (ANT-10 and QOM-15) present in different countries].
  - ME-SA/Ind-2001 (via introductions from South Asia: Pool 2)
  - EA-3 (in Israel & Palestinian Autonomous Territories)
- Serotype A:
  - ASIA/Iran-05 [comprising 4 predominant viral sublineages (SIS-10, SIS-12, SIS-13 and FAR-11)]
  - ASIA/G-VII
- Serotype Asia-1:
  - Sindh-08

Table 3-3: Overview of clinical samples collected and tested from Pool 3 in 2020 (countries highlighted in blue; graph represents clinical submissions since 2005)





Laboratory	Countries of Origin	Number of Samples	
		Clinical Field Cases	*Surveillance Activities*
ŞAP Institute, Turkey	Turkey	220	0
WRLFMD, UK	Pakistan	50	0

Pool 3 headlines:

- Sequencing of samples collected from Pakistan during 2016 to 2020 (see A4.6) show more than half were characterised as O/ME-SA/Ind-2001e indicating that this lineage has become widely established in the country (after it was detected for the first time in 2019). Recent analysis has now identified this sub-lineage in 10 districts within two separate provinces in North-Eastern and North-Western Pakistan.
- A new introduction of the O/ME-SA/PanAsia-2^{ANT-10} lineage into Turkey has been detected (for the first time since 2017) - see A4.7,
- A new genetic clade which has been detected in Iran has been described within the A/ASIA/Iran-05^{FAR-11} sub-lineage (see A4.8).
- The has been no evidence for the expansion of the A/ASIA/G-VII lineage

Hicks H. M., Wadsworth J., Azhar M., Manzoor S., Abubakar M., Khan E., King D. P. and Knowles N. J. (2020) Genome sequence of foot-and-mouth disease O/ME-SA/Ind-2001e strains isolated in Pakistan. *Microbiology Resource Announcements* 9: e00165-20.

Jamal SM, Khan S, Knowles NJ, Wadsworth J, Hicks HM, Mioulet V, Bin-Tarif A, Ludi AB, Shah SAA, Abubakar M, Manzoor S, Afzal M, Eschbaumer M, King DP, Belsham GJ. Foot-and-mouth disease viruses of the O/ME-SA/Ind-2001e sublineage in Pakistan. Transbound Emerg Dis. 2021 Apr 29. doi: 10.1111/tbed.14134.

3.3.2 Vaccine recommendations for Pool 3

Internationally produced vaccines

- MSD and Boehringer-Ingelheim (Merial)*:
  - O/ME-SA/PanAsia-2 (or suitable alternative)
  - O/Manisa
  - A Iran-05 (or A TUR 06)
  - A22/Iraq
  - Asia-1 Shamir
  - A/G-VII
- Locally produced vaccines (at FGBI ARRIAH):
  - O: Ind-2001, Mya-98, PanAsia, PanAsia-2
  - A; G-VII, Iran-05, Sea-97
  - Asia1: Shamir, Sindh-08
- Locally produced vaccines:
  - O/TUR/07 (PanAsia 2)
  - A05 (A/IRN/17)
  - A/Asia/GVII
  - Asia 1/TUR 15 (Sindh-08)
- Locally produced vaccines (other suppliers in the region):
  - Vetal
  - MEVAC

3.4 Pool 4 Regional synopsis

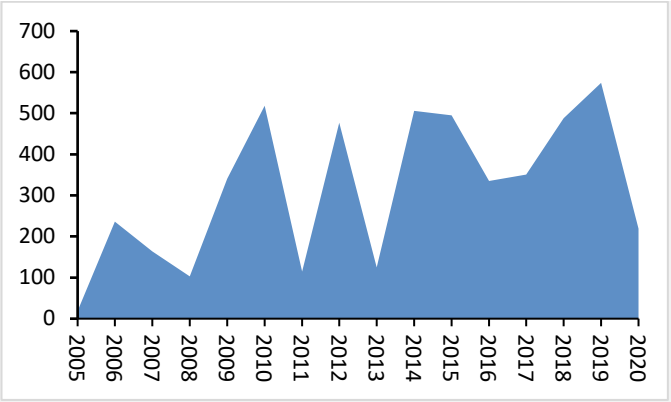
3.4.1 Conjectured circulating FMD viral lineages in Pool 4 during 2020

- Serotype O:
  - EA-2 (Kenya, Tanzania, DR Congo, Uganda)
  - EA-3 (Egypt, Ethiopia, Eritrea, Sudan)
  - EA-4 (Ethiopia, Kenya, Uganda)

- ME-SA/Sharqia-72 (detected in samples collected in Egypt in 2009)
- ME-SA/Ind2001 (in Libya, Tunisia, Algeria and Morocco)

- Serotype A
  - AFRICA/I (Kenya, Tanzania, D.R. Congo)
  - AFRICA/IV (Algeria, Sudan, Eritrea, Egypt)
  - AFRICA/VII (Ethiopia, Egypt)
  - ASIA/Iran-05^{BAR-08} (Egypt)
- Serotype SAT 1
  - I (Kenya, Tanzania)
  - IX (Ethiopia)
- Serotype SAT 2:
  - IV (Kenya, Tanzania)
  - VII (Sudan, Egypt, Mauritania)
  - XIII (Ethiopia, Sudan)
- Serotype SAT 3
  - Only detected in African buffalo in the south of the Queen Elizabeth National Park, Uganda in 1970, 1997 and 2013).

Table 3-4: Overview of clinical samples collected and tested from Pool 4 in 2020 (countries highlighted in blue; graph represents clinical submissions since 2005). *Note: These figures include samples collected in countries in North Africa where FMD outbreaks have occurred since 2013.*



Laboratory	Countries of Origin	Number of Samples	
		Clinical Field Cases	*Surveillance Activities*
RRLSS, BVI, Botswana	Ethiopia	0	60
NAHDIC, Ethiopia	Ethiopia	85	10713
IZSLER, Italy	Tanzania	0	127
FMD Laboratory, Kenya	Kenya	123	3351
WRLFMD, UK	Uganda	11	0

Pool 4 headlines and status in 2020:

- There have been new FMD outbreaks in North Africa (Libya), from where the disease threatens the Maghreb countries.
- SAT 2 was detected (by serology) in Kayonza, Rwanda.
    -
- A new initiative launched during late 2019/early 2020 aims to motivate vaccine producers to supply good quality FMD vaccines into the East African market (see: https://agresults.org/projects/fmd-vaccine)

[1]unpublished sequence data kindly provided by Prof. C. Kasanga, Sokoine University of Agriculture, Tanzania

3.4.2 Vaccine recommendations for Pool 4

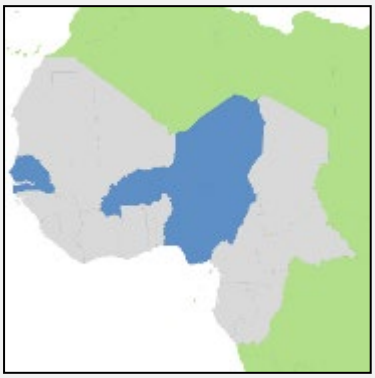
- Internationally produced vaccines:
    - O/Manisa
    - O/PanAsia-2 (or equivalent)
    - A/Eritrea
    - SAT2/Eritrea
- Locally produced vaccines from KEVIVAPI (Kenya):
    - O: K 77/78 - EA1
    - A: K5/80 - G1
    - SAT1: T155/71 - NWZ
    - SAT2: K52/84 - IV
- Locally produced vaccines from Ethiopia:
    - Serotype O (EA-3)
    - Serotype A (Africa-3)
    - Serotype SAT 2 (XIII)
- Locally produced vaccines from BVI (Botswana including the following strains O1Manisa 1/78, O Uganda 5/96, A/Zambia/90, SAT 1 105, SAT 109, SAT 2 251, SAT 2035) and ME-VAC (Egypt)

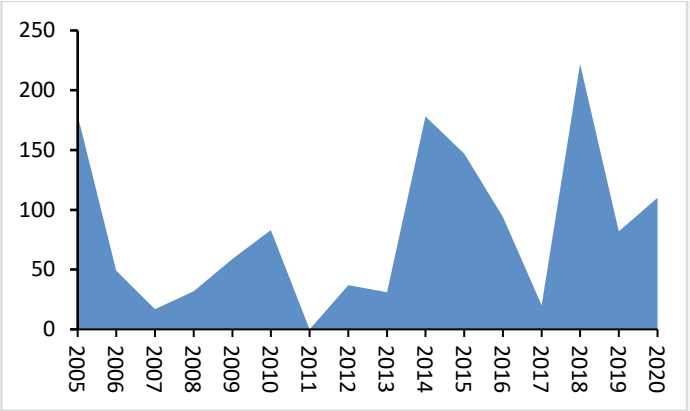
3.5 Pool 5 Regional synopsis

3.5.1 Conjectured circulating FMD viral lineages in Pool 5 during 2019

- Serotype O:
    - WA and EA-3 (Nigeria)
- Serotype A:
    - AFRICA/G-IV & G-VI
- Serotype SAT 1
    - Topotype X (Nigeria and Cameroon)
- Serotype SAT 2:
    - Topotype VII (Mauritania)

Table 3-5: Overview of clinical samples collected and tested from Pool 5 in 2020 (countries highlighted in blue; graph represents clinical submissions since 2005)





Laboratory	Countries of Origin	Number of Samples	
		Clinical Field Cases	*Surveillance Activities*
NCFAD, Canada	Nigeria	28	444
ANSES, France	Burkina Faso, Niger	78	0
NVRI, Nigeria	Nigeria	16*	
LNERV, Senegal	Senegal	4	0

* NVRI, Nigeria is still testing a further 163 samples submitted in 2020

Pool 5 headlines:

- Network laboratories have provided coordinated support to understand the emergence and spread of the O/EA-3 and A/AFRICA/G-IV topotypes in North Africa.
- Collection of good-quality samples from this region remains an important challenge and Network laboratories have implemented novel approaches using nucleic acid recovery from lateral-flow devices as well as RNA transfection methods to characterise FMD viruses causing outbreaks and to fill gaps in surveillance.
- Sample collected and tested by NVRI, Nigeria and NCFAD, Canada have characterised FMD viruses collected from recent field outbreaks, where serotypes O, A and SAT 2 have been detected (see A4.9 and A4.10)
- The emergence of O/EA-3 and A/AFRICA/G-IV (in 2017) in the Maghreb is a significant change of epidemiological status which may substantiate new trans-Saharan connections between North and West Africa which raise the onward risks to FMD-free countries in Europe.

3.5.2 Vaccine recommendations for Pool 5

- Internationally produced vaccines:
  - O/Manisa
  - O/Maghreb
  - O/PanAsia-2 (or equivalent)

- O: 3039
- A: Eritrea
- SAT 2: Eritrea & Zimbabwe

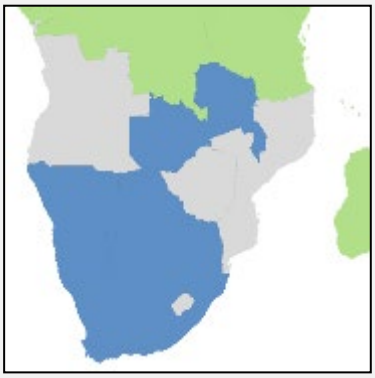
- Locally produced vaccines
  - O: NIG 04/14
  - O: WA and EA-3 topotypes
  - A: NIG 07/13
  - A: West Africa (G-IV lineage)
  - SAT 1: Topotype X
  - SAT 2: NIG 03/12
  - SAT 2: Topotype VII
  - O, A, SAT 1 & SAT 2 (Boru-Vacc, Nigeria)

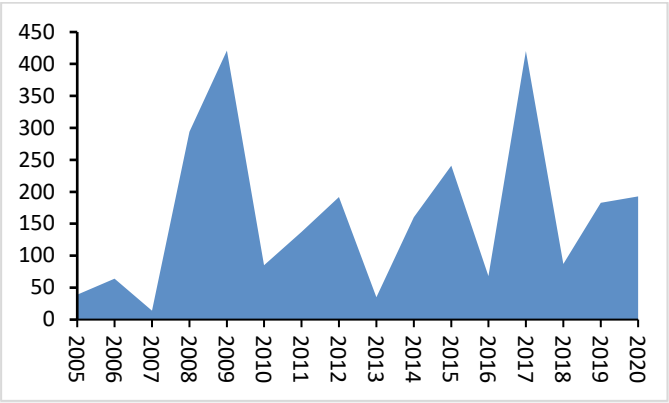
3.6 Pool 6 Regional synopsis

3.6.1 Conjectured circulating FMD viral lineages in pool 6 during 2020

- Serotype SAT 1:
  - Topotypes I, II and III
- Serotype SAT 2:
  - Topotypes I, II and III
- Serotype SAT 3:
  - Topotypes I, II and III)

Table 3-6: Overview of clinical samples collected and tested from Pool 6 in 2020 (countries highlighted in blue; graph represents clinical submissions since 2005)





Laboratory	Countries of Origin	Number of Samples	
		Clinical Field Cases	*Surveillance Activities*
RRLSS, BVI, Botswana	Botswana, Lesotho, Malawi, Namibia, Zambia	30 *	1513
ARC-OVI, South Africa	Eswatini, South Africa, Namibia, Swaziland, Zimbabwe	163	0

*BVI is still testing 32 samples from Botswana submitted in 2020

Pool 6 headlines:

- Sampling of FMD cases in this region has been impacted by the drought in Southern Africa
- There appear to be new risks due to serotype SAT 3 – where recent spread of this serotype may be linked to the drought and movement of animals into new areas
- New SAT 3 outbreaks have been detected in the Zambezi Region of Namibia (see A4.11 for samples collected during 2019).
- Sub-clinical cases (due to SAT 1) have been reported in South Africa.
- Outbreaks due to serotype SAT 2 was detected within the FMD protection zone in South Africa and southern Malawi (see A4.12).

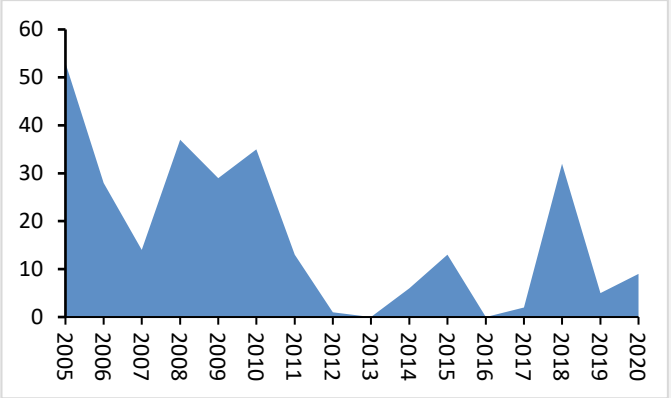
3.6.2 Vaccine recommendations for Pool 6

- Internationally produced vaccines:
  - O: O Manisa
  - SAT 1: SAT105, SAT 109
  - SAT 2: SAT251
  - SAT 3: SAT306, SAT 309
- Locally produced vaccines
  - O: O Manisa
  - SAT 1: SAT105, SAT109, a South African isolate and a Botswana isolate
  - SAT 2: SAT251, SAT2035 and a South African isolate
  - SAT 3: SAT306, SAT309 and a South African isolate

The ARC has developed 5 new vaccine strains are preparing for commercial release of these vaccines

3.7 Pool 7 Regional synopsis

Table 3-7: Overview of clinical samples collected and tested from Pool 7 in 2020 (countries highlighted in blue; graph represents clinical submissions since 2005)



Laboratory	Countries of Origin	Number of Samples	
		Clinical Field Cases	*Surveillance Activities*
Panaftosa, Brazil	South America	0	21

SENASA, Argentina	Argentina	9	12000

Pool 7 headlines:

- Except for Venezuela which has no official FMD status with the OIE, there have been no suspected cases of FMD anywhere in South America during 2020.
- Retrospective analyses has been undertaken for sequences recovered from FMD outbreaks the occurred in Colombia during 2018 (see A4.13).
- Brazil is expected to suspend vaccination in 2023 (some regions will cease vaccination in 2020)
- In Brazil the FMD status of the states of Acre, Paraná, Rio Grande do Sul, and Rondônia to Free from FMD Without Vaccination was recently recognised by the OIE.

3.7.1 Vaccine recommendations for Pool 7

- Internationally produced vaccines:
  - All vaccines used in the region are produced in South America (Argentina, Brazil, Colombia, Paraguay & Venezuela have vaccine manufacturers)
- Locally produced vaccines
  - O: O_1 Campos
  - A: A_{24} Cruzeiro, A/Arg/2001*
  - C: C_3 Indaial*

**Only Argentina uses A/Arg/2001 and C_3 Indaial.*

4 Improving the quality of laboratory tests from FMD reference laboratories

4.1 Proficiency testing schemes (PTS) organised by the Network Partners

Australia

- 2 rounds of both FMD PCR and ELISA PT in 2020 have been provided and distributed to our LEADDR network (9 participating state labs).
- Panels included representation of Serotypes
    - Asia-1 Shamir, O1 Manisa, A Iran 05 for PCR.
    - SAT2 SAU, SAT3 ZIM, O UKG for serological assessment.

Belgium

- EU-RL PT_2020 organised by ANSES, with the participation of Sciensano (joint EU-RL) to this PT as a NRL.

Brazil

- National Reference Laboratories participating
    - Argentina, Brazil, Uruguay, Colombia, Ecuador, Panama, Paraguay, Peru, Trinidad and Tobago, Mexico and Canada.
- Two Proficiency testing schemes
    - FMDV and VSV tests
        - RT-PCR
        - RT-qPCR
        - ELISA-LPBE
        - ELISA 3ABC / EITB
        - VNT test for detection of anti-FMDV antibodies
    - VNT test for detection of anti-VSV antibodies (VSNJV, VSIV, COCV and VSAV)

Canada

- FMDV rRT-PCR proficiency test scheme for 24 analysts from Canadian Animal Health Surveillance Network (CAHSN) Laboratories
- FMD 3ABC cELISA proficiency test scheme for 18 analysts from Canadian Animal Health Surveillance Network (CAHSN) Laboratories

China

- National PT for major animal disease organized by CADC and LVRI in 2020 funded by MARA. The LVRI provided blind samples of FMD serum and SPCE kits for 37 local laboratories.

France

- FMD/SVD Proficiency testing scheme 2020
    - Objective: to evaluate the existing ability of each laboratory to diagnose FMD/SVD outbreaks using virological and serological methods.
    - 38 participants from 37 European countries

Italy

- National Proficiency Testing Scheme organised for ten Regional Labs in Italy.
    - Objective: To practise the regional laboratories in the use of serological and molecular tests for maintaining preparedness in case of national emergency.
    - Completion of PT 2019: panel of 22 sera for FMDV serology, with interpretation of the FMD status of animals (similar to Panel 3 of WRL FMD PTS).
    - 2020: First introduction of PT for molecular assay Framework: Involvement of regional Labs in “FMD exclusion testing” Speed up control measures in secondary outbreaks after incursion in FMD-free country.

Republic of Korea

- The national proficiency tests (2020)
    - 9 Regional Diagnostic Centers
    - FMD antigen and antibody test (twice a year)

Russian Federation

- LPB ELISA for labs of Kyrgyzstan, Kazakhstan, Belarus, Armenia.

Thailand

- Proficiency Testing Scheme 2020
    - FMD serology by liquid phase blocking ELISA (LP-ELISA) and NSPs test for Nation Laboratory in Thailand

USA

- Produced, distributed, and evaluated 257 FMD proficiency test (PT) panels and 134 reference/training panels to the National Animal Health Laboratory Network (NAHLN) laboratories

4.2 Supply of reagents

Argentina

Type of reagent	Quantity	Recipient of the reagent (Laboratories/Countries)
FMD challenge viral suspension for PGP test A24 Cruzeiro A Arg 2001 O1 Campos	200 vials x1 ml	Argentina
3ABC ELISA	20 x 10 plates	Argentina
3ABC Protein	8 vials x1 ml	Argentina
3D Protein/3B Protein	3 vials x 1ml each	Argentina

Australia

Type of reagent	Quantity	Recipient of the reagent (Laboratories/Countries)
Network quality controls (plasmid controls for both IRES and 3D PCR assay quality control monitoring)		LEADDR labs, Australia
inactivated positive control material		Brunei

Belgium

Type of reagent	Quantity	Recipient of the reagent (Laboratories/Countries)
FMD virus	2 × 1 ml	ANSES (EU-RL FMD)
FMD antibody positive serum	5 × 45 ml	ANSES (EU-RL FMD)

Brazil

Type of reagent	**Quantity**	**Recipient of the reagent (Laboratories/Countries)**
FMDV Kits for detection of antibodies against non-structural protein (NSP): Kit Elisa 3ABC - Screening Test	254	Argentina (Biogenesis BAGÓ) Brazil (IBSP, LREF) Colombia (VECOL, ICA) Ecuador (AGROCALIDAD) South Korea (BASIC SCIENCE, PORKCHOP SANDBOX) Paraguay (SENACSA) Taiwan (Tseng Hsiang Life Science Ltd.) Uruguay (DILAVE)
FMDV Kits for detection of antibodies against non-structural protein (NSP): Kit EITB-confirmatory test	236	Argentina (Biogenesis BAGÓ) Brazil (IBSP, LREF, LFDA/RS) Colombia (VECOL, ICA) Ecuador (AGROCALIDAD) South Korea (BASIC SCIENCE, PORKCHOP SANDBOX) Paraguay (SENACSA) Taiwan (Tseng Hsiang Life Science Ltd.) Uruguay (DILAVE)

Type of reagent	Quantity	Recipient of the reagent (Laboratories/Countries)
FMDV Kits for detection of antibodies against structural protein (Liquid Phase Blocking ELISA -LPBE): ELISA CFL FMD "O" ELISA CFL FMD "A" ELISA CFL FMD "C" kits for post vaccination monitoring purposes	335	Brazil (LREF) Colombia (VECOL, ICA) Ecuador (AGROCALIDAD) Paraguay (SENACSA) Uruguay (DILAVE)
FMDV antigen detection kits FMDV/VSV ELISA Typification	20	Brazil (LREF) Colombia (VECOL) Ecuador (AGROCALIDAD) Paraguay (SENACSA)
Cell lines	12	Brazil (Tecpar, Fiocruz, LABZOO-CCZ) Colombia (ID.VET)
Semillade Virus ESTOMATITIS	20	Ecuador (AGROCALIDAD)
Semillade Virus AFTOSA	5	Paraguay (LAUDA)
Antisera NSP (reference material)	37	Ecuador (AGROCALIDAD) Taiwan (Tseng Hsiang Life Science Ltd.) Colombia (ID.VET)

Canada

Type of reagent	Quantity	Recipient of the reagent (Laboratories/Countries)
Pre-coated FMDV 3ABC cELISA plates	69	Canadian Animal Health Surveillance Network (CAHSN) laboratories
FMD 3ABC cELISA panels	19	Canadian Animal Health Surveillance Network (CAHSN) laboratories
FMD rRT-PCR panels	26	Canadian Animal Health Surveillance Network (CAHSN) laboratories
Hybridoma secreting the FMDV 3B monoclonal antibody	2 ml	Pan American Foot and Mouth Disease Center (PANAFTOSA), Brazil

China

Type of reagent	Quantity	Recipient of the reagent (Laboratories/Countries)
LPBE-O	9243	China
LPBE-Asia1	202	
LPBE-A	4241	
NSP-3ABC-ELISA	1428	
SPCE	202	
Conventional Multi-RT-PCR	174	
Real-time RT-PCR	2257	
Typing real-time RT-PCR	175	

France

Type of reagent	Quantity	Recipient of the reagent (Laboratories/Countries)
Primers for typing	200 reactions	LABOCEL/NIGER

Italy

Type of reagent		Quantity
FMDV antigen detection ELISA type O, A, C, Asia1, SAT1-2		103
NSP Ab ELISA KIT (3ABC)		56
SP-Antibody ELISA Kit	FMDV O	1152*
	FMDV A	221
	FMDV Asia1	724*
	FMDV SAT 1	5
	FMDV SAT 2	18

** SP-Antibody ELISA kits for type O and Asia1 were selected for PVM in Kazakhstan*

Request for FMDV antigen detection ELISA kit has decreased of 60% in 2020. A consequence of COVID-19 emergency?

Republic of Korea

Type of Reagent	Product name	Details	Quantity	Recipient of the reagent (Lab / Countries)
Antigen Test	VDx FMDV O qRT-PCR	rRT-PCR kit for serotype O&O/Ind-2001	144	Myanmar, Malaysia, Vietnam
	VDx FMDV A qRT-PCR	rRT-PCR kit for serotype A&A/Sea97	144	
	VDx FMDV Asia1 qRT-PCR	rRT-PCR kit for serotype Asia1	144	
Antibody Test	VDpro FMDV NSP Ab ELISA (Median Diagnostic)	NSP Ab ELISA	480	Myanmar
	FMDV NSP(3ABC) Antibody ELISA (Bionote)	NSP Ab ELISA	480	
	VDpro FMDV SP Ab ELISA (Median Diagnostic)	SP O Ab ELISA	480	
	FMDV SP Antibody ELISA (Bionote)	SP O Ab ELISA	480	

Russian Federation

Type of reagent	Quantity	Recipient of the reagent (Laboratories / Countries)
LPB ELISA	2582	Russia, Kyrgyzstan, Kazakhstan
Ag ELISA	30	Kyrgyzstan
FMD RT-PCR-RT	16	Russia

Thailand

Type of reagents	Supplied nationally and own lab	Remarks
Rabbit Ab/O189	25	National Laboratory in Thailand
Rabbit Ab/Alopburi	28	
Rabbit Ab/Asakolnakon	4	

Type of reagents	Supplied nationally and own lab	Remarks
Rabbit Ab/Asia1	24	
GP Ab/O189	33	
GP Ab/Alopburi	28	
GP Ab/Asakolnakon	4	
GP Ab/ Asia1	27	
Antigen/ O189	55	
Antigen/ Alopburi	60	
Antigen Asakolnakon	2	
Antigen/ Asia1	98	
Strong Positive Control Serum	19	
Weak Positive Control Serum	17	
Negative Control Serum	14	

United Kingdom

Type of reagent	Quantity	Recipient of the reagent (Laboratories / Countries)
Antigens	33 vials	USA
Antisera	30 vials	Argentina, Germany, UK
Controls	45 vials	Eritrea, Hong Kong, Poland, Taiwan
NSP panel	78 vials	South Korea, Saudi Arabia
Antigens, Antisera, Controls and/or NSP sera	1445 vials	Botswana, China, Poland, Republic of Korea, UK, Vietnam
Virus isolates	170 vials	Argentina, Canada, France, Israel, Poland, Russia, Turkey, UK

USA

Type of reagent	Quantity	Recipient of the reagent (Laboratories/Countries)
Cultured cell flasks	330 lots (9,588 flasks)	FADDL
Reagent-grade rabbit FMDV specific antisera	>300 ml	FADDL
Reagent-grade guinea pig FMDV specific antisera	>100	FADDL

4.3 Training courses organised by Network partners

Argentina

- Online training provided on:
  - FMD Aetiology, Pathogenesis and Transmission
  - FMD collection, conditioning and submission of samples
  - FMD Clinical and Laboratory Diagnosis

Brazil

- 22nd October 2020 - Conference on Blue Tongue for Official Veterinarians
  - Uruguay; Edviges Maristela Pituco -PANAFTOSA-PAHO/WHO
- E-training on the Surveillance of vesicular diseases (6 meetings)
  - About 400 veterinarians participated in 6 workshops

Date	Attendees	Instructors
3-5 August 2020	IDAF, Acre	Edviges Maristela Pituco - PANAFTOSA-PAHO/WHO Marcelo Fernandes Camargos - MAPA Katherine Sharlene Barbosa Fragoso - MAPA Gabriel Adrian Sanchez Torres - MAPA Roberto Siqueira Bueno - Iagro/MS Marcio Alex Petró - IDARON/RO
18-21 August 2020	AGED, Maranhão	
14-17 September 2020	IAGRO, Mato Grosso do Sul	
13-16 October 2020	IDARON, Rondônia	
9-13 November 2020	SEAPDR, Rio Grande do Sul	
23-26 November 2020	CIDASC, Santa Catarina	

Canada

- 2020 adaptation of the EuFMD emergency preparedness course to fit the Canadian context
- Foreign Animal Disease Recognition course for Canadian Veterinarians

China

- 6 seminars and workshops organized by provincial labs (Anhui, Ningxia (2), Shaanxi, Jilin and Gansu), experts from LVRI offered support.
- 2 biosafety trainings held in LVRI.

France

- Regional Virtual training on Foot and Mouth Disease (FMD) – "Field Outbreak Investigation and laboratory diagnostics in West and Central Africa (WCA)"

- 18th-19th November 2020
- 14 countries (Benin, Burkina Faso, Côte D'Ivoire, Gambia, Ghana, Guinee, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Chad, Togo).

- Virtual training workshop for Southeastern Europe - "FMDV detection and typing using molecular tools"
  - 30th November and 4th December 2020
  - 15 participants from 8 countries (Turkey, Montenegro, North Macedonia, Serbia, Croatia, Greece, Bulgaria, Ukraine).

Republic of Korea

- Laboratory diagnostic training of regional veterinarians working for Regional Diagnostic Centres
  - 20 veterinarians

Russian Federation

- Four hands-on training courses.
  - 11 participants

Thailand

- Refreshed training for Basic Biosafety and Biosecurity in RRL (Virtural training).

4.4 Collaborative projects

Argentina

Collaborators	Purpose of collaboration	Outcomes
SENACSA Paraguay	Bilateral agreement in the diagnosis and control of zoonoses, and Biosecurity and Biosafety.	
Vietnam	FMD viral characterization	
QIA, South Korea	FMD Vaccine Quality Control	
PID 2013-2022	Development of FMD new generation vaccines based on no infection viral capsides	

Belgium

Collaborators	Purpose of collaboration	Outcomes
BVI, Botswana	bilateral collaboration	Participation of Sciensano in PT organised by BVI
LNV, Burundi	bilateral collaboration	on hold due to Covid restrictions
NVRI, Nigeria;	bilateral collaboration	on hold due to Covid restrictions
KULeuven, Belgium; Addis Ababa University, Ethiopia	JOINT international networking project	on hold due to Covid restrictions

Brazil

Collaborators	Purpose of collaboration	Outcomes
National Centre for Foreign Animal Disease (NCFAD), Canadian Food Inspection Agency, Canada	Full genome sequencing of historical strains FMDV isolates in South America	New Generation Sequencing (NGS) data for South American FMDV isolates (Sequenced: 35/35 FMDV-O and 64/76 FMDV-A)
The Pirbright Institute, UK; National Centre for Foreign Animal Disease (NCFAD), Canadian Food Inspection Agency, Canada	Validation new b-ELISA 3ABC	Report on the estimation of the diagnostic sensitivity and specificity of the b-ELISA 3ABC based on a known panel. Kit made available to support countries in foot-and-mouth disease surveillance, contributing to the Hemispheric Foot-and-Mouth Disease Program (PHEFA)
COSALFA countries (South American commission for the fight against Foot-and-Mouth Disease) [all South America & Panama]	Preparation of Action Plan 2021-2025 Hemispheric Program for the Eradication of Foot-and-Mouth Disease PHEFA	Document to be approved by COHEFA, 15th December 2020 This plan contains programmatic guidelines for national plans. Vaccine suspension forecast by 2026 across continent.

Canada

Collaborators	Purpose of collaboration	Outcomes
Botswana Institute for Technology Research and Innovation (BITRI); Botswana Vaccine Institute (BVI); The Pirbright Institute, UK	Development of a multiplex FMD lateral flow strip test for FMDV antigen detection and serotyping	Multiplex lateral flow strip test for FMDV serotypes A, O, SAT 1, 2, & 3
National Veterinary Research Institute (NVRI), Nigeria	Capacity building for National and Regional Foot-and-Mouth-Disease Control Strategy in Nigeria	Enhanced capacity for FMDV diagnosis, characterization of circulating FMDV serotypes
Boehringer Ingelheim	Determination of the 50% protective dose (PD50) of FMD vaccines in pigs	Data on potency of FMD vaccines in pigs
Animal and Plant Quarantine Agency, South Korea	Comparative studies for Foot and Mouth Disease virus diagnostics and vaccines in Cattle	Validated FMD diagnostic kits, efficacy of FMD vaccines in cattle

Collaborators	Purpose of collaboration	Outcomes
University of Calgary, Alberta, Canada	Application of the split TreA enzyme assay for detection of antibodies to FMDV Non-Structural Proteins (3ABC)	Rapid FMD 3ABC antibody detection assay
Shaddari Inc., Montreal, QC, Canada	Computational tool for foot-and-mouth disease vaccine matching	A vaccine matching tool that can rely on either VNT data or FMDV P1 sequences
The Pirbright Institute, UK	Point-of-care test for FMDV detection	Validated strip test for FMDV antigen detection

China

Collaborators	Purpose of collaboration	Outcomes
Kazakh National Agrarian University, Kazakhstan (Prof. Gulnaz Ilgekbayeva)	Cooperative creation and application studies of new products for prevention and control of major transboundary animal diseases	Constructed the FMD marker vaccines Established the platform for expression and *in vitro* assembly of FMD VLPs
Korea Atomic Energy Research Institute	Research and development of FMD viral like particle (VLP) （ finished in July，2020）	Immune optimization and mechanism of targeting dendritic cells with FMD VLPs

Italy

Collaborators	Purpose of collaboration	Outcomes
The Pirbright Institute (UK)	Continuous validation and improvement of diagnostic kits (ELISA), new developments	• Recombinant products (Integrin, VLPs) in ELISA kits • Development of new prototype tests (pan-SP serology, 146S integrity) • Cross-reactivity of SP Ab-ELISAs • Antigen profiling on selected strain in the framework of AgResult Project
University of Turin (Italy)	Development of multiplex LFD for FMDV serotyping in field conditions	Two prototypes of LFDs 1. EuroAsian serotypes: O, A, Asia 1, pan-FMD 2. SAT1, SAT2, pan-SATs

Collaborators	Purpose of collaboration	Outcomes
University of Glasgow (UK)	To time outbreaks of specific serotypes and inform epidemiological models of disease spread in the context of pastoralist livestock movements in FMD endemic settings	• Profiling of SP-Ab in sera from longitudinal studies • Exploitation of pool 4 topotype-specific realtime-PCRs

Republic of Korea

Collaborators	Purpose of collaboration	Outcomes
National Center for Veterinary Diagnosis, Department of Animal Health, Hanoi, Vietnam	To carry out comparative studies of Avian influenza virus and Foot and mouth disease virus between Korea and Vietnam	Data and materials (2016-2024)
National Animal Health and Production Research Institute, General Directorate of Animal Health and Production, Phnom Penh, Cambodia National Animal Health Laboratory, Vientiane Lao PDR	To study on genetic characterization of foot and mouth disease viruses and avian influenza virus in FMD and AI endemic countries (Cambodia and LAO PDR)	Data and materials (2018-2022)
NCFAD, Canada	Collaborative validation studies of solid phase competitive enzyme-linked immunosorbent assay and rapid detection kits for antibodies to NSPs for FMDV	Data and materials (2019~2020)
Central Disease Investigation Laboratory, Dhaka, Bangladesh	To study on genetic characterization of foot and mouth disease viruses in Bangladesh	Data and materials (2020~2024)
The Pirbright Institute, UK	To carry out a collaborative research project on Molecular epidemiology and NGS platform studies on foot and mouth disease virus (FMDV) between APQA, Korea and WRLFMD, United Kingdom	Data and materials (2020-2021)

Nigeria

Collaborators	Purpose of collaboration	Outcomes
NCFAD, Canada	Capacity building for the development of a diagnostic kit (In-house ELISA) as part of a National and Regional Foot-and-Mouth Disease Control Strategy (2019–2022)	
EuFMD	Study on the evaluation of the role of small ruminants in the spread and endemicity of Foot-and-Mouth Disease in Northern Nigeria	

Russian Federation

Collaborators	Purpose of collaboration	Outcomes
Mongolia	Assessment of immunity level in animals vaccinated against FMD and detection of possible virus circulation in zones where vaccination is practiced (at the stage of signing)	Eradication of highly dangerous diseases including FMD in Mongolian livestock. Continues to 2022.
China (People's Republic of); Mongolia	Agreement on cross border trade and TADs risk reduction between China, Mongolia and Russia	Interactions in case of emergencies associated with dangerous animal diseases including FMD
Armenia; Azerbaijan; Georgia; Iran; Turkey	Cooperation on the prevention and control of foot and mouth disease and other transboundary animal diseases between the countries of the Caucasus, Russia and Iran (GF-TADs)	Exchange of information on outbreaks of diseases, vaccination of animals
	Joint CIS measures for FMD prevention and control	FMD prevention and control. Continues to 2025

Thailand

Collaborators	Purpose of collaboration	Outcomes
WRL	PT participating and sample confirmation	QA Maintain and collaboration
DTRA-MORU	BSL-3 renovation	New BSL3 facility
NIAH-Japan	2021 Scientific Meeting planning	Scientific and research collaboration

United Kingdom

Collaborators	Collaborative project	Outcomes
AU-PANVAC, Ethiopia	OIE Twinning Project	Vaccine QA/QC for Africa
FLI, Germany	Validation of PCR lysis buffer methods	Optimise biosafe methods for FMDV
IZSLER, Italy	Development of FMD ELISA tests	On-going new ELISA tests for FMD diagnosis
SUA, Tanzania;	Improved tools for the surveillance and diagnosis of FMD	Understanding the epidemiology of FMD in endemic settings
TVLA, Tanzania	Serological assays for FMD	Post-vaccination testing and surveillance
KSRVI, Kazakhstan	Development of new vaccine matching tests for FMD	Generate validation data for field tests
IZSLER, Italy; ANSES, France; Lelystad, The Netherlands	Validation of NSP tests	Inter-laboratory exercise for NSP assays

Appendix 1 - Details of clinical samples from field cases from countries in FMDV endemic regions tested during 2020

Laboratory	Samples from	Total	O	A	C	Asia 1	Sat 1	Sat 2	Sat 3	Untyped	NVD	Comments
ANSES	Burkina Faso	12	-	-	-	-	-	-	-	11	1	
	Niger	66	-	-	-	-	-	-	-	27	39	
APQA	-	-	-	-	-	-	-	-	-	-	-	Draft Data
ARC-OVI												
	Eswatini	3	-	-	-	-	-	-	-	-	3	
	Namibia	35	-	-	-	-	-	-	-	-	35	
	South Africa	125	-	-	-	-	-	33	-	-	92	
BVI												
	Botswana	14	-	-	-	-	3	-	-	-	11	
	Malawi	2	-	-	-	-	-	2	-	-	-	
	Namibia	8	-	-	-	-	-	2	4	-	2	
	Zambia	6	5	-	-	-	-	-	-	-	1	
CSIRO	-	-	-	-	-	-	-	-	-	-	-	Draft Data
FADDL	-	-	-	-	-	-	-	-	-	-	-	
FGI-ARRIAH	Russia	6	6	-	-	-	-	-	-	-	-	
FMD laboratory	Kenya	123	48	-	-	-	35	-	-	-	40	
ICAR-Directorate of FMD*	India	306	145	2	-	-	-	-	-	-	159	Draft Data
IZSLER	-	-	-	-	-	-	-	-	-	-	-	
LNERV	Senegal	4	-	-	-	-	-	-	-	-	-	Draft Data
LVRI	China	27	5	-	-	-	-	-	-	10	12	
NAHDIC	Ethiopia	85	30	6	-	-	10	29	-	10	-	
NCFAD	Nigeria	28	2	16	-	-	-	3	-	-	7	
NVRI	Nigeria	16	10	6	-	-	-	-	-	-	-	
PANAFTOSA	-	-	-	-	-	-	-	-	-	-	-	
RRLSEA	Cambodia	91	36	-	-	-	-	-	-	48	7	Samples from 2018
	Lao PDR	9	9	-	-	-	-	-	-	0	-	
	Thailand	258	195	-	-	-	-	-	-	40	23	
Şap Institute	Turkey	220	110	-	-	-	-	-	-	5	105	Draft Data
SENASA	Argentina	9	-	-	-	-	-	-	-	-	9	
WRLFMD												
	Cambodia	9	9	-	-	-	-	-	-	-	-	
	Laos	5	5	-	-	-	-	-	-	-	-	
	Pakistan	50	30	5	-	9	-	-	-	6	1	One sample tested dually positive for serotypes O and Asia-1
	Sri Lanka	23	15	-	-	-	-	-	-	4	4	
	Thailand	16	12	4	-	-	-	-	-	-	-	
	Uganda	11	-	-	-	-	-	-	-	9	2	
	Vietnam	39	29	-	-	-	-	-	-	7	3	

* Numbers for 2019

Appendix 2 - Vaccine matching studies undertaken by Network partners during 2019

Vaccine efficacy is influenced by both vaccine potency and vaccine match and it is possible that a poor match may to some extent be compensated by high potency vaccines and by administering more than one dose at suitable intervals. The use of oil adjuvant is also expected to improve efficacy. Thus, a vaccine with a weak antigenic match to a field isolate, as determined by serology, may nevertheless afford some protection if it is of sufficiently high potency. Therefore, in the absence of a good match, or where the match is unknown, vaccines of high potency should preferably be used. The r_1 values shown below, represent the one way serological match between vaccine strain and field isolate, calculated from the comparative reactivity of an antiserum, raised against the vaccine in question, to the vaccine virus and the field isolate.

Key:

M	Matched with the vaccine
B	Borderline
N	Not matched with the vaccine

For VNT:

$r_1 \geq 0.3$ – suggest that there is a close relationship between field isolate and vaccine strain. A potent vaccine containing the vaccine strain is likely to confer protection

$r_1 \leq 0.3$ - suggest that the field isolate is so different from the vaccine strain that the vaccine is unlikely to protect.

For LB-ELISA:

$r_1 \geq 0.4$ – suggest that there is a close relationship between field isolate and vaccine strain. A potent vaccine containing the vaccine strain is likely to confer protection

$r_1 \leq 0.4$ - suggest that the field isolate is so different from the vaccine strain that the vaccine is unlikely to protect.

Botswana

	R_1 value per Vaccine virus strain			
	SAT 105	SAT 109	SAT 2035	SAT 251
BOT 08/2020	0.36	0.1		
NAM 08/2020			0.31	0.09

China

Isolate	Lineage	Animal	Vaccine Strain (O/BY/2010)	Methods Used
2020-19A137	Mya-98	cattle	M	VNT
20004	Ind-2001	cattle	M	VNT
19A039	CATHAY	pig	N	VNT

Kenya

- 2-Dimensional VNT test used

Name of Field isolate	Vaccine strain	
	O K77/78	SAT1 T 155/71
K14/20	0.2	
K45/20	0.35	
K5/20	0.4	
K11/20	0.54	
K8/20		0.2
K10/20		0.5
K18/20		0.66

Russian Federation

Isolate	Russia PanAsia/2000	Russia PanAsia/2012	PanAsia2	Russia Sea/2014
O/Zabaikalsky/2020	0.54	0.28	0.38	0.88

South Africa

Isolate	Vaccine strain: SAT 2 SAR/3/04	Vaccine strain: SAT 2 KNP/1/10
SAT 2/SAR/01/20	0.97	0.97

Thailand

Country/ topotype	No. of Sample	r-value by LP ELISA Serotype O/Thai Vaccine Strain O/189/87		
		≤ 0. 19	0.2-0.39	≥ 0.4
Thailand	38	-	4	34
Cambodia	11	-	-	11

Turkey

	Vaccine strain		
	OTUR07	OTUR17	O1 MANİSA
O/Zonguldak/131/2019 (QOM15)	M	M	M
O/Kocaeli/26/2020 (QOM15)	M	M	M
O/Ardahan/5/2020 (QOM15)	M	M	M
O/Balikesir/22/2020 (QOM15)	M	M	-

United Kingdom

Note:

N	No Match ($r_1 < 0.3$)
M	Match ($r_1 \geq 0.30$)

Strain	Serotype O		O 3039		O_1 Manisa		O/TUR/5/2009		O_1 Campos	
	Topotype	*Lineage*	R_1	*Titre*	R_1	*Titre*	R_1	*Titre*	R_1	*Titre*
ALG/1/2019	EA-3	-							0.59	2.08
EGY/34/2017	EA-3	-	0.69	1.80	0.47	2.21	0.50	1.88		
ERI/03/2017	EA-3	-	0.54	1.81	0.42	2.02	0.39	1.93		
ERI/08/2017	EA-3	-	0.71	1.93	0.49	2.02	0.45	1.95		
TUN/1/2019	EA-3	-							065	2.12
MOR/1/2019	EA-3	-							0.49	2.00
SRL/16/2018	ME-SA	-	0.59	1.75	0.34	1.94	0.62	2.04		
SRL/14/2019	ME-SA	-	0.79	1.79	0.49	2.12	0.83	2.11	0.28	1.93
BHU/1/2019	ME-SA	Ind-2001							0.58	2.31
PAK/46/2019	ME-SA	Ind-2001							0.62	2.28
SRL/01/2019	ME-SA	Ind-2001	0.76	1.77	0.40	2.03	0.81	2.10	0.39	2.08
SRL/17/2019	ME-SA	Ind-2001	0.66	1.80	0.47	2.08	0.79	2.15	0.29	1.95
PAK 46/2019	ME-SA	Ind-2001	0.37	1.54	0.4	1.94	0.54	1.84	0.26	1.90
VIT/13/2020	ME-SA	Ind-2001	0.46	1.64	0.48	1.98	0.71	1.98	0.78	2.24
VIT/19/2019	ME-SA	PanAsia	0.6	1.76	0.59	2.07	0.87	2.07	0.79	2.24
PAK/12/2019	ME-SA	PanAsia-2							0.32	2.00
PAK 3/2020	ME-SA	PanAsia-2	0.55	1.71	0.4	1.94	0.98	2.10	0.56 0.36	2.19 2.05
PAT/3/2019	ME-SA	PanAsia-2							0.39	1.90
TUR/4/2019	ME-SA	PanAsia-2							0.51	2.02
VIT/15/2019	SEA	Mya-98	0.26	1.40	0.23	1.66	0.39	1.72	0.15	1.61
VIT/31/2019	SEA	Mya-98	0.37	1.51	0.25	1.68	0.37	1.80	0.24	1.82
VIT/13/2019	SEA ME-SA	Mya-98 Ind-2001	0.36	1.52	0.19	1.58	0.34	1.71		

Strain	Serotype A		A/IRN/05		A/TUR/20/06		A22/IRQ		A/ERI/3/98		A/G-VII		A/SAU/95	
	Topotype	*Lineage*	R_1	*Titre*	R_1	*Titre*	R_1	*Titre*	R_1	*Titre*	R_1	*Titre*	R_1	*Titre*
EGY/02/2018	AFRICA		0.03	1.46	0.11	0.96	0.12	1.51	0.42	2.18	0.00	0.00		
ERI/07/2018	AFRICA		0.10	1.45	0.07	0.77	0.23	1.79					0.08	1.26
KEN 14/2017	AFRICA	G-I											0.24	1.76
KEN 17/2017	AFRICA	G-I											0.36	1.92
ZAM 04/2018	AFRICA	G-I											0.16	1.58
ZAM 05/2018	AFRICA	G-I											0.16	1.57
UGA 28/2019	AFRICA	G-I											0.21	1.67
UGA 42/2019	AFRICA	G-I											0.18	1.64
ALG 02/2017	AFRICA	G-IV											0.70	2.16
ALG 03/2017	AFRICA	G-IV											0.62	2.13
EGY 19/2016	AFRICA	G-IV											0.19	1.62
EGY 02/2018	AFRICA	G-IV											0.16	1.55
SUD 09/2018	AFRICA	G-IV											0.09	0.81
SUD 10/2018	AFRICA	G-IV											0.28	1.79
ETH 35/2018	AFRICA	G-IV											0.09	1.30
ETH 48/2018	AFRICA	G-IV											0.05	0.67
PAK/30/2016	ASIA	Iran-05	0.60	2.23	0.50	1.58	0.47	2.00						
PAK/73/2019	ASIA	Iran-05	0.93	2.45	0.23	1.25	0.68	2.16						
PAK/01/2020	ASIA	Iran-05	0.14	1.64	0.17	1.11	0.37	1.90						
PAK/02/2020	ASIA	Iran-05	0.07	1.30	0.00	0.00	0.09	1.26						

Strain	Serotype Asia-1		Shamir	
	Topotype	*Lineage*	R_1	*Titre*
PAK/32/2016	Sindh-08		0.18	1.72
PAK/75/2019	Sindh-08		0.50	2.16

Strain	Serotype SAT 2		SAT 2/ERI		SAT 2/ZIM	
	Topotype	*Lineage*	R_1	*Titre*	R_1	*Titre*
EGY 1/2018	VII	Ghb-12	0.28	1.34	0.11	1.37
EGY 7/2018	VII	Lib-12	0.83	1.72	0.32	1.96
EGY 34/2018	VII	Lib-12	0.81	1.71	0.3	1.93
ERI 19/2019	VII	Lib-12	0.68	1.57	0.25	1.80
ERI 28/2019	VII	Lib-12	0.76	1.62	0.25	1.80

Appendix 3 - Nucleotide sequence analysis

FMDV nucleotide sequence data for phylogenetic analysis

Testing Laboratory	Sample Country	Region Sequenced	Total	O	A	C	ASIA-1	SAT 1	SAT 2	SAT 3	FMDV GD	Notes
ANSES	Burkina Faso	VP1	12						4			
	Niger	VP1	66		17				1			
ARC-OVI	South Africa	VP1	29						29			
	South Africa	Complete Genome	10						10			includes historical samples
BVI	Botswana	VP1	9 *					1		4		Testing on-going
	Botswana	VP1	32									
	Malawi	VP1	2						2			
	Namibia	VP1	8						2	4		
	Zambia	VP1	6	5								
FGI-ARRIAH	Russia	VP1	2	2								
IZSLER	Tanzania	VP1	91	24	27			27	13			Historical samples (2012 – 2018)
LVRI	China	VP1	46	46								
	China	Complete Genome	2	2								
NCFAD	Nigeria	VP1	28	2	14				3		9	
PANAFTOSA	Argentina	Complete Genome	19	5	14							historical samples
	Bolivia	Complete Genome	1	1								historical samples
	Brazil	Complete Genome	36	7	29							historical samples
	Chile	Complete Genome	1	1								historical samples
	Colombia	Complete Genome	19	11	8							historical samples
	Ecuador	Complete Genome	3	1	2							historical samples
	Guyana	Complete Genome	1	1								historical samples
	Paraguay	Complete Genome	2	1	1							historical samples
	Peru	Complete Genome	2	1	1							historical samples
	Uruguay	Complete Genome	2	1	1							historical samples

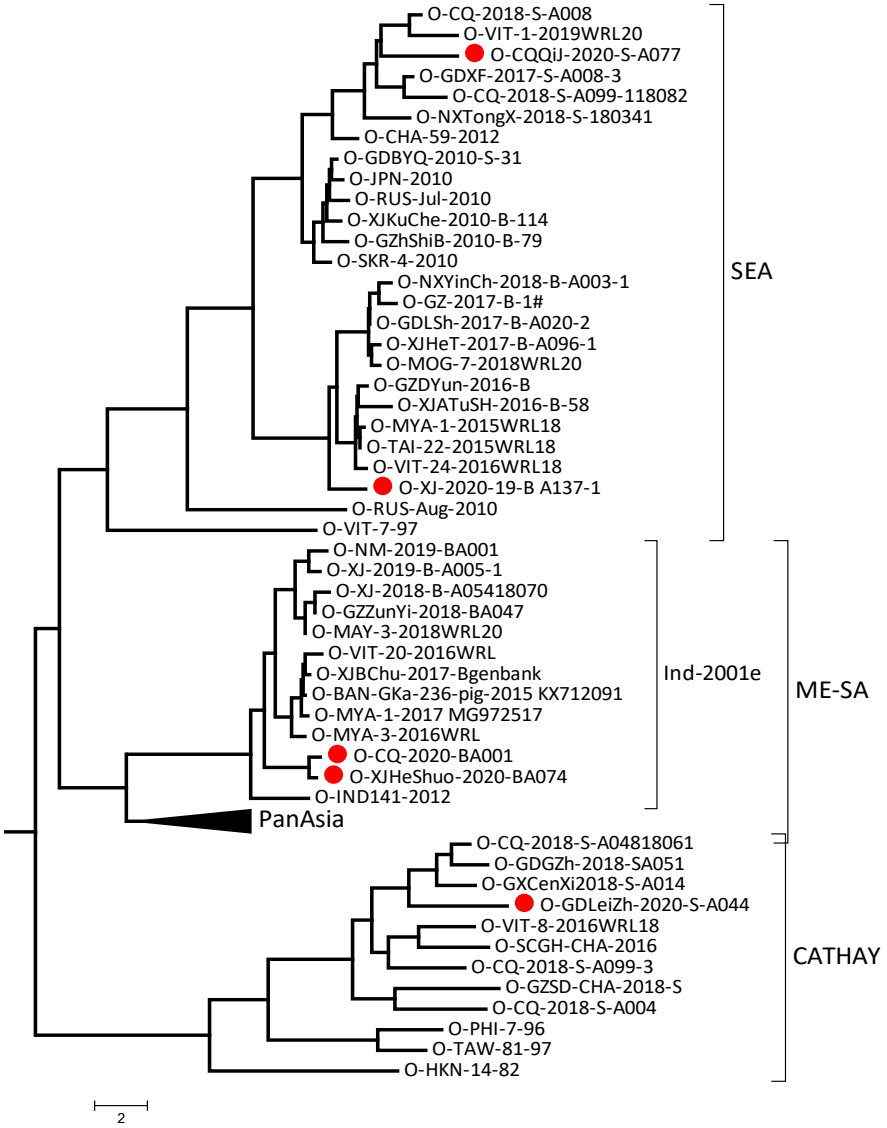
	Venezuela	Complete Genome	6	3	3		historical samples
RRL SEA	Cambodia	VP1	13	13			Samples from 2018
	Lao PDR	VP1	7	7			
	Thailand	VP1	24	24			
WRLFMD	Cambodia	VP1	9	9			
	Lao PDR	VP1	5	5			
	Pakistan	VP1	44	30	5	9	
	Sri Lanka	VP1	15	15			
	Thailand	VP1	16	12	4		
	Vietnam	VP1	29	29			

** BVI is currently in the process of sequencing a further 32 samples from Botswana received in 2020.*

Appendix 4 - Selected phylogenetic trees for 2020

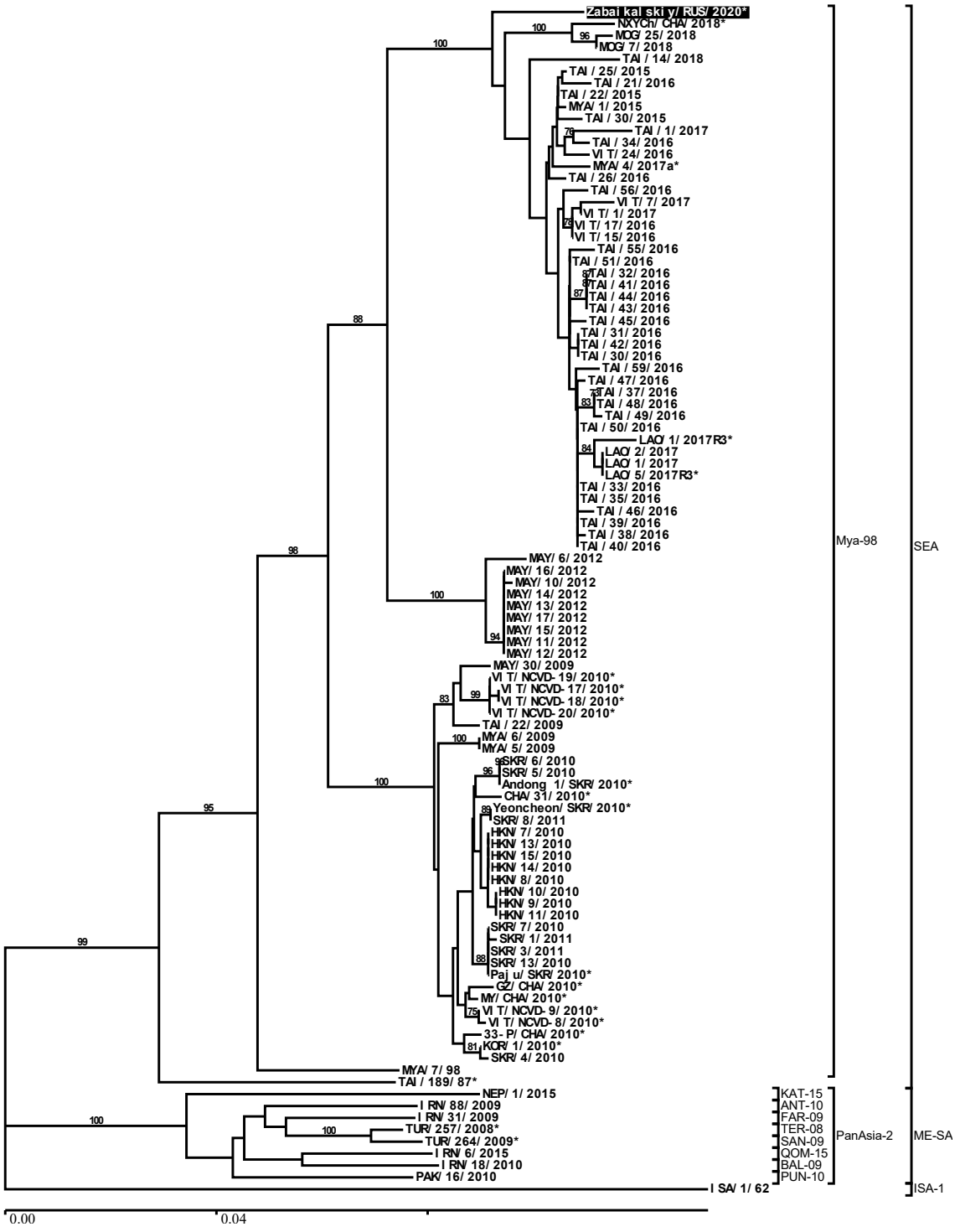
A4.1: FMDV lineages circulating in China

(Analyses from LVRI, China)



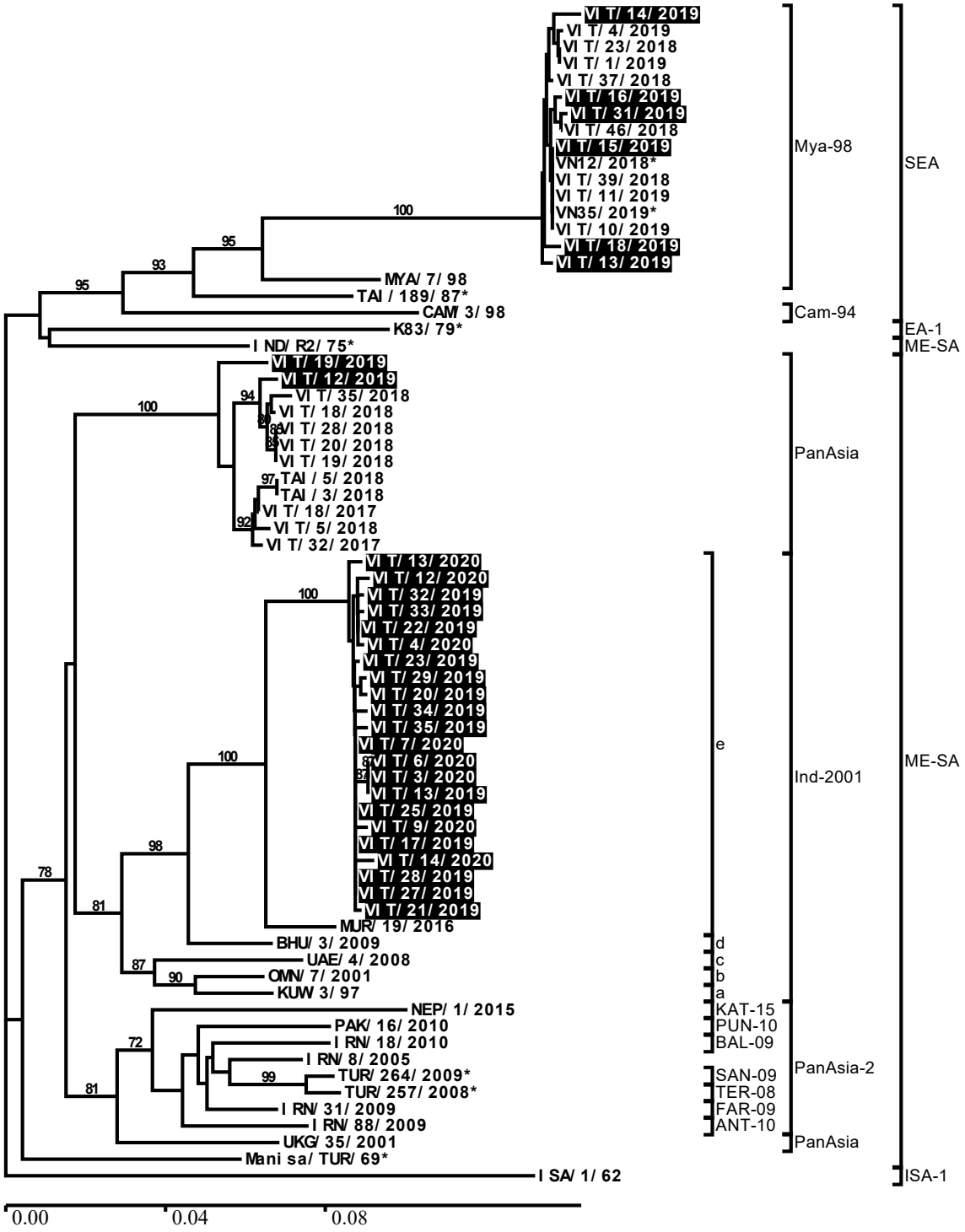
A4.2: Sequences associated with an FMD outbreak in Zabaikalskiy Kray, Russian Federation (January 2020)

(Analyses from ARRIAH, Russia and WRLFMD)



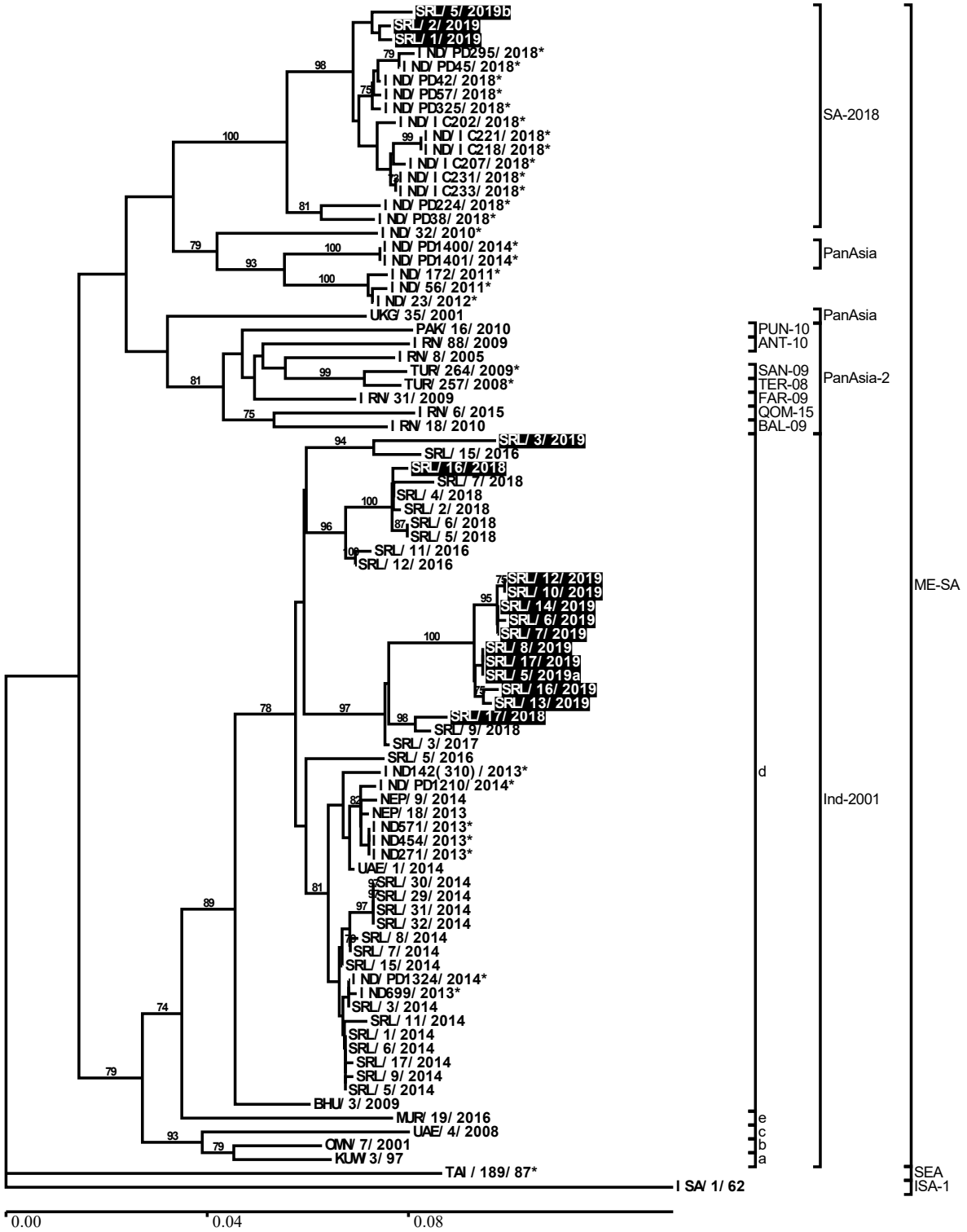
A4.3: Diverse serotype O FMDV lineages circulating in Vietman during 2019-20

(Analyses from RAHO6, Vietnam and WRLFMD)



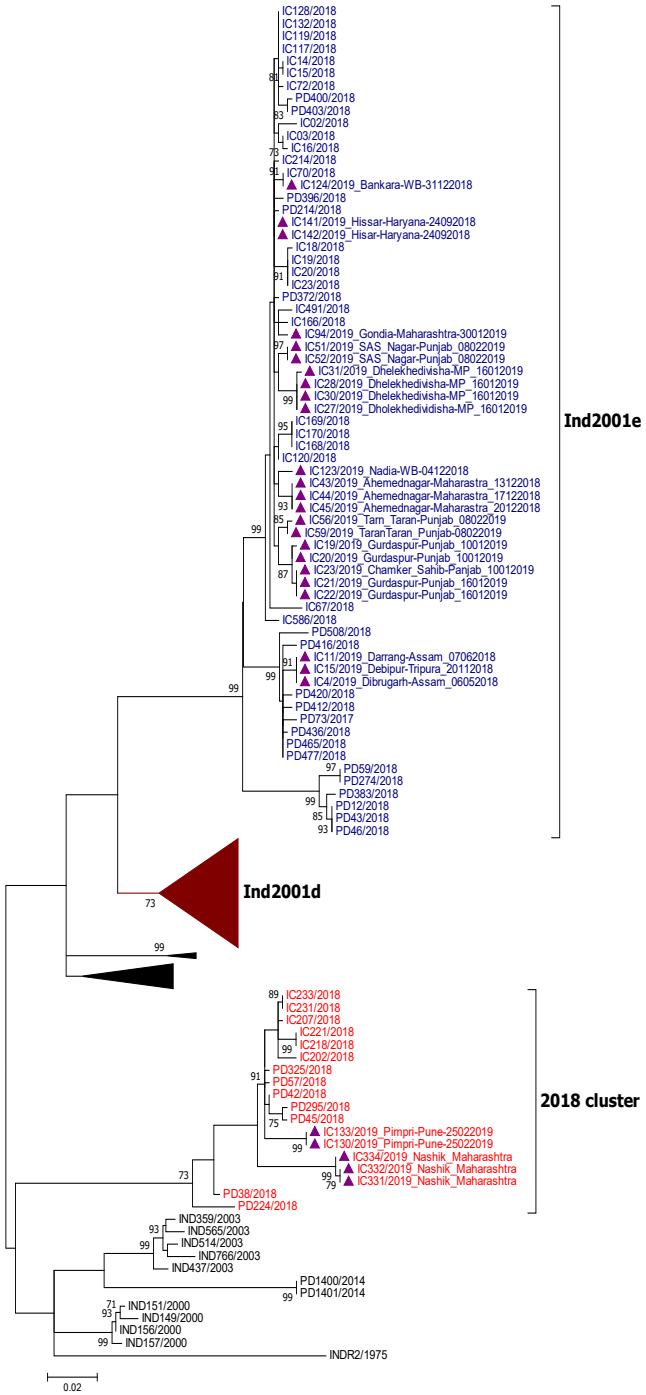
A4.4: A new serotype O lineage in Sri Lanka called O/ME-SA/SA-2018 (for similar Indian sequences see A4.5)

(Analyses from The Department of Animal Production and Health, Sri Lanka and WRLFMD)



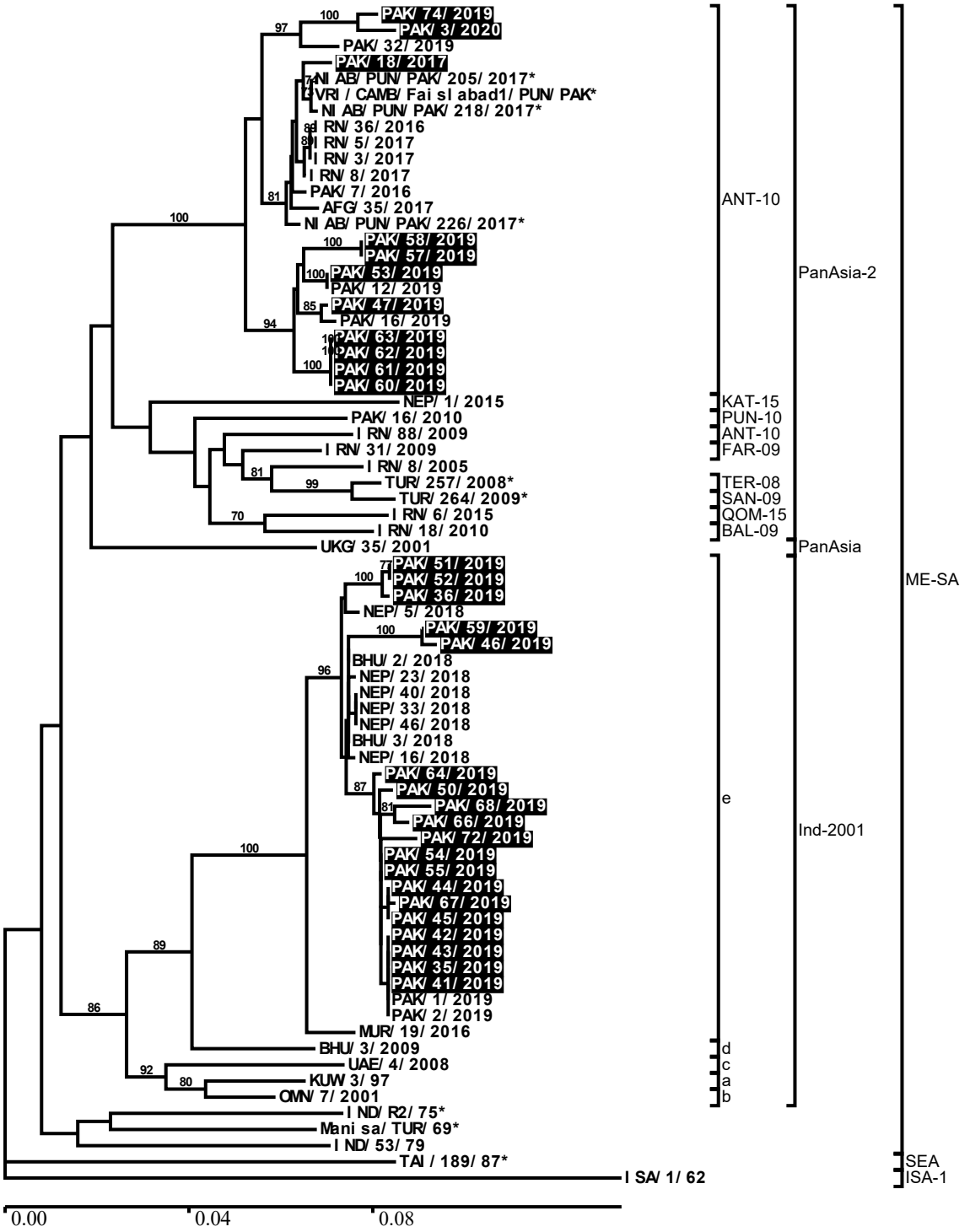
A4.5: Serotype O viruses detected in India during 2019

(Analyses from ICAR-DFMD, India)



A4.6: Serotype O viruses in Pakistan (including evidence for further outbreaks due to O/ME-SA/Ind2001e)

(Analyses from FAO Office Pakistan and WRLFMD)

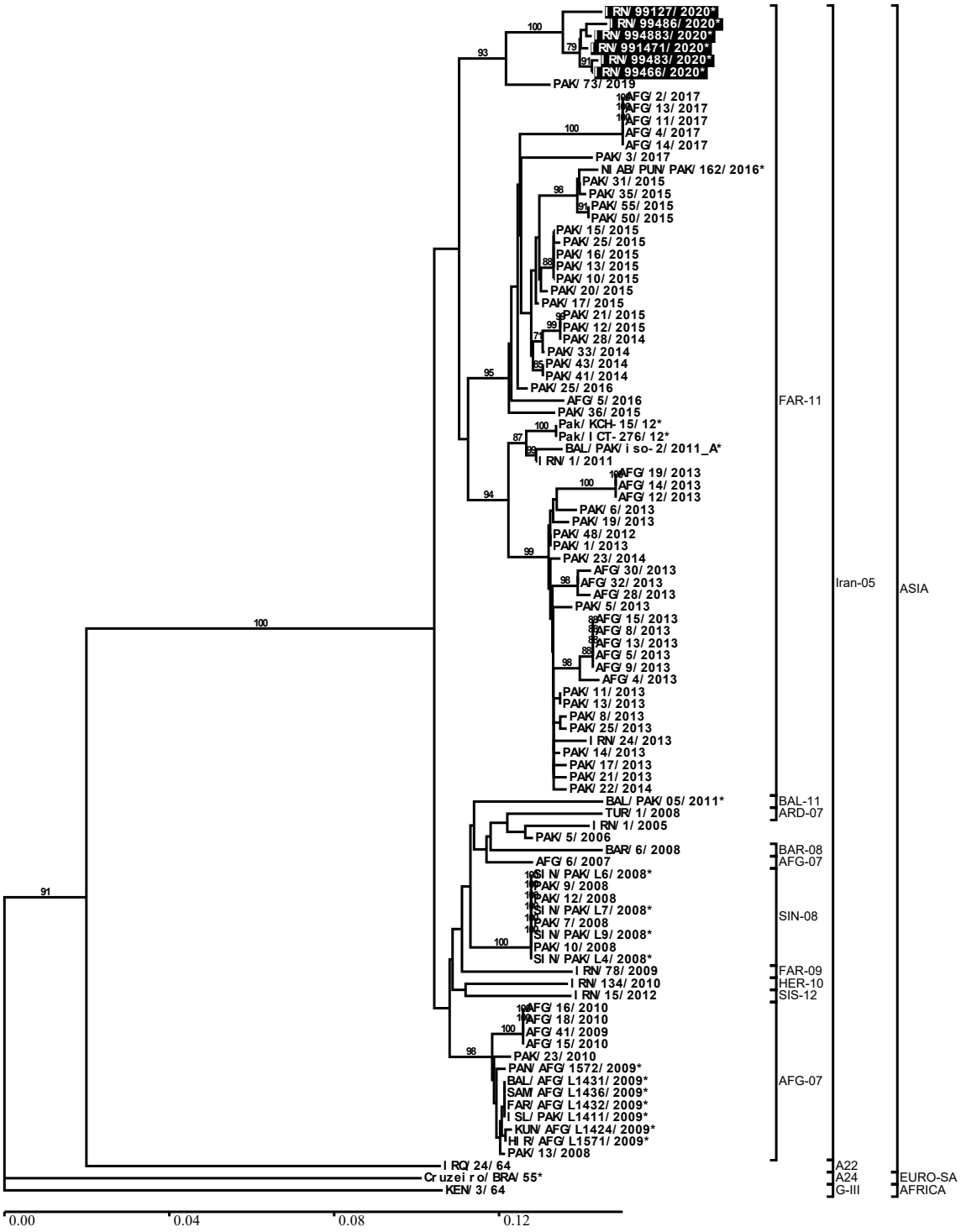


A4.7: Serotype O viruses in Turkey where case due to O/ME-SA/PanAsia-2^{ANT-10} have been detected for the first time since 2017.

(Analyses from SAP-Institute, Turkey and WRLFMD)

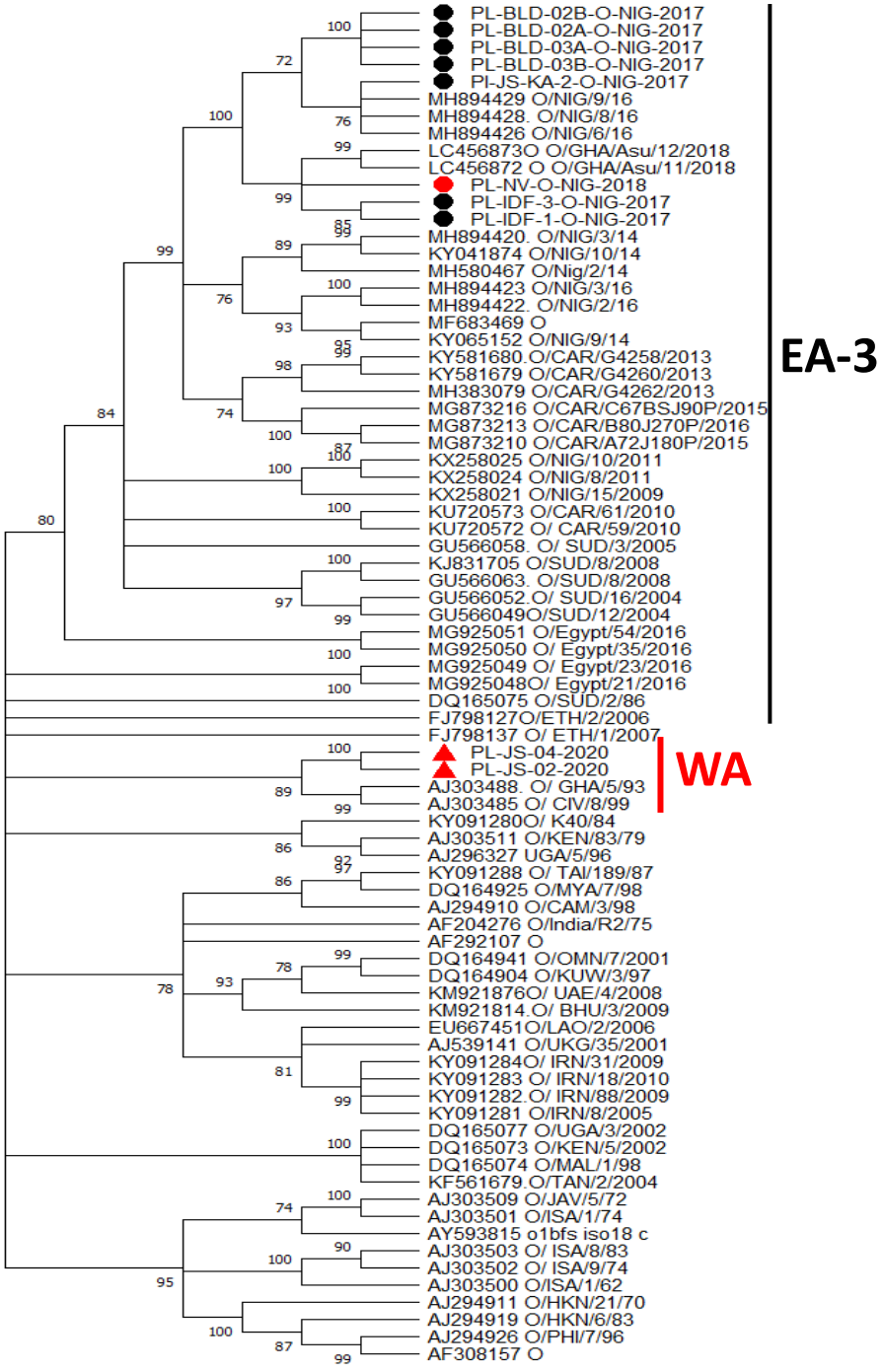
A4.8: Emergence of a new A/ASIA/Iran-05^{FAR-11} clade in Iran

(Analyses from CVL, Iran Veterinary Organisation, Iran and WRLFMD)



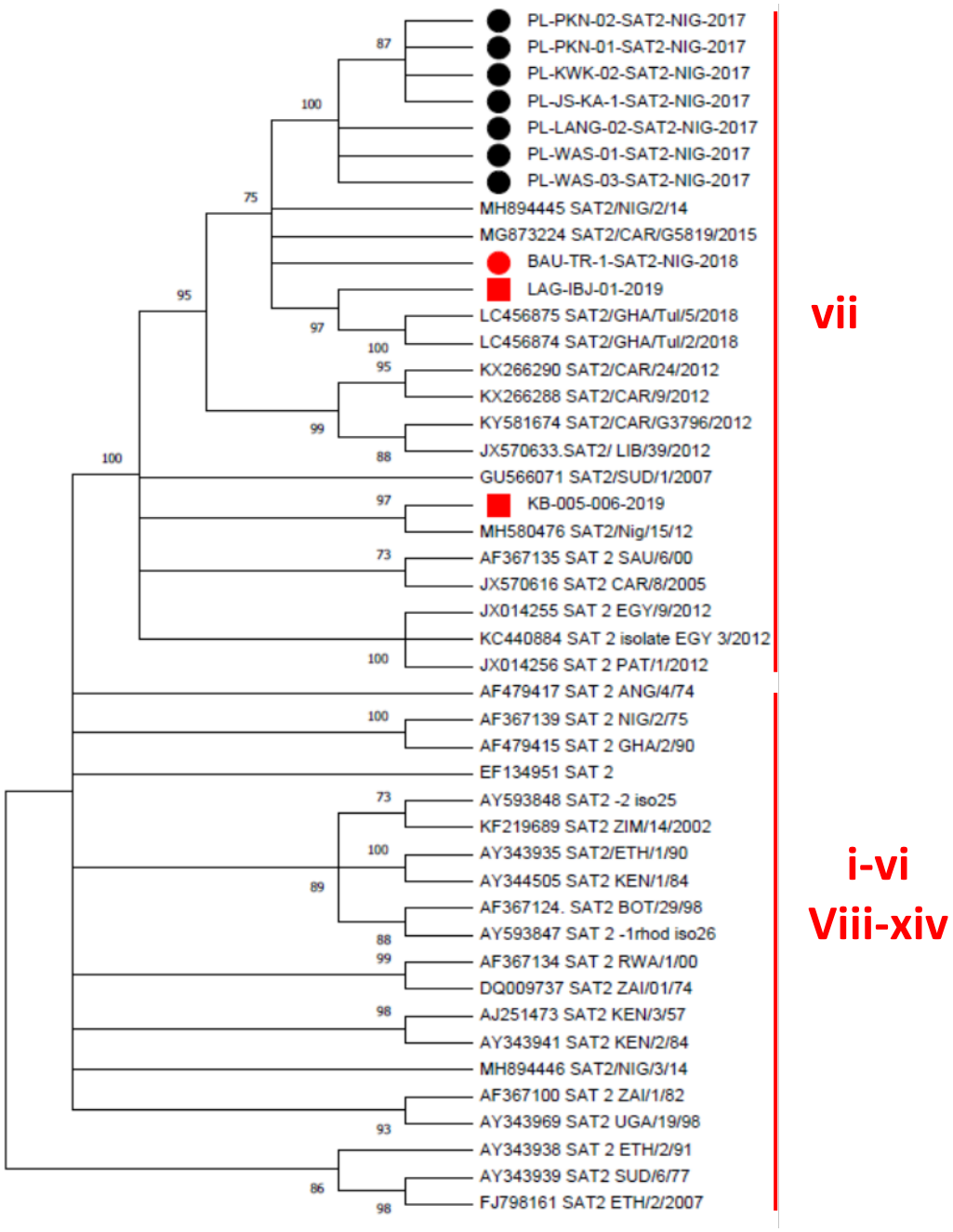
A4.9: Serotype O viruses circulating in Nigeria (2017-2020)

(Analyses from NVRI, Nigeria and NCFAD, Canada)



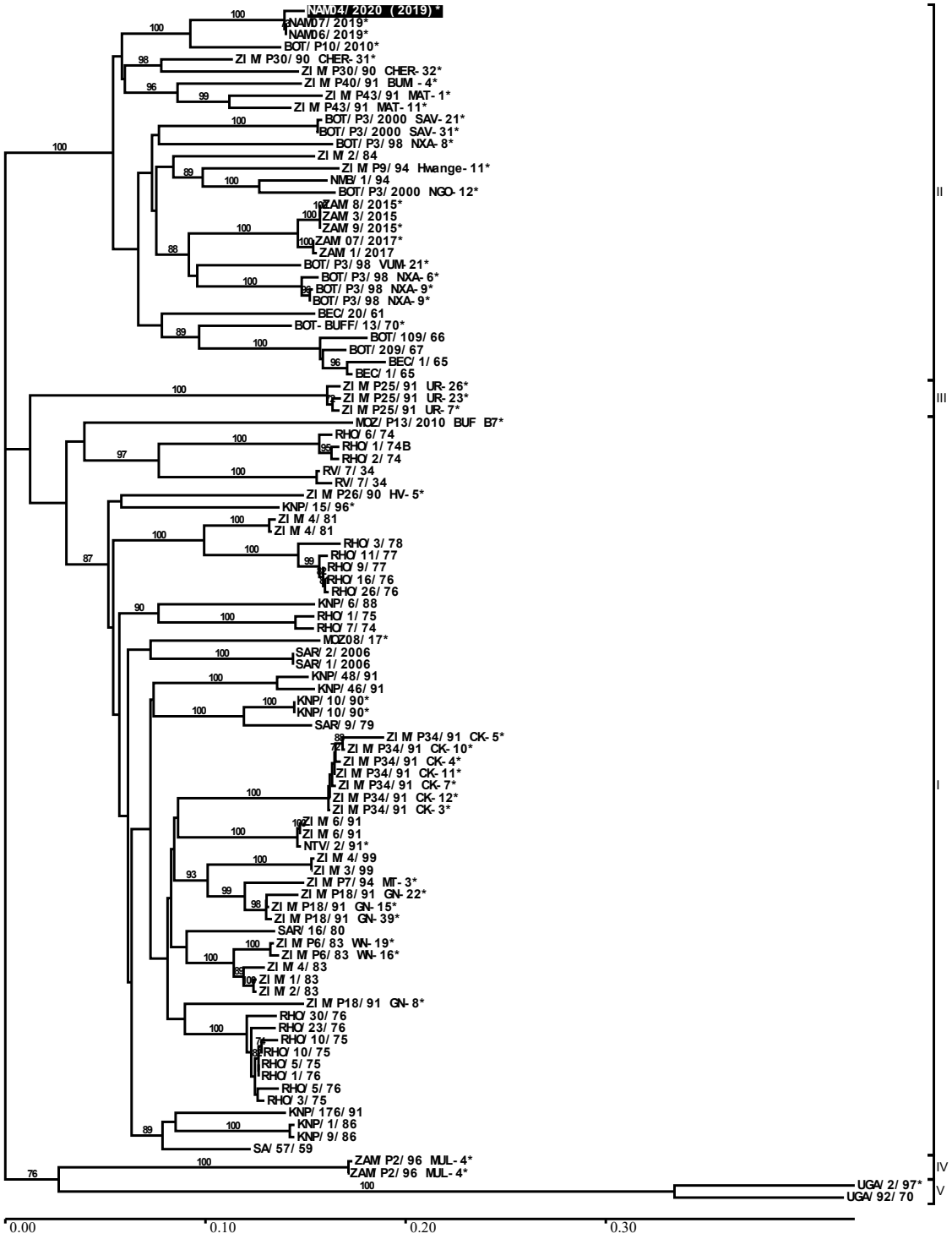
A.4.10 Serotype SAT 2 viruses in Nigeria (2017-2019)

(Analyses from NVRI, Nigeria and NCFAD, Canada)



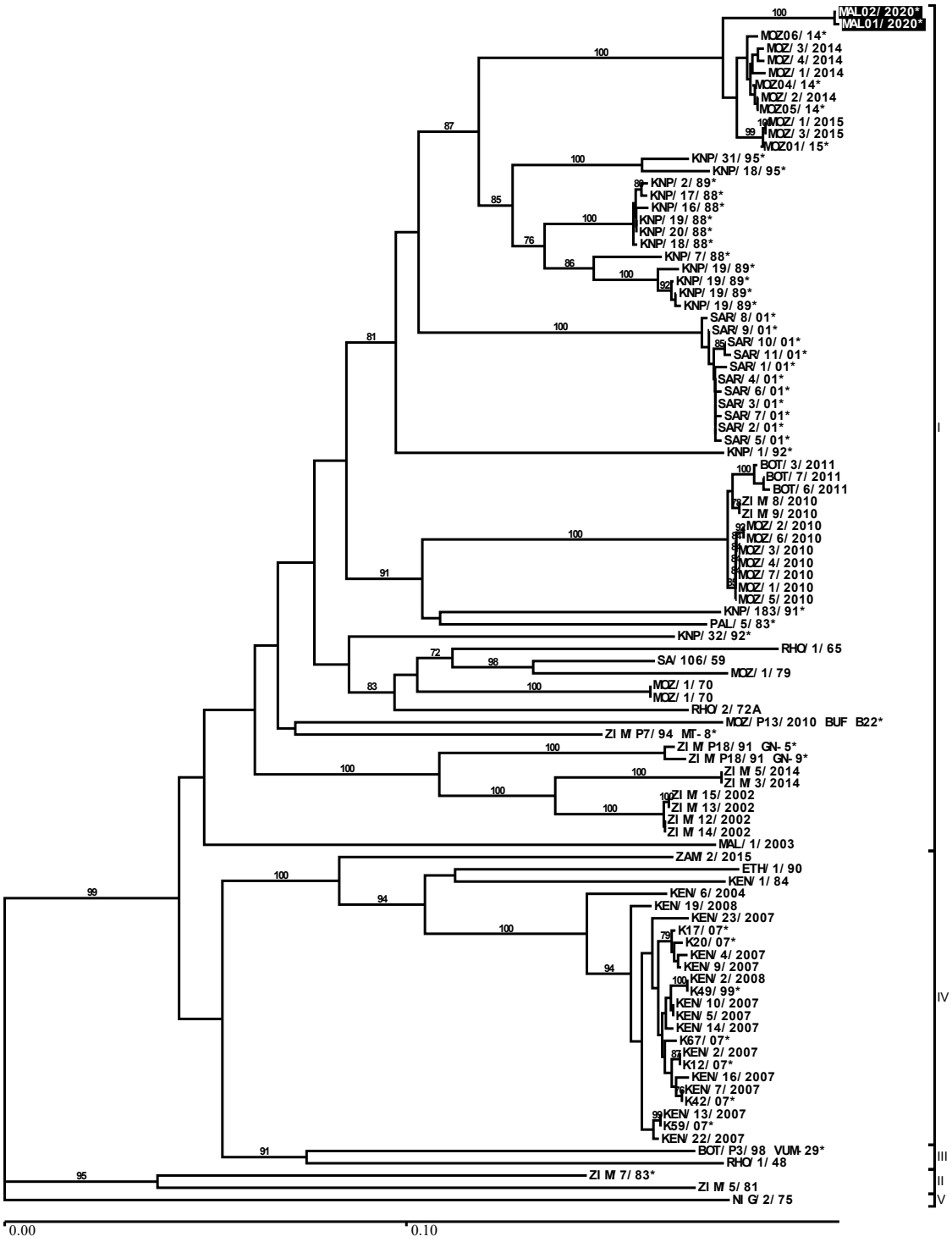
A.4.11: SAT 3 cases in Nambia

(Analyses from BVI, Botswana and WRLFMD)



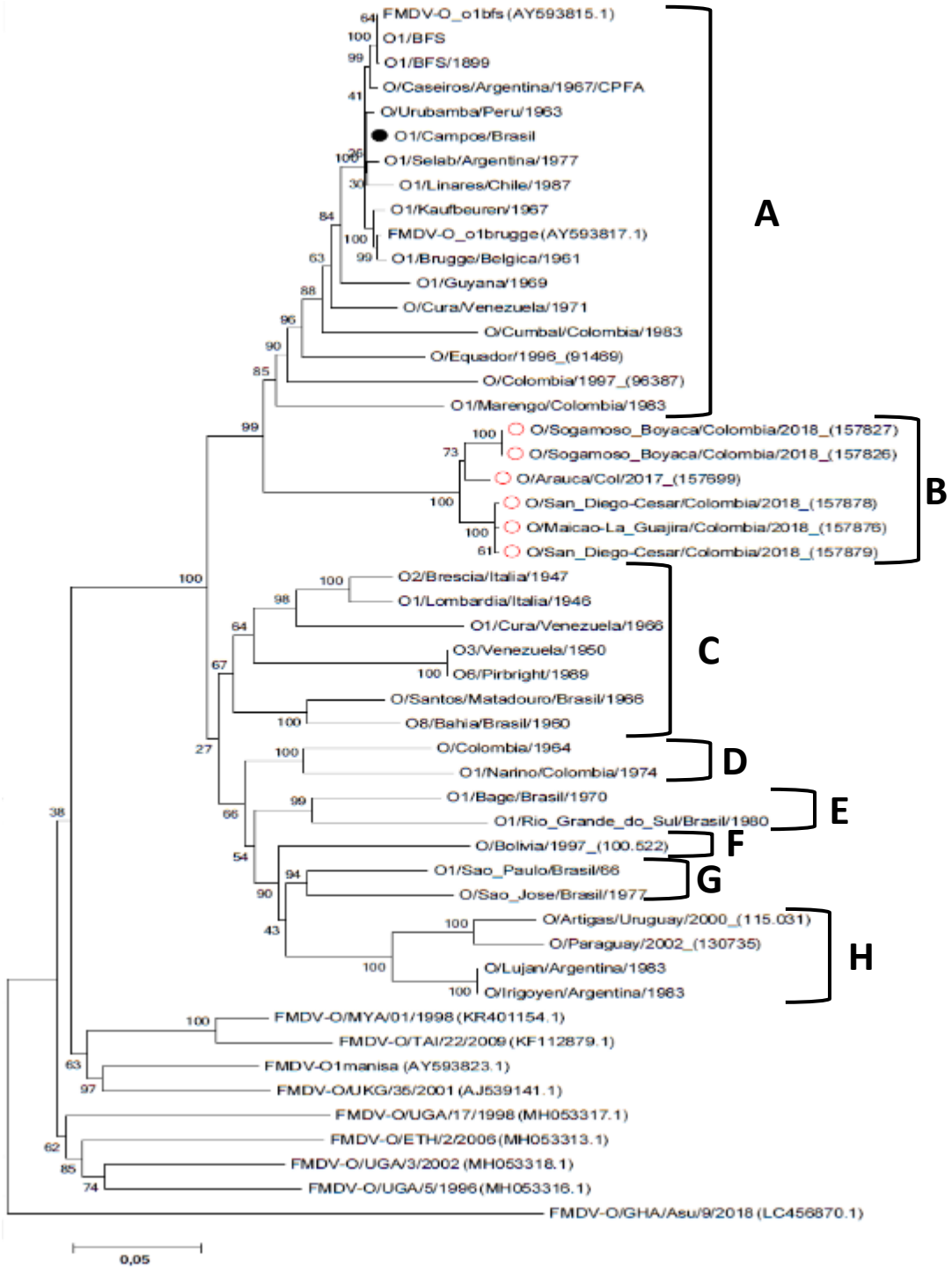
A4.12: SAT 2 outbreaks in Malawi

(Analyses from BVI, Botswana and WRLFMD)



A.4.13: Retrospective analyses of serotype O sequences recovered from outbreaks in Colombia (2018)

(Analyses from PANAFTOSA)



Appendix 5 - The 15th Annual Meeting of the OIE/FAO FMD Reference Laboratory Network

2nd and 3rd December 2020

Meeting attendees (virtual format):

Core Members

	OIE Reference Laboratory for Foot and Mouth Disease, Dirección de Laboratorio Animal, SENASA, Argentina Unfortunately, **Andrea Pedemonte** was unable to connect to the meeting due to technical difficulties, but she provided a presentation via email.
	OIE collaborating Centre for validation, quality assessment and quality control of diagnostic assays and vaccine testing for vesicular diseases in Europe, and FAO Reference Centre for Vesicular Diseases, Sciensano, Belgium: **David Lefebvre, Kris De Clercq**
	OIE Regional Reference Laboratory for Sub-Saharan Africa (RRLSSA), Botswana Vaccine Institute (BVI), Botswana: **Joseph Hyera, Moagabo Kaebetswe, Mokganedi Mokkopasetso, Mpolokang Elliot Fana**
	OIE Reference Laboratory for FMD, Pan American Foot-and-Mouth Disease and Veterinary Public Health Center, Pan American Health Organization/World Health Organization (PANAFTOSA/VPH-PAHO/WHO), Rio de Janeiro, Brazil: **Edviges Maristela Pituco**
	FAO FMD Reference Laboratory, National Centre for Foreign Animal Disease National Centres for Animal Disease, Canadian Food Inspection Agency, Canada: **Charles Nfon**
	OIE and China National FMD Reference Laboratory, Lanzhou Veterinary Research Institute (LVRI), CAAS, People's Republic of China: **Dang wen, Jijun He, Jianhong Guo**

	OIE FMD Reference Laboratory, French Agency for Food and, Environmental and Occupational Health & Safety (ANSES), France: **Labib Bakkali Kassimi, Romey Aurore, Souheyla Benfrid, Stéphan Zientara**
	FAO Reference Centre for FMD in South Asia, Indian Council for Agricultural Research (ICAR) Directorate of Foot-and-Mouth Disease, Mukteswar, Nainital (Uttarakhand), India: **Jajati Keshari Mohapatra, Saravanan Subramaniam**
	OIE/FAO FMD Reference Laboratory, Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna (IZSLER), Italy: **Arianna Bregoli, Emiliana Brocchi, Giancarlo Ferrari, Giorgio Varisco, Giulia Pezzoni, Marco Bugnetti, Santina Grazioli**
	OIE Reference laboratory for Foot and Mouth Disease, Animal and Plant Quarantine Agency (QIA), Republic of Korea: **Cha Sang-Ho, Daraelim, Jong-Hyeon Park, Soyoon Ryoo**
	FAO Reference Centre for FMD for Central Asia and West Eurasia and OIE Reference Laboratory for FMD, Federal Governmental Institute, Centre for Animal Health (FGI ARRIAH), Vladimir, Russian Federation: **Iiya Chvala**
	FAO Reference Laboratory for FMD in Africa and OIE FMD Reference Laboratory, Transboundary Animal Diseases Programme, ARC-Onderstepoort Veterinary Institute (ARC-OVI), South Africa: **Livio Heath, Pamela Opperman with apologies received from Francois Maree**
	OIE Regional Reference Laboratory for Foot and Mouth Disease in the South East (RRLSEA) Department of Livestock Development, Thailand: **Kingkarn Boonsuya Seeyo, Sahawatchara Ungvanijban**
	FAO World Reference Laboratory and OIE FMD Reference Laboratory, The Pirbright Institute Pirbright, United Kingdom: **Anna Ludi, Antonello Di Nardo, David Paton, Don King, Hannah Baker, Nick Knowles, Valerie Mioulet**
	FAO Reference Centre for FMD and other vesicular diseases for the Americas and the Caribbean and OIE FMD Reference Laboratory, Foreign Animal Disease Diagnostic Lab, Plum Island Animal Disease Center (PIADC), United States of America: **Consuelo Carrillo, Jamie Barnabei, Robin Holland**

Affiliates

	Australian Animal Health Laboratory (AAHL), Australia: **Nagendra Singanallur, Petrus Jansen van Vuren, Wilna Vosloo**
	NATIONAL Animal Health Diagnostic & Investigation Center (NAHDIC), Ethiopia: **Daniel Gizaw**
	Foot and Mouth Disease Laboratory, Kenya: **Abraham Sangula**
	National Veterinary Research Institute, Vom, Plateau State, Nigeria: **Hussaini Ularamu**
	Laboratoire National d'Elevage et de Recherches Vétérinaires (LNERV), Senegal: **Gaye Laye Diop, Modou Moustapha**
	Şap Institute (and WELNET FMD), Ankara, Turkey: **Abdulnaci Bulut, Can Cokcaliskan**
AU-PANVAC	Pan African Veterinary Vaccine Center for African Union (AU-PANVAC), Ethiopia: **Ethel Chitsungo**

OIE/FAO Representatives

	Food and Agriculture Organization of the United Nations: **Astrid Tripodi, Estelle Kanyala, Samia Metwally, Christian DeBattisti**
	OIE – World Organization for Animal Health: **Min-Kyung Park**
	The European Commission for the Control for Foot-and-Mouth Disease: **Carsten Potzsh, Etienne Chevanne, Farbrizio Rosso, Kees van Maanen, Madhur Dhingra, Muhammad Javed Arshed, Nick Lyons, Paolo Motta, Melissa McLaws**
	Laboratory Leaders for Regional Roadmaps: **Rajeev Ranjan**

TUESDAY 1ST DECEMBER 2020, DAY 1

Opening of meeting and adoption of agenda (Don King)

Recent achievements of the Network are listed below.

- Publication of the 2019 Annual Network Report summarising the global situation regarding the distribution of FMD in different regions of the world.
- Website (www.foot-and-mouth.org) has been updated to contain a "static" FMD dashboard.
- New inter-laboratory study to calibrate VNT methods has been funded by EuFMD.
- Two manuscripts with contribution from Network partners have been submitted for publication:
    - History of serotype C and recommendations to prevent re-introduction of the serotype – submitted to *Virus Evolution*
    - FMD Reference materials highlighting current gaps in available reagents – submitted to *Scientific and Technical Review of the OIE*

Update from the OIE (Min Kyung Park)

Summary of country applications for FMD submitted to the OIE during 2020:

- Chinese Taipei has been granted a zone FMD-free without vaccination.
- Brazil has merged two zones which are FMD-free with vaccination.
- Colombia has regained FMD free (with vaccination) status in four separate zones.
- Kyrgyzstan has been endorsed for an official OIE control programme.
- South Africa's FMD OIE status is still suspended.

A revision of the OIE Terrestrial Animal Health Code (Chapter 8.8 *Infection with foot and mouth disease virus*) has been circulated to members for comment. The next foreseen revision of the FMD Chapter (3.1.8) in the OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals will be during the 2022/2023 cycle.

Update from FAO (Samia Metwally)

It is recognised that there is a need to strengthen the support for countries to move from progressive control pathway (PCP: http://www.fao.org/eufmd/global-situation/pcp-fmd/en/) stage 0 to 1 and during Day 2 of this meeting PCP support officers will be introduced to the Network. The FAO and OIE have formed GCC-FMD (global coordination committee of FMD) which will coordinate the FMD global strategy over the next 5-year period. The partners included are PANAFTOSA, AU-IBAR, SEACFMD, Regional Economic Community, EuFMD, WRLFMD, GFRA, OIE Working Group on Wildlife, India and Ethiopia and *ad hoc* invited guests.

A new book on veterinary vaccines will be published by the end of the year.

During this year's meeting, there was no update from OIE or FAO regarding the impact of the Nagoya Protocol (https://www.cbd.int/abs/) on work that is central to the Network (such as exchange and use of field samples, development of FMD vaccine strains and new diagnostic tests). In view of the importance of the Protocol to our activities, the consensus was that this should be kept on the agenda with a further update on the coordinated activities of OIE, FAO and WHO requested for next year's meeting.

Action O20-01 Include an agenda item for an update on the Nagoya Protocol at next year's meeting

Global Review (Don King)

In common with the international FMD Reference Laboratory activities of other Network partners, the number of field samples received this year to the WRFMD has decreased as a consequence of COVID-19 restrictions. During 2020, only 161 samples have been received from 5 countries in comparison to 400-700 samples that are normally tested.

From samples tested, recent sequence data indicate that the O/ME-SA/Ind-2001e lineage is becoming more established in Pakistan: this lineage was detected for the first time in 2019 (in two FMDV positive samples) and during 2020, 19 out of 50 samples were characterised as O/ME-SA/Ind-2001e. This shipment also highlighted the genetic diversity of FMD viruses causing other outbreaks in Pakistan where circulating lineages include O/PanAsia-2^{ANT-10}, A/ASIA/Iran-05 (SIS-13, FAR-11 sub-lineages and two isolates in un-named clades) and Asia 1/Sindh-08. Elsewhere, a new FMD viral lineage within the O/ME-SA topotype has been identified in Sri Lanka. These sequences are distinct to the PanAsia, PanAsia-2 and Ind-2001 lineages and genetically related to contemporary viruses collected in India (see Annex 1).

The WRLFMD has developed a new probe enrichment method that can be used to increase the analytical sensitivity of full genome sequencing methods for FMDV. During 2020, this method has been applied to environmental samples (with low viral copy number) collected in Cameroon (see: https://www.wrlfmd.org/sites/world/files/quick_media/WRLMEG-2019-00044-CAR-GTR-O-O_001.pdf).

Following on from work described at the meeting in 2019, further work has been undertaken in partnership with AU-PANVAC to improve vaccine selection for endemic countries. The basis of this work is the measurement of heterologous antibody responses using regional reference antigens (for examples see: https://www.wrlfmd.org/node/2096/). Looking forward, there are opportunities for the Network to contribute to this work, specifically to help define cut-offs for the serological assays that are used to monitor post-vaccination responses.

Action O20-02 Include an agenda item for vaccine selection for endemic pools.

Pool 1: Southeast Asia (Kingkarn Boonsuya Seeyo)

During 2020, samples have been received from Thailand (n=235), Cambodia (n=84) and Lao PDR (n = 9). Surveillance has also taken place in Thailand, with 78.9% of animals testing positive for FMDV-specific NSP antibodies.

Pool 1: East Asia and China (Dang wen)

A total of five outbreaks have been reported in China. Thirty-five samples have been sequenced and were found to comprise O/SEA/Mya-98 (n=16, 2 genetic groups with 92-93% genetic identity), O/CATHAY (n=15) and O/ME-SA/ind-2001 (n=4). There were no reports of outbreaks due to serotypes A and Asia 1 during 2020. The FMD vaccine strain O/BY/2010 appears to be a good match against the circulating serotype O strains collected from China by VNT except O/CATHAY.

Pool 1: East Asia and South Korea (Jong-Hyeon Park)

No outbreaks of FMD were recorded in South Korea during 2020; however, post-vaccination monitoring and NSP sero-surveillance studies are ongoing where SP (serotype O) positivity

rates are >80% for cattle and pigs. An overview of the national FMD vaccination campaign was presented, where multivalent vaccines are currently being supplied from three companies (O-3039/O1-Manisa, A22 from BI, O-Campos, A/Arg-2001, A24 Cruzeiro from Biogenesis Bago and O-Primorsky + A-Zabaikalsksy from Russia) and are for both pigs (breeding and fattening) as well as cattle.

Pool 1: Russia (Ilya Chvala)

One FMD outbreak occurred in 2020 in cattle located at the border with Inner Mongolia, China. Sequence data characterised the causative FMD virus belonging to the O/SEA/Mya-98 lineage. Clinical signs were only observed in cattle; no clinical signs were seen in small ruminants. For three years samples, have been collected from wildlife – mostly Mongolian gazelle, where testing is underway. Current results show that both SP and NSP antibodies have been detected in these animals over the past two years where FMD outbreaks in cattle in the same region have occurred.

Pool 2: India (Jajati Keshari Mohapatra)

During 2020, ICAR-DFMD has been involved in testing for COVID-19 samples. For FMD, there have been 51 serotype O outbreaks and 1 serotype A outbreak. Over the past few years, the O/ME-SA/Ind-2001d has been superseded by O/ME-SA/Ind-2001e. Recent testing has highlighted sequences for 22 isolates that clustered distinctly and represent a novel lineage (tentatively named O/ME-SA/2018). The presentation summarised recent positive vaccine matching results for the IND R2/1975 vaccine strain.

UPDATE – Overnight there was an exchange of sequences between WRLFMD and ICAR-DFMD to determine whether the sequences for samples from Sri Lanka cluster with those isolated from India (O/ME-SA/2018 clade). These two outbreaks appear to be linked suggesting that this new lineage is already present in two countries. The situation will need to be monitored (see Annex 1).

Pool 3: Turkey and WELNET FMD (Abdulnaci Bulut)

The Thrace region of Turkey has remained free since May 2010. In Anatolia, serotype O has been the only FMD serotype detected since 2018 (i.e., no detected cases due to serotypes A and Asia 1). During 2020, 220 samples were received from 137 outbreaks: the majority of sequences (n=58) were characterised as belonging to the O/ME-SA/PanAsia-2^{Qom-15} sub-lineage, although two sequences for samples collected during August were genotyped as O/ME-SA/PanAsia-2^{Ant-10} that represent a new introduction of this sub-lineage into Turkey. National surveillance activities have tested 19471 sera for NSP-specific antibodies and 2374 sera for post vaccination monitoring. Vaccine matching indicates that the current vaccine strains (O TUR 07, O TUR 17 and O1-Manisa) are well matched against samples collected during 2019-20; however, there were difficulties to isolate a virus from the ANT-10 samples and therefore no vaccine matching was performed. Regional co-ordination is facilitated via the WELNET FMD where work undertaken by ANSES has assessed capacity and performance of national veterinary diagnostic labs in West Eurasia. A protocol has also been prepared (with EuFMD) to outline sample collection and testing by the Şap Institute and International FMD Reference Laboratories. Sharing of laboratory data has been discussed as part of two tripartite meetings (with Turkey, Iran and Pakistan) and further meetings with Transcaucasian countries.

Pool 4: Kenya – East Africa (Abraham Sangula)

One hundred and twenty-three samples have been submitted to the FMD Laboratory, Embakasi, Kenya during 2020. Using antigen-ELISA, serotype O (n=48) and SAT 1 (n=35) have been detected; however, no sequencing analyses have been undertaken. Serological testing has generated positive NSP results for 40.2% (n=1941) of samples, while VNT and SPCE diagnostic methods have also been used to test sera for post-vaccination monitoring purposes. Both local and internationally produced FMD vaccines have been used for control – and vaccine matching testing has been performed for O K77/78 and SAT 1T 155/71 vaccine strains.

Pool 4: Ethiopia – East Africa (Daniel Gizaw)

During 2020, investigation of field outbreaks of FMD in Ethiopia has been impacted by COVID-19 restrictions. Out of 85 samples received to NAHDIC from 12 outbreaks, antigen ELISA was used to serotype samples as O (n=30), A (n=6), SAT 1 (n=10) and SAT 2 (n=29) – a further 10 samples were FMDV negative. Serological export testing has occurred for small ruminants, in which 1.2% were positive for NSP antibodies, and cattle, for which 14.7% were positive.

Pool 5: Nigeria – West Africa (Hussaini Ularamu)

In the past twelve months, 179 epithelial samples have been collected from cattle goats and sheep where serotypes O and A have been detected. Further samples comprising bovine meat juice (n=396), swine meat juice (n=69) together with cattle sera (n=1,060) have been collected as part of a collaborative project with NCFAD, Canada.

Pool 5: Senegal – West Africa (Modou Moustaphe)

Serotype O was identified in samples collected in 2018; however, samples collected recently need to be sent to WRLFMD for confirmation. A further 236 samples were received from Guinea – of which 92 tested positive.

Pool 4-6: Sub-Saharan Africa (Livio Heath)

In March 2020 there was an FMD outbreak in the protection zone (PZ) located in Limpopo Province. Clinical samples (n=125) have been received of which 33 have been serotyped as SAT 2 (topotype I). Sequence data indicates that the causative FMDV originated in buffalo and are distinct from earlier FMD outbreaks that occurred during 2019 (Jan/Feb and Dec 2019). Samples have also been received from Namibia and Swaziland for export purposes; these were all negative by RT-PCR. During 2020, sera have also been received for serological testing, where two positive reactors for samples collected in Zimbabwe have been identified. An in-house SPCE is now used to detect FMDV-specific antibodies for serotypes SAT 1, SAT 2 and SAT 3 (as a more rapid way to screen samples compared to the LPBE), while commercial kits are used for serotype O and A antibodies. Vaccine matching has been performed on the SAT 2 samples against the SAT 2 SAR/3/04 and SAT 2 KNP/1/10 vaccine strains and ARC has developed five new vaccine strains that are being prepared for commercial release and will be available to the region. The current risks in Pool 6 (Southern Africa) are serotype SAT 2 topotype I as well as serotype SAT 3, which has recently spread in parts of the region, perhaps due to the drought and movement of animals into new areas.

Pool 4-6: Sub Saharan Africa (Mokganedi Mokopasetso)

There has been a decrease in samples submitted to RRLSSA (Botswana) during 2020: clinical samples received during the year include 8 from Namibia (serotypes SAT 3 and SAT 2), 46 from Botswana (serotype SAT 1), 6 from Zambia (serotype O) and 2 from Malawi (serotype

SAT 2). Final analyses for some of these samples is still underway, although sequencing analyses has detected the following FMD virus lineages: SAT 1/III (Botswana), O/EA-2 (Zambia), SAT 3/II (Namibia) and SAT 2/I (Malawi). Particular regional concern surrounds (i) the spread of O/EA-2 in Zambia (from Pool 4: East Africa) and the onward potential for this virus topotype to move further south into Southern Africa (Pool 6) and (ii) the on-going situation regarding serotype SAT 3 in Zambia and Namibia that motivates more surveillance studies in buffalo. Additional samples have been received for serological testing (by NSP, LPBE and VNT) and vaccine matching results were report for a SAT 1 isolate (BOT/8/2020) for two BVI vaccine strains: SAT 105 (matched) and SAT 109 (not matched).

Pool 7: South America (Maristela Pituco)

There have been no reports of FMD in South America for >3 years and no samples from suspect FMD cases were received during 2020; however, testing continues to be performed for differential diagnostic purposes (vesicular stomatitis, Senecavirus A, bluetongue and poxvirus infection). The lab also performed vaccine tests for quality control. A project is currently underway to sequence historical South American FMDV strains (1950-2018) in partnership with CFIA, Canada. Since 2019, South America has used a bivalent FMD vaccine with O_1 Campos and A_{24} Cruzeiro, except for Argentina which continues to use quadrivalent vaccine (O_1 Campos, A_{24} Cruzeiro, A Arg/2001 and C_3 Indaial). The plan is to withdraw vaccination by 2026. Panaftosa has organized a proficiency testing for FMD/VS with the attendance of 20 laboratories from American continent. Furthermore, Panaftosa developed and validated a new ELISA 3ABC kit with higher sensitivity and specificity appropriate to the current epidemiological situation in the region. In partnership with MAPA/Brazil, the laboratory delivered 7 FMD e-training courses.

Pool 7: South America (presentation provided by Andrea Pedemonte)

This presentation summarised activities that have been undertaken during 2020 at SENASA, Argentina where differential diagnostic tests have been used to detect the presence of a range of livestock infectious agents in samples submitted from suspect FMD cases (bovine papular stomatis, vesicular stomatitis, bovine herpes virus-1, contagious ecthema, and BVD). Sera samples (n=12,000) have also been tested to demonstrate the absence of FMDV circulation in Argentina and to monitor population immunity after vaccination.

WEDNESDAY 2ND DECEMBER 2020, DAY 2

Update from CSIRO (Wilna Vosloo)

The name of the Geelong laboratory has changed from AAHL to Australian Center for Disease Prevention (ACDP). The COVID-19 pandemic has impacted ongoing international collaborations including work to assess virus inactivation techniques, vaccine matching, serotype-specific PCRs and the development of new NGS methods. Recent work undertaken in Australia has assessed surveillance approaches that can be adopted to regain FMD free status; results indicate that non-invasive bulk (herd-level) testing by real-time RT-PCR (such as bulk milk and rope chews) have the potential to speed up and reduce costs associated with disease surveillance after outbreaks in a country (further details will be provided in in a presentation to the Open Session of EuFMD in Dec 2020).

Update from SCIENSANO (David Lefebvre)

No samples were received during 2020 from international partners. The OIE twinning project in Nigeria (with NVRI, Vom) has concluded and the research and surveillance outputs have been published in *Frontiers in Veterinary Science*. Work to establish a partnership with the FMD Lab in Burundi is still on-going, although to date no new samples have been received.

Update from ANSES (Labib Bakkali Kassimi)

During 2020, LFD and swab samples have been obtained from Burkina Faso and Niger. From these samples, 15 viral isolates have been generated (from the swabs) that are currently being typed and sequenced. In order to assess the capacity and expertise of veterinary laboratories, ANSES (with support of EuFMD) has undertaken a new survey to review the strengths and weaknesses of diagnostic testing for FMD and other "FAST" transboundary animal diseases involving REMESA (8 laboratories) and the south-eastern European neighbourhood (9 laboratories). A similar exercise has been carried out for 38 European countries. ANSES has organised a proficiency testing scheme for FMD/SVD (under the EU-RL); where thirty-eight countries have participated. From a research perspective, ANSES has started to develop a triplex real time RT-PCR to detect FMDV (including a GAPDH house-keeping control and the 3D assay defined in the OIE Manual, and where the 5'UTR target has been replaced with a new assay that detects 2B). Once validated, the goal is to provide a ready-to-use master mix for FMD laboratories.

Update from IZSLER (Santina Grazioli)

No FMD clinical samples have been received from overseas during 2020. There has been a 60% reduction in the request for antigen detection ELISA kits produced by IZSLER ELISA that could be connected to the COVID 19 emergency, with the logistic difficulties also for shipment of materials overseas. Currently the structural protein serotype O kits is most popular. IZSLER have recently developed of a multiplex LFD with 4 reaction lines (for type O, A, Asia 1 typing) in a single strip using the same set of well characterized MAbs, previously selected for the Ag-ELISA kit. Validation with field samples is in progress in collaboration with NRLs in endemic areas, as well as studies to develop a multiplex LFD for typing SAT1 and SAT2 viruses. Diagnostic performance of FMDV detection and serotyping assays on clinal samples collected in Tanzania during 2012-2018 has been conducted. The performance of the virological assays was compared, including a set of five serotype-specific real-time RT-PCRs for EA types/topotypes in order to compare the diagnostic performance including the capability to serotyping. During 2020, sera collected from a small-scale vaccination trial in Georgia and Armenia has been evaluated. The study analysed the onset and duration of neutralizing antibodies elicited after the first and the second vaccination in groups of small and large ruminants kept under controlled field conditions. Unfortunately, the humoral response against the vaccines analysed was modest and not expected to induce a protective and long-lasting population immunity.

Update from NCFAD (Charles Nfon)

During 2020, clinical samples (n=28) have been received and analysed from Nigeria (in partnership with NVRI, Vom) where serotypes O (EA-3 and WA), A (AFRICA/G-IV) and SAT 2 (VII) have been detected. For SAT 2, sequences have revealed two genetic clusters, that may indicate virus introduction into the country. Once full genome sequencing has been completed data will be exchanged with WRLFMD. NCFAD, WRLFMD and NVRI are currently working together to organise vaccine matching work for representative samples from Nigeria.

Update from APHIS, Plum Island (Consuelo Carrillo)

FMD diagnostic testing at Plum Island during 2020 has only involved domestic samples; all of these were negative. APHIS has also been involved with recent VS and RHD-2 cases in the USA. Due to COVID-19 social distancing measures there has been a delay in research and diagnostic objectives. In response to the request during last year's meeting for large volumes for sera from vaccinated animals, APHIS can make available the following sera for distribution to Network partners: A Saudi-95 and SAT 1 ZIM collected at 21 days post vaccination.

Action O20-05 WRLFMD to add a new page to the Network website that lists available reference sera

Update from AU-PANVAC (Ethel Chitsungo)

AU-PANVAC harmonises vaccine registration and approves pre-registration certificates as well as post-registration certificates (for batch control). The OIE Twinning project (2019- 2022 with WRLFMD) aims to establish this capacity for FMD. AU-PANVAC has been invited to assist with the AgResults competition (https://agresults.org/projects/fmd-vaccine).

Update from EuFMD with overview of FMD vaccine survey for endemic countries (Kees van Maanen)

This presentation briefly summarised recent activities of EuFMD which are now expanded to support the control of FAST (FMD and similar transboundary) diseases (http://www.fao.org/eufmd/what-we-do/en/) . During 2020, EuFMD (with WRLFMD) have delivered a FMD Laboratory Investigation Training Course (3rd edition) and have implemented work for vaccine security (led by David Mackay), where a a new analytical model is being established to predict FMD vaccine demand for endemic countries. The presentation highlighted that an expert elicitation (seeking feedback from Network partners) is ongoing with the expectation that the model will be completed by the end of January 2021.

Introduction to regional LabNet leaders

The purpose of the regional laboratory networks (LabNets) is to harmonise diagnostics, share data, carry out training courses and have webinars in support of the regional FMD RoadMaps. The current LabNet leaders are Amer Younes Ahmed Saleh for the Middle East, Rajeev Ranjan for South Asian Association for Regional Cooperation (SAARC), Abdulnaci Bulut for West EurAsia, P. Makaya for Southern African Development Communities (SADC), Alfred Wejuli for East Africa, Lo Mbargou for West Africa, Richard Ngandolo Nare Bongo for Central African Republic. Abdulnaci Bulut and Rajeev Ranjan attended this meeting and briefly introduced their roles and highlighted opportunities for collaboration with the Network. The difficulties are commitment from countries for this type of work and overcoming poor communication during outbreaks (information is often received too late). It was agreed that the Network would continue to invite the regional LabNet leaders to future Annual meetings.

Progressive Control Pathway (PCP) Support Officers (PSOs) Etienne Chevanne

Etienne Chevanne introduced the concept of PCP FMD Support Officers (PSOs). These individuals advise countries on disease control policies and risk-based approaches for moving through the PCP including the planning and implementation of country-level plans. So far, thirteen PSOs have been assigned to 28 countries; however, approximately 31 additional countries are considered to need assistance from a PSO. There is also a need for new PSOs that speak languages such as Chinese, Russian, French, and Arabic. A PSO training

development framework has been drafted and the FAO/OIE invite experts from the Network to sign up to become a PSO. David Paton commented how being a PSO helps to understand the wider issues regarding FMD control and Kees van Maanen highly recommended becoming a PSO. *If you are interested in becoming a PSO please e-mail FAO-FMD@fao.org. Additional information can also be found here: http://www.fao.org/eufmd/global-situation/pcp-fmd/pcp-support-officers/en/.*

Review of global and regional risks by Network partners

The Annual Report from the Network (for recent example see: https://www.foot-and-mouth.org/sites/foot/files/user-files/research-paper/pdf/11-20/OIE-FAO%20FMD%20Ref%20Lab%20Network%20Report%202019.pdf collates data from different sources to map the distribution of important FMD lineages and highlight how these viruses may move in the future. Based on recent transboundary spread, there are currently five lineages included in these maps for Serotype O: O/ME-SA/Ind-2001, O/ME-SA/PanAsia, O/ME-SA/PanAsia-2, O/SEA/Mya-98 and O/EA-3. Maps for serotype A include A/ASIA/Iran-05, A/ASIA/G-VII and A/ASIA/Sea-97 lineages, while serotype Asia 1 and SAT 2 (topotype VII) are shown in separate maps. The meeting participant reviewed these maps and agreed that the following points should be accommodated during the 2020 update:

A020-07 – Suggestion for updating global and regional risk maps

- In view of recent epidemiological events, include new maps to show the distribution of O/EA-2 and A/AFRICA/G-IV
- Consider whether are now lower risks associated with A/ASIA/G-VII in Pool 3 due to the reduced number of cases that have been reported due to this lineage in the region (2019/2020).
- Highlight that there are few (or no) opportunities for live animal movements across the India-Pakistan border
- Highlight that the spread of O/ME-SA/Ind-2001 into Egypt is constrained by the main pathway for animal importation into the country (which is from countries to the south)
- Include text to explain that serotype Asia 1 cases are due to two separate genetic lineages (Pools 2 and 3, respectively)
- Consider whether the colour scheme could more clearly show the historical distribution of the viruses
- Include updated text to explain the purpose of the arrows
- Where possible, adopt the UN Geoscheme definition of regions in the narrative text

New data-sharing and display tools

Proposal: a harmonised system to collect and display laboratory and field data from the Network (Antonello Di Nardo)

In order to help collate laboratory and field data from the Network, the WRLFMD proposes that a simple Excel sheet is used by the partners to collect the metadata associated with samples collected from FMD outbreaks. This talk introduced a simple .xls sheet that might be used to collect these data to facilitate data sharing and enhance post-processing analysis.

A020-08 – ALL PARTNERS: please provide feedback on the feasibility of using this Excel format to report data and make any suggestions to improve the form.

The talk also briefly introduced an FMD open–access project which will allow users to explore of FMD data in real-time, including investigation of vaccine efficacy and protection as well as the endemic spread of the disease. The ideas for this project are currently being discussed with EuFMD and will include an FMDV sequence database (described below), bioinformatics pipeline and APIs, reporting module and visualisation client.

A020-09– WRLFMD and EuFMD welcome feedback – ALL PARTNERS, please respond to this survey to capture system requirements:

https://forms.office.com/Pages/ResponsePage.aspx?id=Eh70v1zu20izMQzOHucOut-ijsc2qwZOo151ynO2MwhUN01SUFVROTc3TTRYRklEMTU3WU1FTUsyQy4u&wdLOR=c62C7239C-7FB3-854B-A0AD-AA977B792E0B

FMDbase: a new "open access" database for FMDV sequences (Nick Knowles)

WRLFMD is developing FMDbase: a new "open access" database for FMDV sequences. This database is being scripted in MySQL and will contain GenBank, WRLFMD VP1 and complete genome sequences. The current number of sequences that will be added to FMDbase is 17,146, of which 2,062 are complete or near-complete genome sequences. It is anticipated that the database will be available during the early part of 2021. External users will be able to access the content via a web-portal with different security levels: public or private (unpublished data). It is currently anticipated that the Network MoU will cover data exchange between partners within the Network and once the system is established the WRLFMD hopes that the database will be widely used by different FMD Reference Laboratories.

COVID-19 experiences from Network partners

As anticipated, COVID-19 has significantly impacted on the work of the Network during 2020. Almost all of the presentations from the partners highlighted a reduction in samples tested as a consequence of local restrictions to send veterinary teams out to the field and difficulties to organise international shipments during this period. Furthermore. staff from a number of the laboratories have been engaged with the priorities of national COVID-19 diagnostics and equipment has been re-purposed for SARS-CoV-2 diagnostics. There were also examples of work being impacted by restrictions in the availability of reagents (such as PCR kits) and PPE.

Samia Metwally – Through her contacts it appears that people can go into the field to collect samples; however, there is limited, to no PPE. There also appears to be a decrease in the diagnostic tests that are available. A report is being written about this and Samia will share the results.

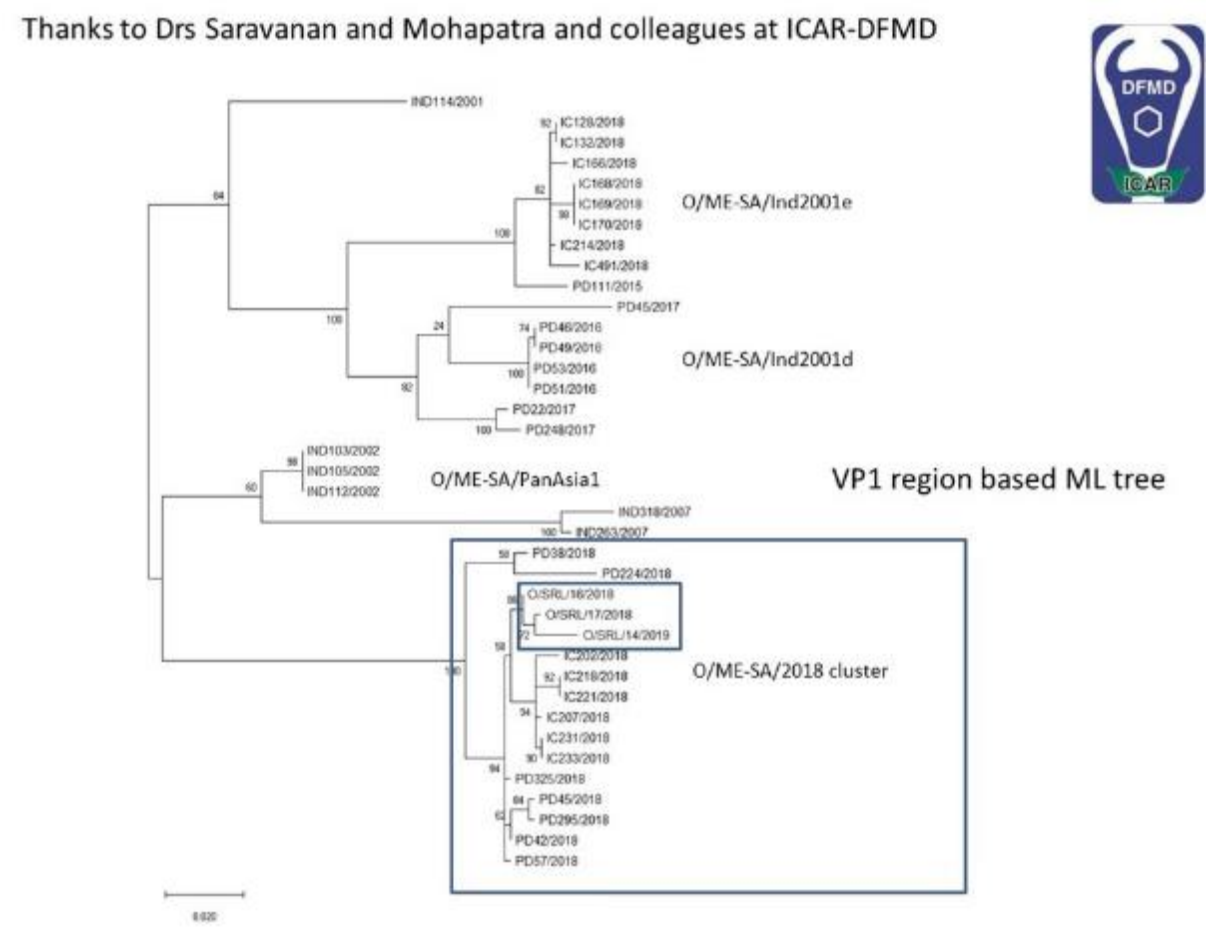
Action O20-03 Samia Metwally to share the results of the impact of COVID-19 with the Network

Min Kyung Park – As of yet there has been no decrease in the number of OIE-status applications, but this may only be reflected next year. However, the OIE has indications that there has been a delay in some sero-surveillance activities and the implantation of certain control measures.

Suggestion to carry out survey within the network to assess impact.

Action O20-04 WRLFMD will circulate a short survey (via Survey Monkey) to be completed by all partners and affiliates Results will be fed back to all partners as well as the OIE/FAO.

Annex 1: Phylogenetic analyses demonstrating close genetic relationship between Indian (coded PD) and Sri Lankan (coded O/SLR) FMD viruses within the “new O/ME-SA/2018” clade



Annex 2:

ACTION LOG: Progress on actions from previous meetings

Completed	Open (in progress)	Open (no progress)

Action number	Owner(s)	Description and review
C4-17	David Lefebvre, Labib Bakkali Kassimi, Andrea Pedemonte, Consuelo Carrillo and Charles Nfon	To establish a working group to coordinate the review of the FMD chapter of the OIE Terrestrial Manual. **Open but no imminent update in the OIE Manual is planned for 2020.**
O2-17	ANSES, IZSLER SCIENSANO, NCFAD and WRLFMD	Review data from samples that generated inconsistent NSP results and report back to the Network with these findings (for the tests provided by ThermoFisher and ID.vet – but not with the indirect ELISA provided by IZSLER. A short publication on the NSP harmonisation exercise is in draft and awaiting feedback from all collaborators. NCFAD should also be included in these conversations. **Observations from the European interlaboratory study have been published: Browning et al., 2020 – JVDI.**
C5-18	WRLFMD/ALL	WRLFMD (and other partners) to consider whether a review article should be written to collate historical information on serotype C and to recommend the process to formally remove this serotype from FMD viruses circulating in endemic countries. **Closed – the review article has been submitted to *Virus Evolution.***
C6-18 (see C4-17)	ALL	Working Group to prepare recommendations for appropriate modifications to the sections in the OIE Manual that describe vaccine-matching methods – including any relevant comments from the GFRA meeting held in 2017. There are no OIE manual updates planned for the next six months. This action will remain open as work is still being carried out by Network members to determine the best course of action **Ongoing – Min Kyung Park will provide an update during this meeting.**
C10-18:	Labib Bakkali Kassimi	Working Group to prepare a questionnaire will be sent out to help standardise sample nomenclature (lab coding maybe included) **Ongoing – point will be discussed during 2020 meeting (Day 2)**
O2-18	Don King	Don King to send around a draft figure of how viral pools are linked. Figure was attached to the minutes (see Appendix 1) with feedback requested for early 2020. **Figure was sent – and some feedback was received. Final version of the figure needs to be prepared.**

O3-18	Anna Ludi	To draft a document containing the BVS currently available at The Pirbright Institute. Other institutes including industry could then add to this list (only large quantities would be included). This could include a reference panel. **Ongoing – list of available bovine vaccination sera has been included in a review article submitted to the OIE. Network website still needs to be updated.**
C2-19	Min Kyung Park and Don King	Investigate whether a short article for the OIE bulletin can be published for 2020 **Completed – text sent to the OIE**
C3-19	ALL	The Nomenclature Steering Group requires a new coordinator (since Kasia Bankowska left WRLFMD)– Please send any nominations to WRLFMD **Open**
C4-19	ALL	Proposed laboratory capabilities required for different countries in the PCP pathway – to feed into the global PTS that is managed by WRLFMD **Closed – feedback regarding laboratory capability and the PCP will be incorporated into the interpretation of PT results for the exercise that will be reported in early 2021.**
O1-19	All	Other reference laboratories that are not OIE/FAO may also need to sign a type of MoU so that can be shared more easily within the Networks, specifically sequencing information. WRLFMD will investigate further. **Open**
O2-19	All	The O/EA-3 sequence data should be shared to study how this lineage is moving across Africa. This could include strains from WRL, ANSES and NCFAD. **O/EA-3 sequence data from NVRI, ANSES, IZSLER, NCFAD and WRL has been collated – with a view to formally reporting these data (as a joint paper?)**
O8-19	All	The annual report will be started in the New Year. Please reply to Mark Henstock e-mail regarding laboratory reports for 2019 activities. **Closed – the 2019 network report has been published.**
O5-19	Samia Metwally	There is a tri group reviewing Nagoya (representing OIE/FAO/WHO). Samia Metwally will get the most updated information from this committee. **Update at the 2020 meeting**