Food and Agriculture Organization of the United Nations

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

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

Foot-and-Mouth Disease

January-March 2021
Quarterly report

FAST Reports
Foot-and-mouth And Similar Transboundary animal diseases

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

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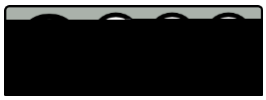


Contents

Abbreviations and acronyms

BVI	Botswana Vaccine Institute
EIDRA	Emerging Infectious Disease Research Association
EuFMD	European Commission for the Control of Foot-and-Mouth Disease
FAST reports	Foot-and-mouth and similar transboundary animal diseases reports
FGBI “ARRIAH”	Federal Governmental Budgetary Institution “Federal Centre for Animal Health”
FMD	Foot-and-mouth disease
FMDV	Foot-and-mouth disease Virus
FMDV GD	Foot-and-mouth disease Virus Genome detected
FMDV NGD	Foot-and-mouth disease Virus Genome not detected
GF-TAD	Global Framework for the Progressive Control of Transboundary Animal Diseases
LVRI	The National Reference Laboratory for FMD, The Lanzhou Veterinary Research Institute, Chinese Academy of Agricultural Sciences
MEVAC	International Facility for Veterinary Vaccines Production (Egypt)
NT	Not tested
NVD	No virus detected
OIE	World Organisation for Animal Health
PIADC	Plum Island Animal Disease Center
rRT-PCR	Real-time reverse transcription polymerase chain reaction
SAARC	South Asian Association for Regional Cooperation
SADC	Southern Africa in collaboration with the Southern African Development Community
SAT	Southern African Territories
SEACFMD	South-East Asia and China FMD campaign
SSARRL	Sub-Saharan Africa Regional Reference Laboratory
SVD	Swine vesicular disease
VETBIS	Veterinary Information System of Turkey
VI	Virus Isolation
WAHIS	World Animal Health Information System (of the OIE)
WRLFMD	World Reference Laboratory for Foot-and-Mouth Disease

1. Highlights and headlines

Welcome to this new issue of the FMD Quarterly Report where we describe results for samples received from Bahrain, Cambodia, Israel, Laos, Nigeria, Thailand and Uganda. New sequence data has also been shared from Burkina Faso (via ANSES), India (via ICAR-DFMD), Israel (via KVI), Mauritius (via ANSES), Namibia (via SSARL at BVI, Botswana) and Niger (via ANSES). Sample submissions to International FMD Reference Laboratories have been impacted by the on-going COVID-19 pandemic: despite these current difficulties, the OIE/FAO FMD Laboratory Network (https://www.foot-and-mouth.org) welcomes countries to submit appropriate clinical samples for laboratory analyses – testing is free-of-charge, for further information or assistance with shipments, please contact donald.king@pirbright.ac.uk.

These data highlight two new events:

[1] **Samples from Mauritius:** In recent years, particular attention has focused on FMD viruses that circulate in Pool 2 (South Asia) and the frequency by which these viruses can seed new outbreaks elsewhere. Previous examples of viruses that have spread from Pool 2 include O/ME-SA/Ind-2001 (d and e sub-lineages) and A/ASIA/G-VII. In this report, we describe new sequence data that have been provided by ANSES (France) for samples collected on the Island of Rodriguez in Mauritius during March 2021. Analsyses demonstrate that these new sequences belong to the O/ME-SA/Ind-2001e lineage – however, they appear to be distinct from sequences that were detected in Mauritius during 2016.

[2] **Samples from Bahrain:** FMDV sequence data for the samples collected in Bahrain have been characterised as belonging to two East African viral lineages (O/EA-3 and A/AFRICA/G-I). We understand that these samples are from cattle that have been recently imported from Somalia which explains the unexpected origin of these viruses.

A new review article published by the OIE/FAO FMD Laboratory Network provides an overview of the history of serotype C and evidence that this serotype is no long circulating in susceptible hosts (see: https://academic.oup.com/ve/advance-article/doi/10.1093/ve/veab009/6178807). Now that more than sixteen years have passed since the last serotype C outbreak (in Kenya and Brazil in 2004), this paper also makes recommendations to reduce the possibility that this serotype is reintroduced into the field.

Don King, Pirbright April 2021

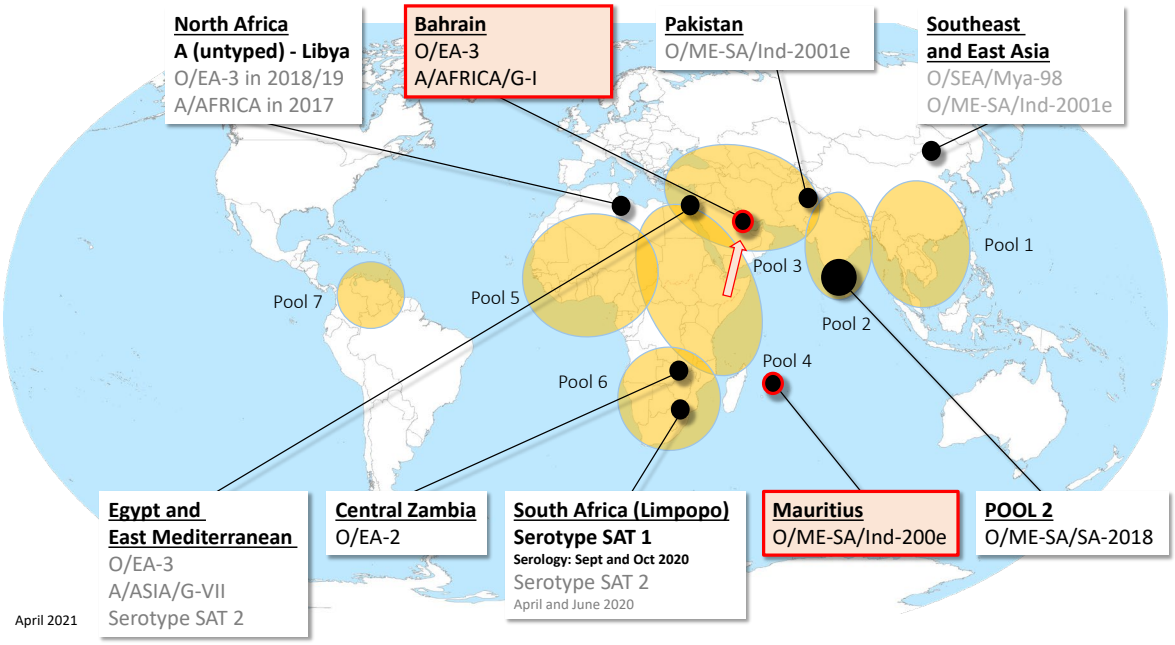


Figure 1: Recent FMD global outbreaks (new headline events reported January-March 2021 are highlighted) with endemic pools highlighted in orange. Source: WRLFMD. Map conforms to the United Nations World Map, June 2020.

2. General overview

Endemic Pools represent independently circulating and evolving foot-and-mouth disease virus (FMDV) genotypes; within the pools, cycles of emergence and spread occur that usually affect multiple countries in the region. In the absence of specific reports, it should be assumed that the serotypes indicated below are continuously circulating in parts of the pool area and would be detected if sufficient surveillance was in place.

POOL	REGION/COUNTRIES	SEROTYPES PRESENT
1	**SOUTHEAST ASIA/CENTRAL ASIA/EAST ASIA** Cambodia, China, China (Hong Kong SAR), Taiwan Province of China, Democratic People's Republic of Korea, Republic of Korea, Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, Russian Federation, Thailand, Viet Nam	A, Asia 1 and O
2	**SOUTH ASIA** Bangladesh, Bhutan, India, Mauritius, Nepal, Sri Lanka	A, Asia 1 and O
3	**WEST EURASIA & MIDDLE EAST** Afghanistan, Armenia, Azerbaijan, Bahrain, Georgia, Iran (Islamic Republic of), Iraq, Israel, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Lebanon, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Syrian Arab Republic, Tajikistan, Turkey, Turkmenistan, United Arab Emirates, Uzbekistan	A, Asia 1 and O (SAT 2)
4	**NORTH AFRICA** Algeria, Egypt, Libya, Morocco, Tunisia	A, O and SAT 2
	EASTERN AFRICA Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan, Uganda, United Republic of Tanzania, Yemen	O, A, SAT 1, SAT 2 and SAT 3
5	**WEST/CENTRAL AFRICA** Benin, Burkina Faso, Cabo Verde, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Sao Tome and Principe, Senegal, Sierra Leone, Togo	O, A, SAT 1 and SAT 2
6	**SOUTHERN AFRICA** Angola, Botswana, Malawi, Mozambique, Namibia, South Africa, Zambia, Zimbabwe	SAT 1, SAT 2 and SAT 3 (O, A)[†]
7	**SOUTH AMERICA** Colombia, Venezuela (Bolivarian Republic of)	O and A

[†] *only in Angola and north Zambia as spill-over from pool 4*

3. Summary of FMD outbreaks and intelligence

3.1. Global overview of samples received and tested

The location of all samples detailed in this report can be seen on the map below. More detailed maps and sample data, on a country by country basis, can be found in the following sections of this report.

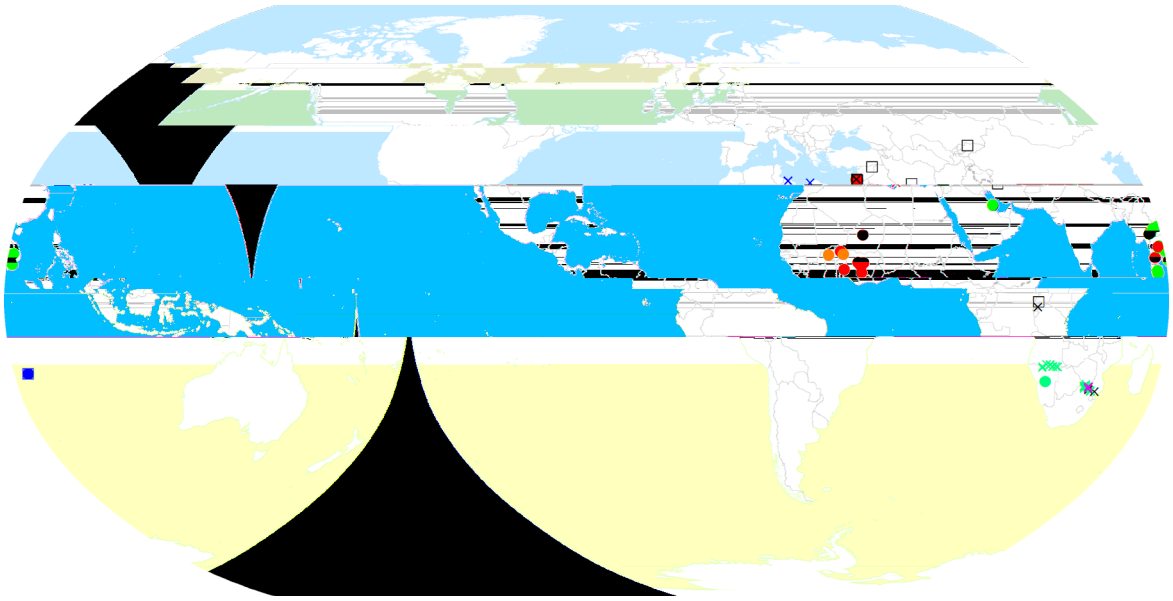


Figure 2: Samples tested by WRLFMD or reported in this quarter. ● indicates samples analysed; × indicates new outbreaks reported to the OIE, but where results to define the genotype have not been reported; □ indicates reports of FMD from other sources. Shape colours define the serotype detected ●O; ●A; ●C; ●Asia1, ●SAT1, ●SAT2, ●SAT3, ○ FMD not detected, ● serotype undetermined/not given in the report.

Source: WRLFMD. Map conforms to the United Nations World map, June 2020.

3.2. Pool 1 (Southeast Asia/Central Asia/East Asia)

The Kingdom of Cambodia

A batch of nine samples was received to WRLFMD on 22 December 2020. All were confirmed as serotype O and genotyping showed them all to belong to the ME-SA/PanAsia lineage.

The Lao People's Democratic Republic

A batch of five samples was received to WRLFMD on 22 December 2020. All samples were confirmed as serotype O and genotyping showed all to belong to the ME-SA/Ind-2001e sublineage.

The Kingdom of Thailand

A batch of 16 samples was received to WRLFMD on 22 December 2020. Twelve samples were confirmed as serotype O and the remaining four were serotype A. Genotyping showed the type O viruses to belong to the ME-SA/Ind-2001e sublineage and the type A viruses to the ASIA/Sea-97 lineage.

3.3. Pool 2 (South Asia)

No new outbreaks of FMD were reported in South Asia.

3.4. Pool 3 (West Eurasia and Middle East)

Kingdom of Bahrain

A batch of 40 samples was received on 9 March 2021. FMD type O was identified in three samples, type A in one sample and FMDV genome was detected in one additional sample; 36 samples were NVD. Genotyping showed the type O viruses to belong to the EA-3 topotype and the type A virus to the AFRICA/G-I lineage.

The Islamic Republic of Iran

The first instance of naturally acquired FMDV infection in dogs has been reported (see Waters et al., 2021). The sample was from one of 5 young dogs that had died after being fed the carcasses of lambs which died during an FMD outbreak on a farm in Iran in 2016.

The report contains no evidence that dogs are able to contract the disease from live infected animals or that they are capable of spreading the disease as a result of being infected. ProMED post: [20210225.8212791]

According to the Iran Veterinary Organization (IVO) 1,405,493 large ruminants and 16,009,422 small ruminants were vaccinated against FMD between 1st January and 1st April 2021 with trivalent vaccines (O, A, Asia1) which were either locally produced or imported. The vaccination of nomadic animals was done free of charge

State of Israel

On the 8 January 2021, three VP1 sequences were received from the Kimron Veterinary Institute and on 01/03/2021, six samples were received. All sequences/samples belonged to FMD type O and genotyping showed them to belong to the ME-SA/PanAsia-2^{QOM-15} sublineage.

FMD was reported to the OIE in January and February (OIE event ID: 37437).

OIE World Animal Health Information System

FMD was reported in northern Israel in January and March by the OIE and Israel's Veterinary Services (VSAH).

ProMed posts: 20210107.8079606 and 20210127.8141870 and 20210312.8243802

The Kyrgyz Republic

An anonymous source has reported observations of suspected foot and mouth disease on a farm in Chuyskaya Oblast.

ProMED post: 20210110.8090048

The Lebanese Republic

The National News Agency reported that a vaccination campaign has started against Foot-and-Mouth Disease in cattle in the district of Caza de Bent Jbaïl, Mohafazat Nabatîyé.

ProMED post: 20210219.8201498

The Syrian Arab Republic

According to an unofficial/media report, there is a widespread outbreak of Foot-and-Mouth Disease in northeastern Syria.

ProMED post: 20210216.8194894

The Republic of Turkey

Turkey reported 26 outbreaks in cattle (n=19) and small ruminants (7). FMD is endemic in Anatolia and the identified sublineages are still O PanAsia-2^{Qom15} and O PanAsia-2^{ANT10}. Both are well matched to the vaccines currently in use. Serotypes A and Asia1 have not been detected since January 2018 and July 2015, respectively.

The Thrace region has been free with vaccination since May 2010

Update from the Transcaucasus region:

The 2021 spring vaccination campaigns are currently underway in Georgia, Azerbaijan, and Armenia, following a risk-based approach according to their respective national FMD control strategies.

Georgia has conducted risk-based vaccination since 2017. The entire population of cattle and small ruminants of eastern Georgia is considered at high risk of FMD and therefore regularly vaccinated. In western Georgia, villages are targeted based on their proximity to live animal markets, migrating animals, and borders with Turkey and non-controlled territories.

Azerbaijan plans to conduct a post-vaccination serological survey for large and small ruminants after this spring vaccination

3.5. Pool 4 (North and Eastern Africa)

The Arab Republic of Egypt

About 3.03 million large and small ruminants were vaccinated against FMD within the context of a massive campaign launched on 6 February 2021 by the Egyptian veterinary services with locally produced vaccine recently modified by adding the serotype A lineage (A/AFRICA/G-IV) to the vaccine as a response to the outbreak reported in October 2020 caused by this lineage. (Source: GOVS)

The State of Libya

FMD was reported to the OIE in January (OIE event ID: 33808)

OIE World Animal Health Information System

Recently, the NCAH has launched a FMD mass vaccination campaign targeting all cattle populations (~25000 doses are available), where currently 94,000 doses have been distributed to 43 animal health offices in the east, west, and south of Libya. In parallel blood samples are being collected to be tested against FMD and other transboundary animal diseases.

The Republic of Rwanda

FMD was reported to the OIE in January (OIE event ID: 37581)

OIE World Animal Health Information System

The Republic of Uganda

A batch of 11 samples was received to WRLFMD on 16 December 2020. FMD viral genome was detected in 9 samples but no serotype confirmed. Genotyping is underway and results will be reported shortly.

Foot-and-Mouth Disease has been affecting Animals in Kiruhuura District (sub-counties of Kikatsi, Kenshunga, Kashongi, Kinoni and

Kiruhura Town Council) since November. Authorities have stopped all animal movements within and outside the district and suspended all animal slaughter in all centres to help stop the spread of the disease.

ProMED post: 20210201.8156219

3.6. Pool 5 (West/Central Africa)

Burkina Faso

On the 30 March 2021, four VP1 sequences were received from ANSES. Genotyping showed they belonged to the SAT2/VII/Lib-12 lineage.

Republic of the Niger

On 30 March 2021, 19 VP1 sequences were received from ANSES. Genotyping showed 18 of them to belong to the A/AFRICA/G-IV lineage, while one belonged to the SAT2/VII/Lib-12 lineage.

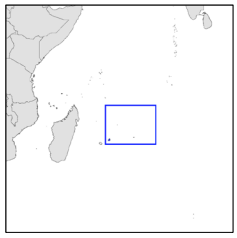
The Federal Republic of Nigeria

On 1 February 2021, a batch of seven samples was received. All were identified as FMD type A and genotyping showed they belonged to the AFRICA/G-IV lineage.

On 24 February 2021, a further batch of 12 samples was received. Six samples were identified as FMD SAT 2. FMD virus genome was found in a further two samples and four were NVD.

3.7. Pool 6 (Southern Africa)

Republic of Mauritius



On 26 March 2021, two VP1 sequences were received from ANSES. The samples from which they originated were collected on 10/03/2021 from cattle at Saint Gabriel on the island of Rodriguez. Genotyping showed they belonged to the O/ME-SA/Ind-2001e sublineage.

FMD was reported to the OIE in January (OIE event ID: evt_3625)

OIE World Animal Health Information System

The source of the outbreak remains unknown. Authorities have applied measures to reduce the risk of spread: quarantine; official disposal of carcasses, by-products, and waste, movement control inside the country; disinfection; ante- and post-mortem inspections.

From 57 cases in dairy and mixed-breed cattle, 16 deaths were recorded.

ProMED post: 20210314.8247240 and 20210327.8273130

The Republic of Mozambique

FMD was reported to the OIE in January (OIE event ID: 35436)

OIE World Animal Health Information System

The Republic of Namibia

FMD was reported to the OIE in January (OIE event ID: 36008)

OIE World Animal Health Information System

The Republic of South Africa

FMD was reported to the OIE in January and March (OIE event IDs: 33576, 36933, 28323, 32311 and 36933)

OIE World Animal Health Information System

3.8. Pool 7 (South America)

No new outbreaks of FMD were reported in South America.

3.9. Extent of global surveillance

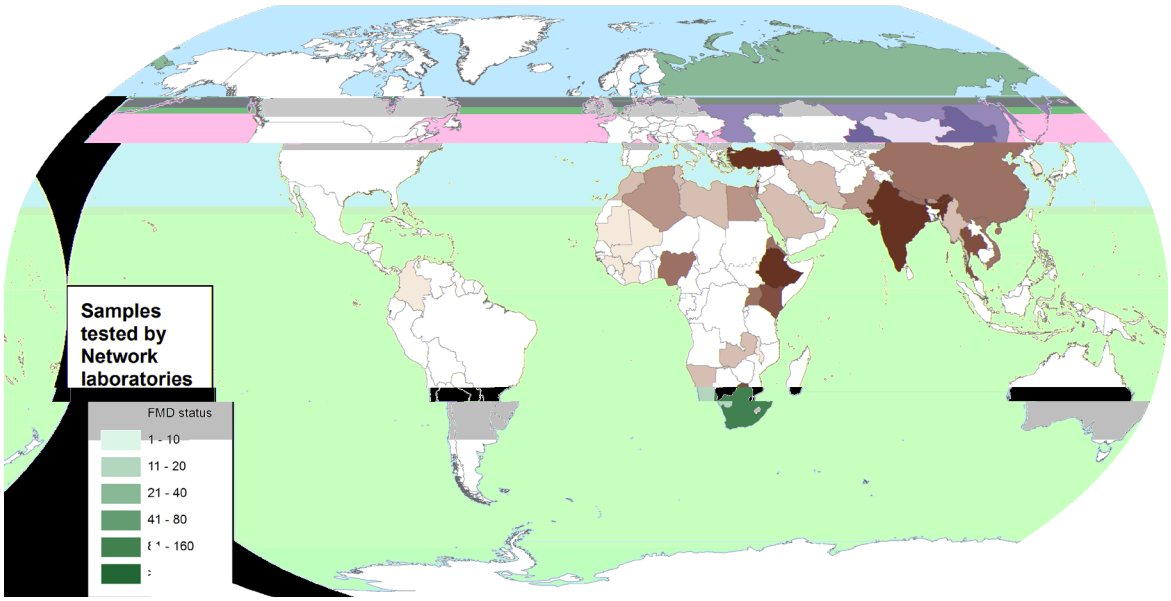


Figure 3: Samples received during 2019 from FMD outbreaks (routine surveillance that is undertaken in countries that are FMD-free without vaccination is not shown). Data from presentations given at the OIE/FAO Reference laboratory Network annual meeting (https://www.foot-and-mouth.org/Ref-Lab-Network/Network-Annual-Meeting)

Source: WRLFMD. Map conforms to the United Nations World map, June 2020.

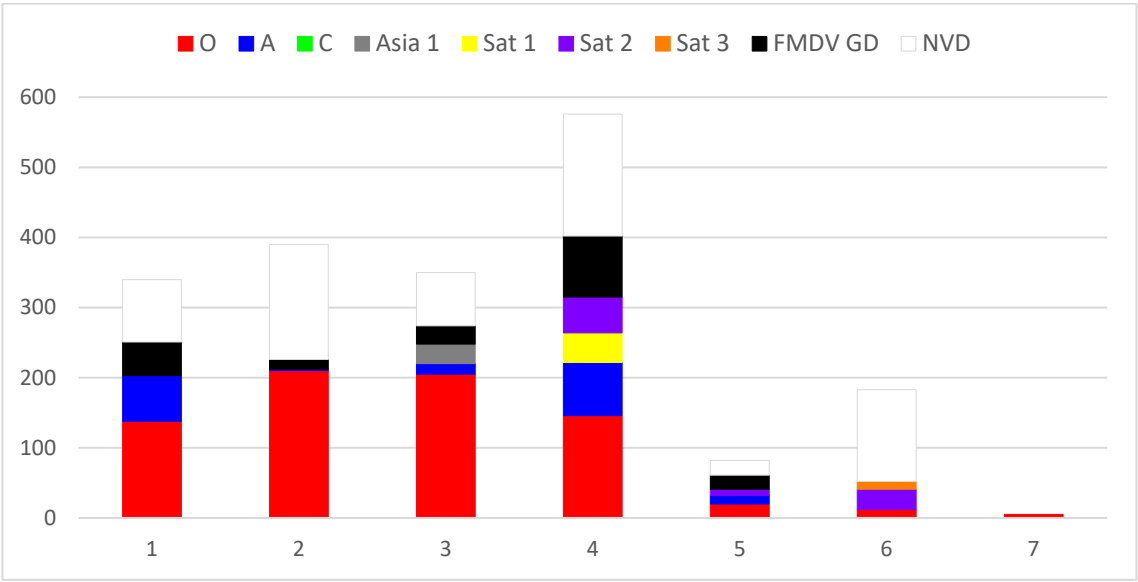


Figure 4: Representation of different FMDV serotypes detected in samples tested from the FMD endemic pools by the OIE/FAO FMD Laboratory Network during 2019 (NVD = no virus detected; GD = genome detected)

In regions where FMD is endemic, continuous evolution of the virus generates geographically discrete lineages that are genetically distinct from FMD viruses found elsewhere. This report displays how different FMD lineages circulate in different regions; these analyses accommodate the latest epidemiological intelligence to assess the relative importance of the viral strains circulating within each regions (see Table 1, below).

Table 1: Conjectured relative prevalence of circulating FMD viral lineages in each Pool. For each of the regions, data represent the relative importance of each viral lineage [prevalence score estimated as a percentage (%) of total FMD cases that occur in domesticated hosts]. These scores (reviewed at the OIE/FAO FMD Laboratory Network meeting in December 2020) can be used to inform the PRAGMATIST tool (see Annex 3). Recent changes to increase risks are shown in red, while a reduction in risk is shown in green.

Lineage	Southeast / Central / East Asia [Pool 1]	South Asia [Pool 2]	West Eurasia & Middle East [Pool 3]	North Africa	Eastern Africa [Pool 4]	West / Central Africa [Pool 5]	Southern Africa [Pool 6]	South America [Pool 7]
O ME-SA PanAsia-2			35					
O ME-SA PanAsia	10							
O SEA Mya-98	33							
O ME-SA Ind2001	20	80	7	10				
O EA or O WA			3	55	55	70		
O EURO-SA								80
O CATHAY	10.5							
A ASIA Sea-97	26							
A ASIA Iran-05	0		27					
A ASIA G-VII		16	15					
A AFRICA				25	22	15		
A EURO-SA								20
Asia-1	0.5	4	12.5					
SAT 1				0	8	5	27	
SAT 2			0.5	10	14	10	57	
SAT 3					1		16	
C								

A number of outbreaks have occurred where samples have not been sent to the WRLFMD or other laboratories in the OIE/FAO FMD Laboratory Network. An up-to-date list and reports of FMD viruses characterised by sequencing can be found at the following website: http://www.wrlfmd.org/country-reports/country-reports-2020.

Results from samples or sequences received at WRLFMD (status of samples being tested) are shown in Table 2 and a complete list of clinical sample diagnostics made by the WRLFMD from January to March 2021 is shown in Annex 1: (Summary of submissions). A record of all samples received by WRLFMD is shown in Annex 1: (Clinical samples).

Table 2: Status of sequencing of samples or sequences received by the WRLFMD from January to March 2021 (* indicates a batch carried over from the previous quarter).

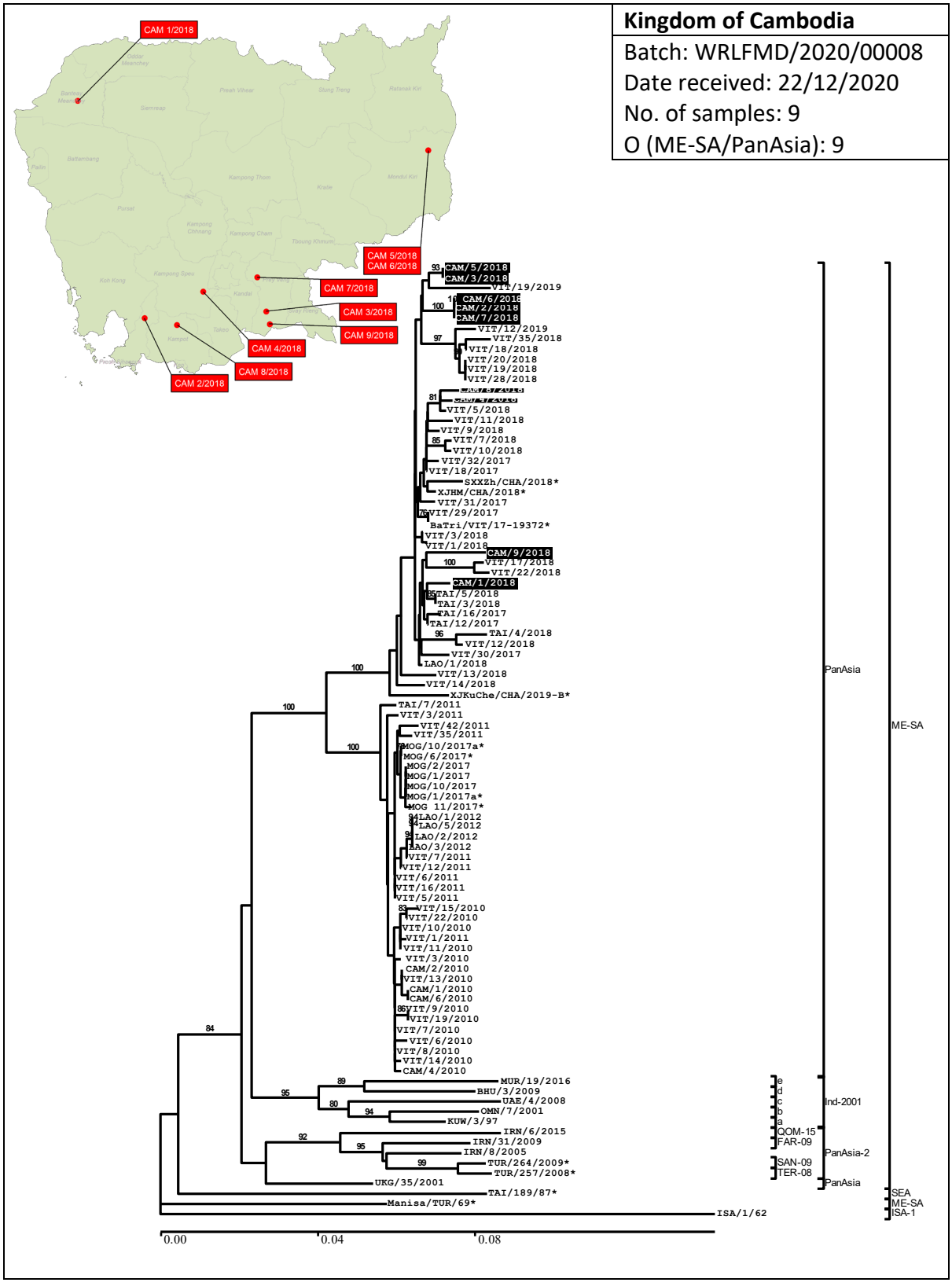
WRLFMD Batch No.	Date received	Country	Serotype	No. of samples	No. of sequences	Sequencing status
WRLFMD/2020/00006*	16/12/2020	Uganda	pending	11	-	pending
WRLFMD/2020/00007*	22/12/2020	Thailand	O	12	12	completed
			A	4	4	completed
WRLFMD/2020/00008*	22/12/2020	Cambodia	O	9	9	completed
WRLFMD/2020/00009*	22/12/2020	Lao P.D.R.	O	5	5	completed
WRLFMD/2021/00002	01/02/2021	Nigeria	A	7	7	completed
WRLFMD/2021/00003	24/02/2021	Nigeria	SAT2	6	6	completed
WRLFMD/2021/00004	01/03/2021	Israel	O	6	6	completed
WRLFMD/2021/00005	09/03/2021	Bahrain	O	3	3	completed
			A	1	1	completed
			Total	**53**	**53**	

Table 3: VP1 sequences submitted by other FMD Network laboratories to the WRLFMD from January to March 2021.

WRLFMD Batch No.	Date received	Country	Serotype	Date Collected	No. of sequences	Submitting laboratory
WRLMEG/2021/00001	08/01/2021	Israel	O	2021	3	KVI
WRLMEG/2021/00002	18/02/2021	Vietnam	O	2020	4	RAHO6
WRLMEG/2021/00003	25/02/2021	Namibia	SAT2	2020	2	BVI
WRLMEG/2021/00004	26/03/2021	Mauritius	O	2021	2	ANSES
WRLMEG/2021/00005	30/03/2021	Niger	A	2019-2020	18	ANSES
			SAT2	2019	1	
WRLMEG/2021/00006	30/03/2021	Burkina Faso	SAT2	2021	4	ANSES
				Total	**34**	

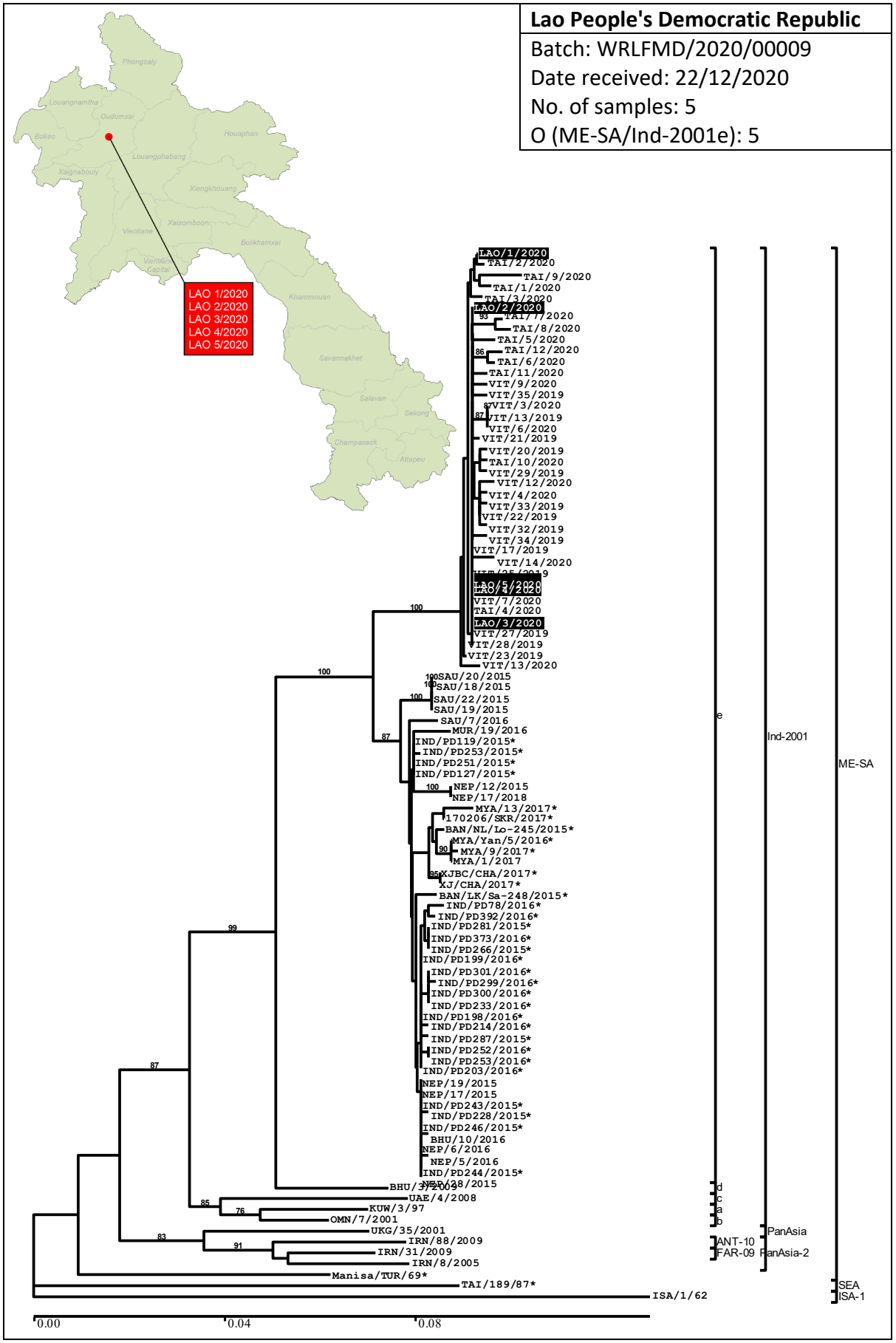
4. Detailed analysis

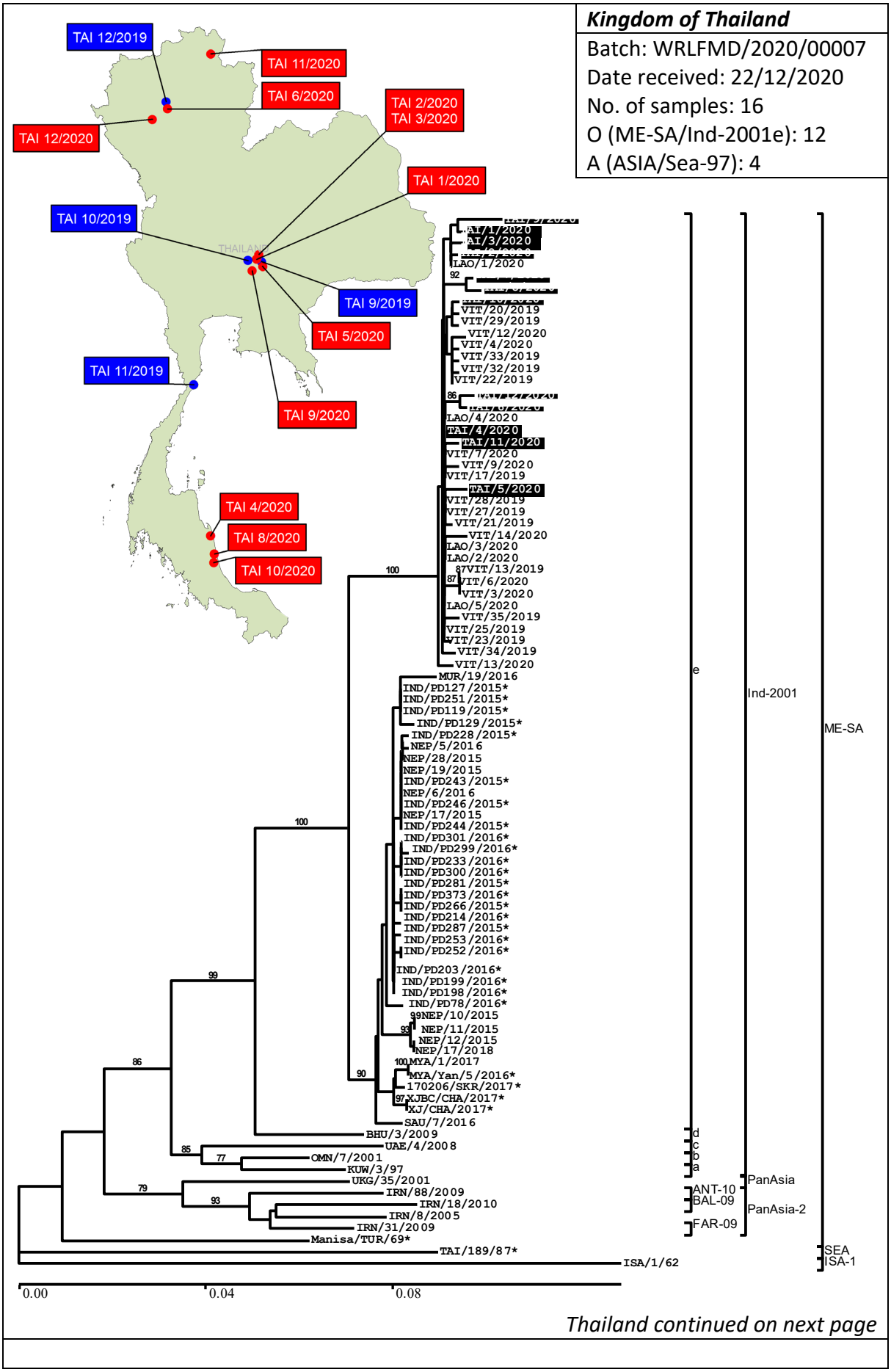
4.1. Pool 1 (Southeast Asia/Central Asia/East Asia)



Lao People's Democratic Republic

Batch: WRLFMD/2020/00009
Date received: 22/12/2020
No. of samples: 5
O (ME-SA/Ind-2001e): 5





Kingdom of Thailand

Batch: WRLFMD/2020/00007
Date received: 22/12/2020
No. of samples: 16
O (ME-SA/Ind-2001e): 12
A (ASIA/Sea-97): 4

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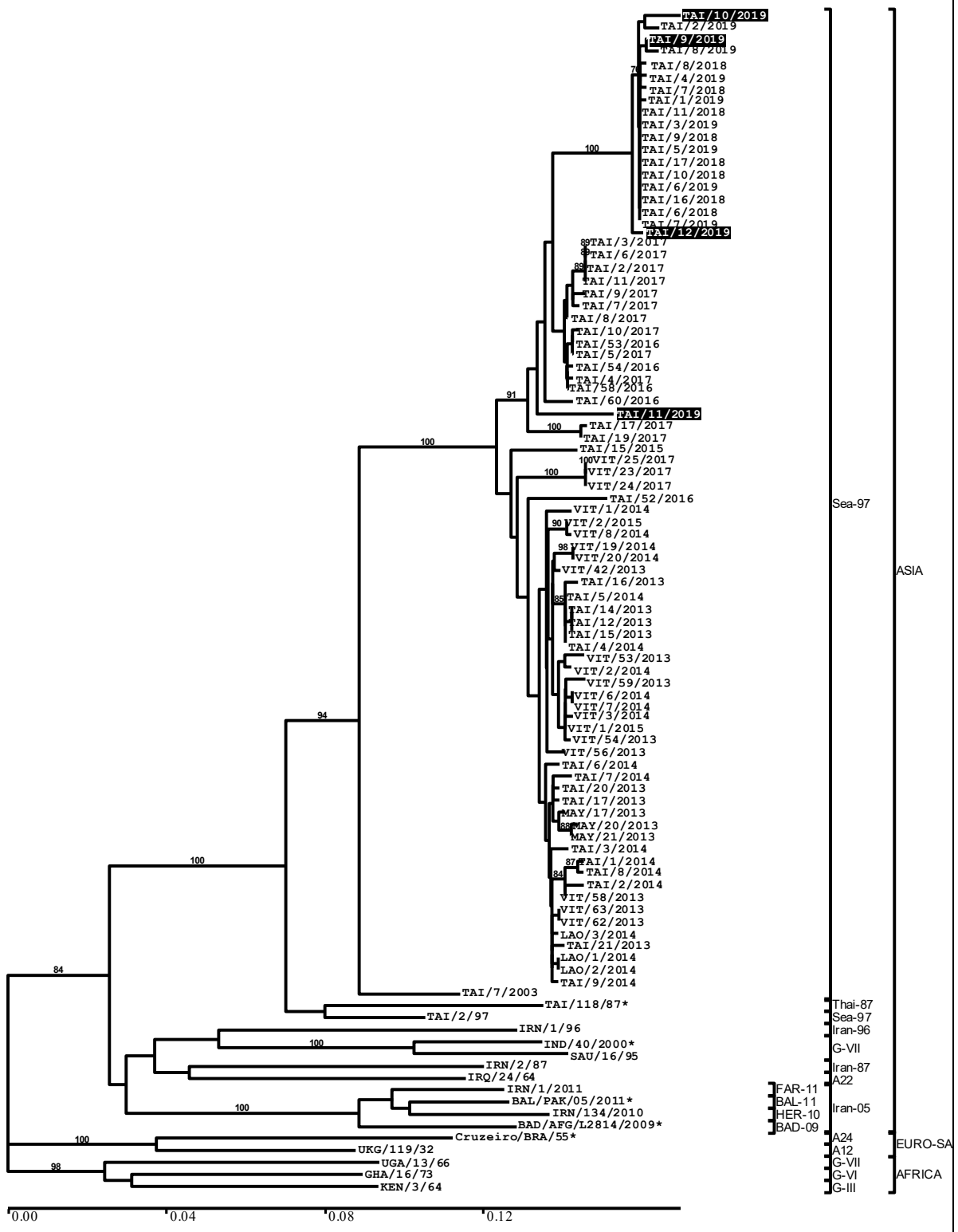
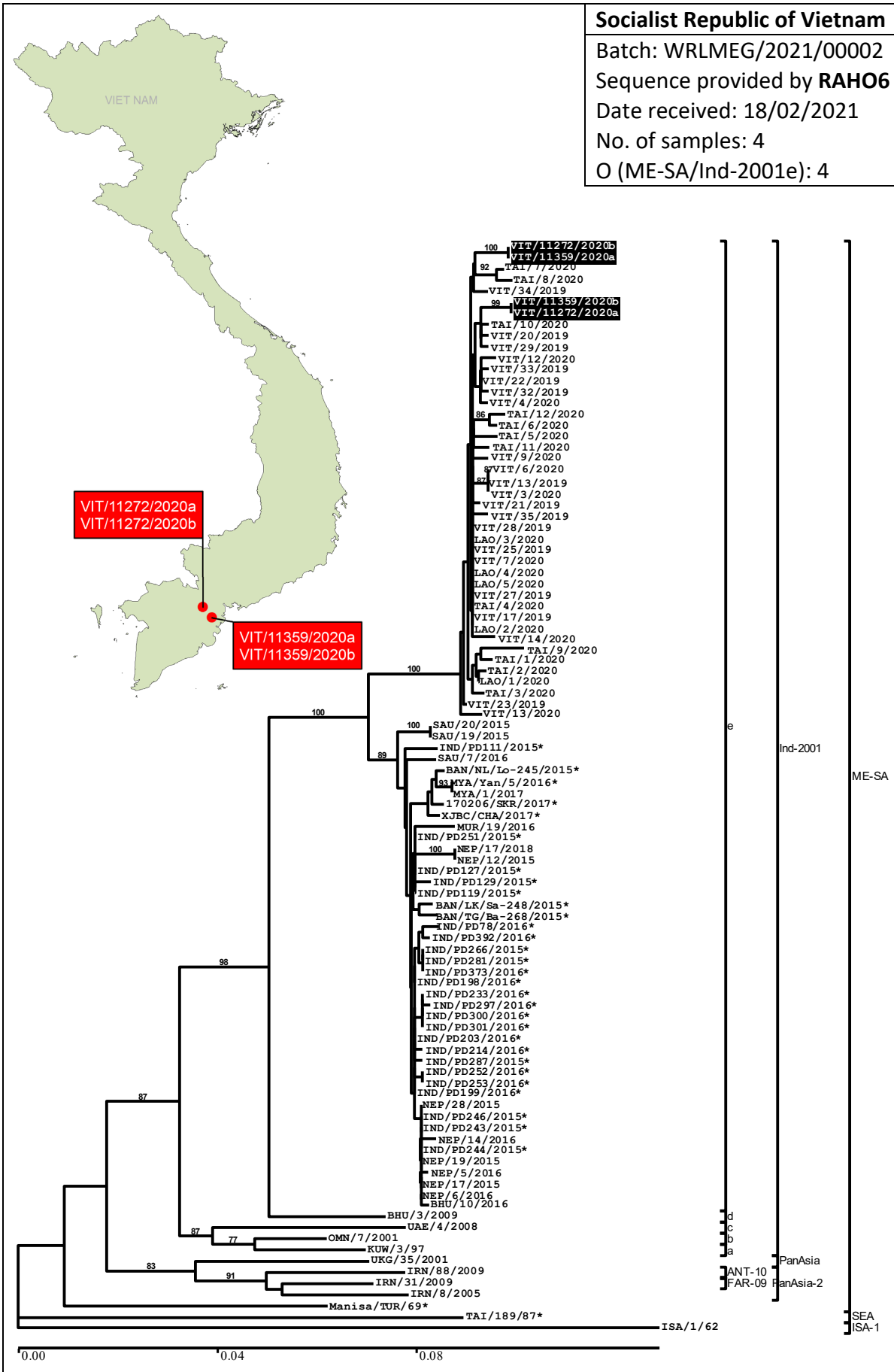
Thailand continued



Socialist Republic of Vietnam

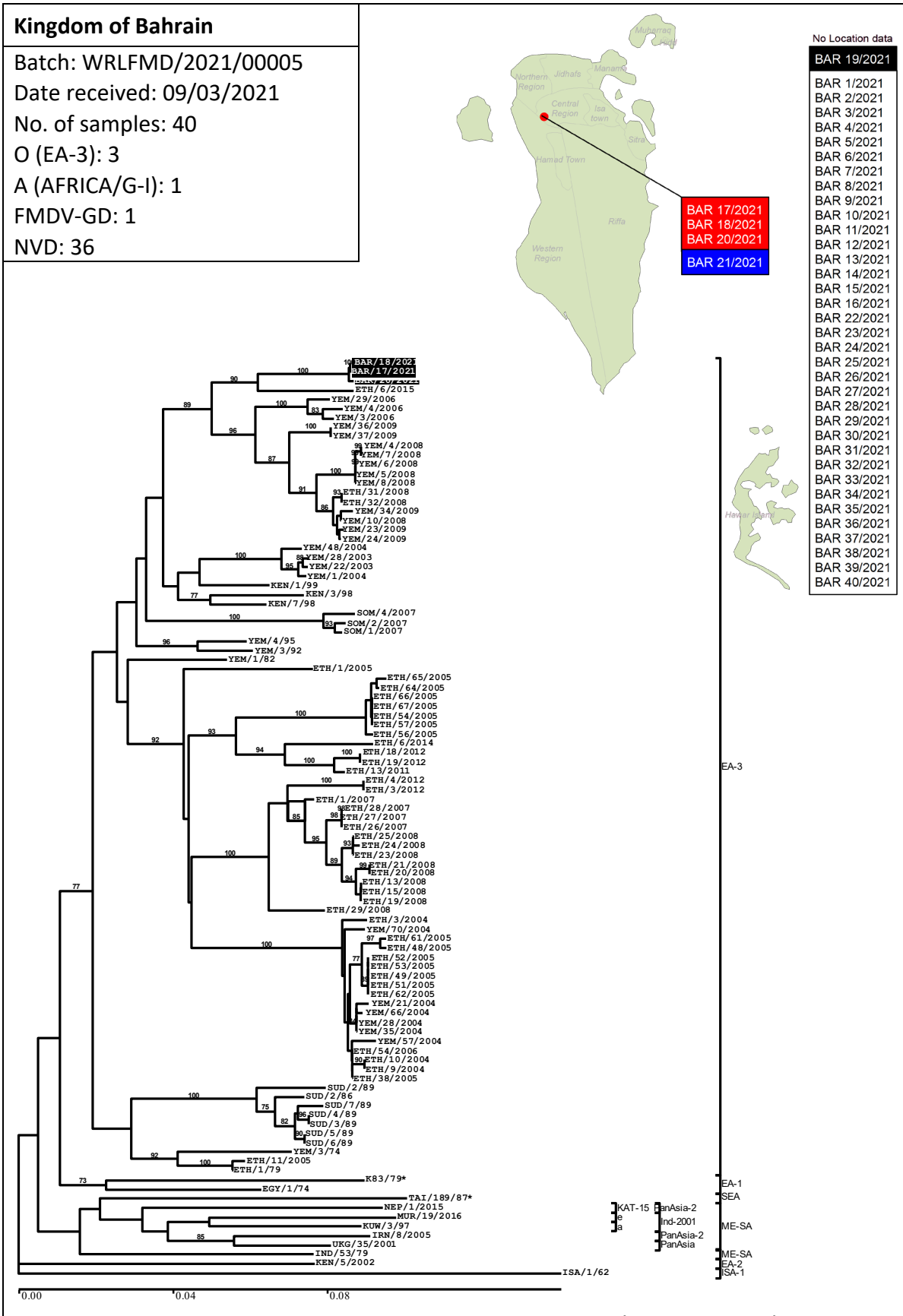
Batch: WRLMEG/2021/00002
Sequence provided by **RAHO6**
Date received: 18/02/2021
No. of samples: 4
O (ME-SA/Ind-2001e): 4



4.2. Pool 3 (West Eurasia and Middle East)

Kingdom of Bahrain

Batch: WRLFMD/2021/00005
Date received: 09/03/2021
No. of samples: 40
O (EA-3): 3
A (AFRICA/G-I): 1
FMDV-GD: 1
NVD: 36



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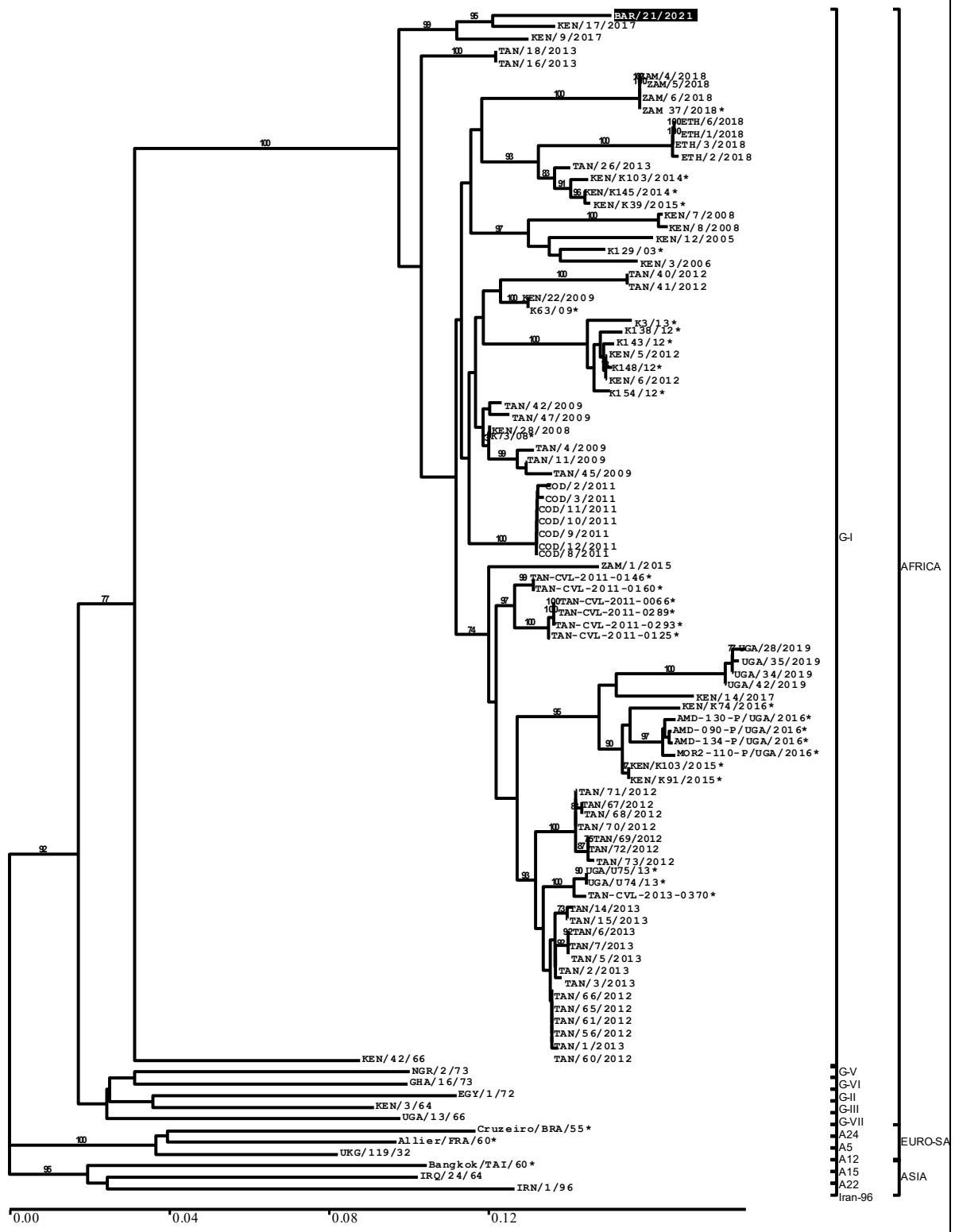
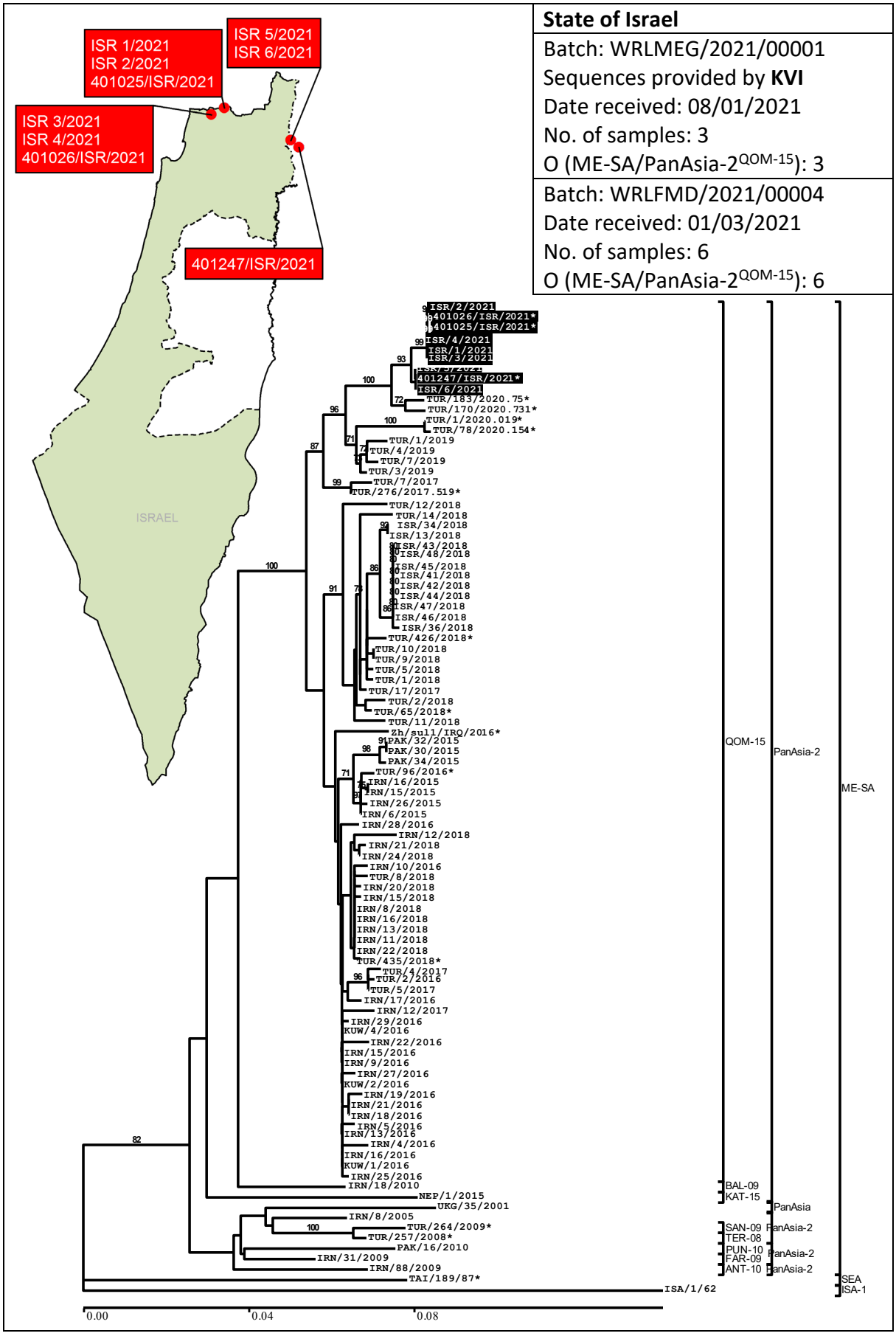
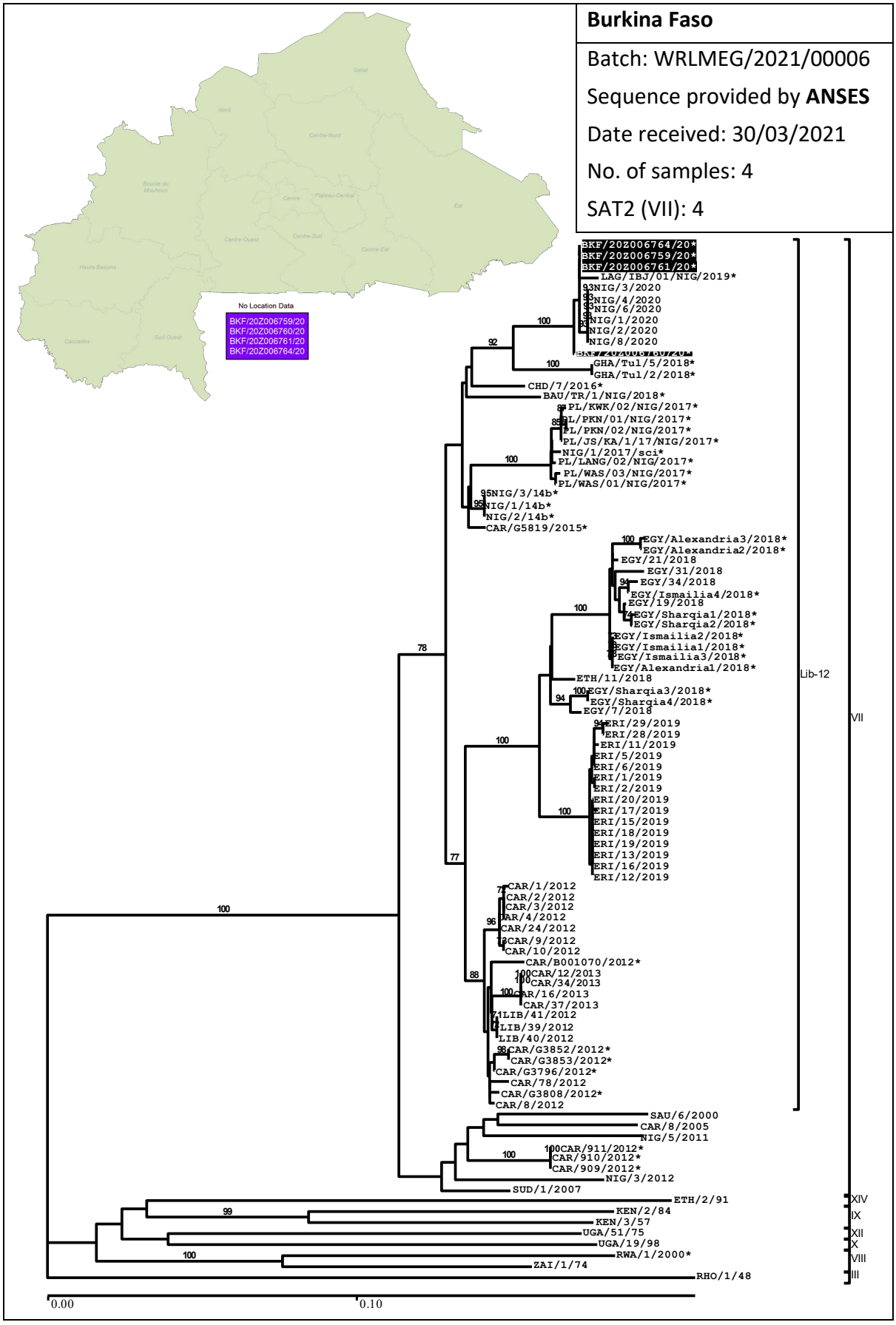
Bahrain continued

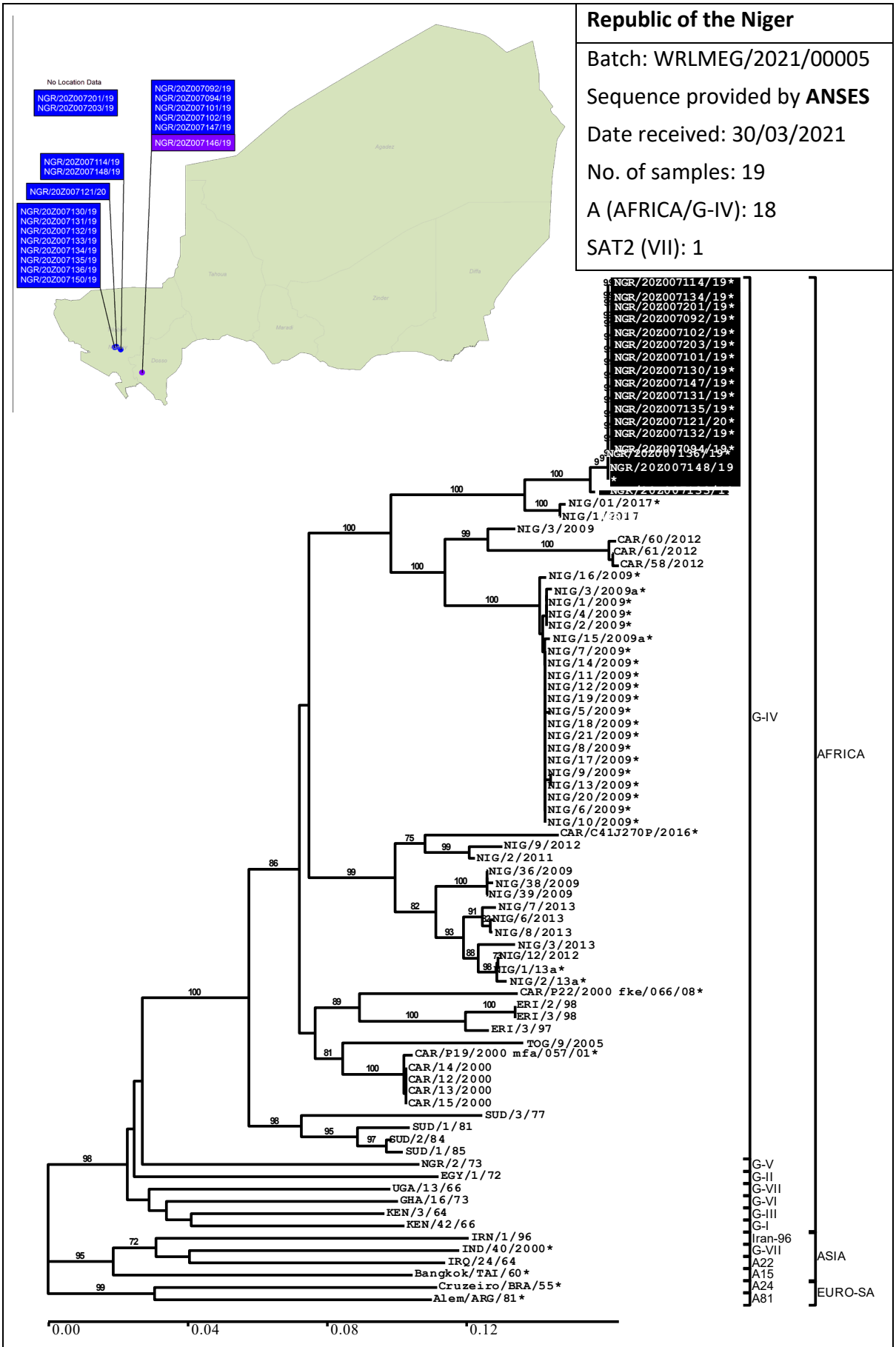




State of Israel
Batch: WRLMEG/2021/00001 Sequences provided by **KVI** Date received: 08/01/2021 No. of samples: 3 O (ME-SA/PanAsia-2^{QOM-15}): 3
Batch: WRLFMD/2021/00004 Date received: 01/03/2021 No. of samples: 6 O (ME-SA/PanAsia-2^{QOM-15}): 6

4.3. Pool 5 (West/Central Africa)





Republic of the Niger

Batch: WRLMEG/2021/00005

Sequence provided by **ANSES**

Date received: 30/03/2021

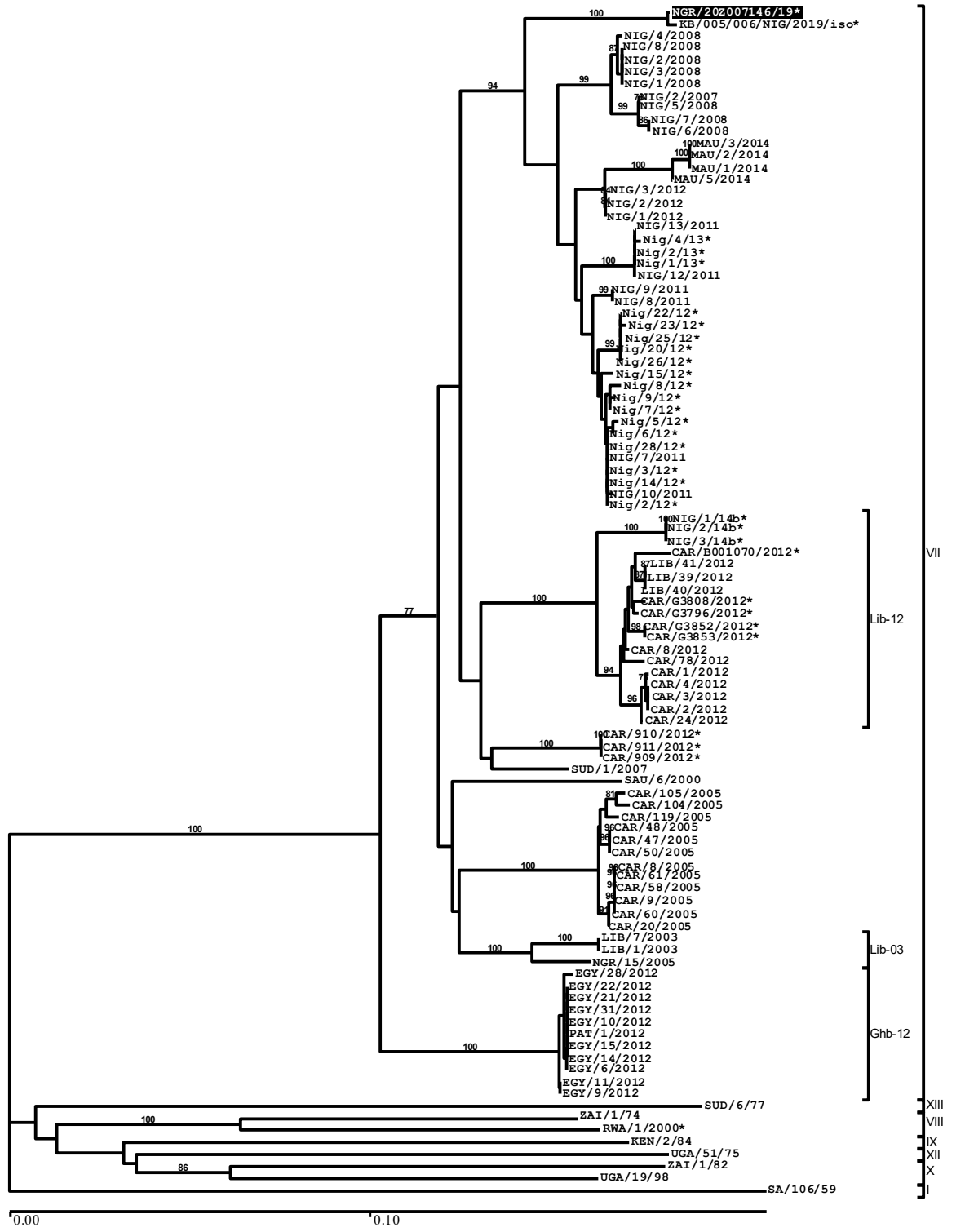
No. of samples: 19

A (AFRICA/G-IV): 18

SAT2 (VII): 1

Niger continued on next page

Niger Continued



Federal Republic of Nigeria

Batch: WRLFMD/2021/00002

Date received: 01/02/2021

No. of samples: 7

A (AFRICA/G-IV): 7

Batch: WRLFMD/2021/00003

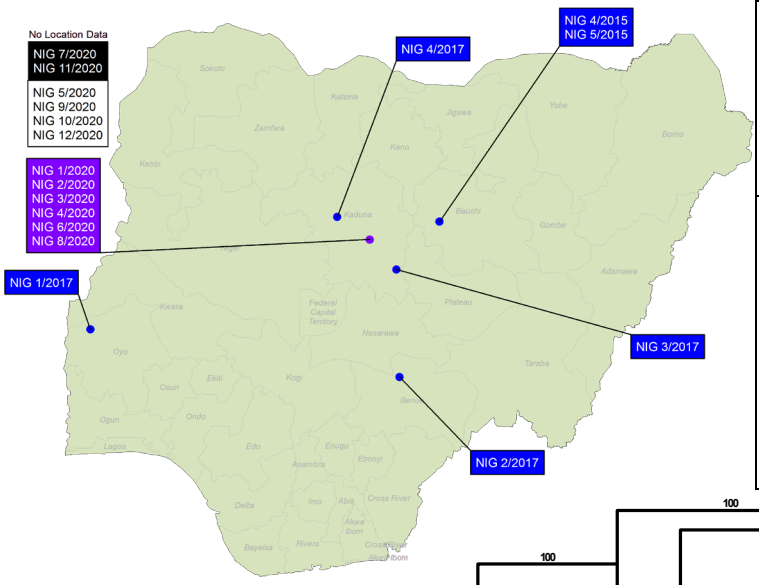
Date received: 11/01/2020

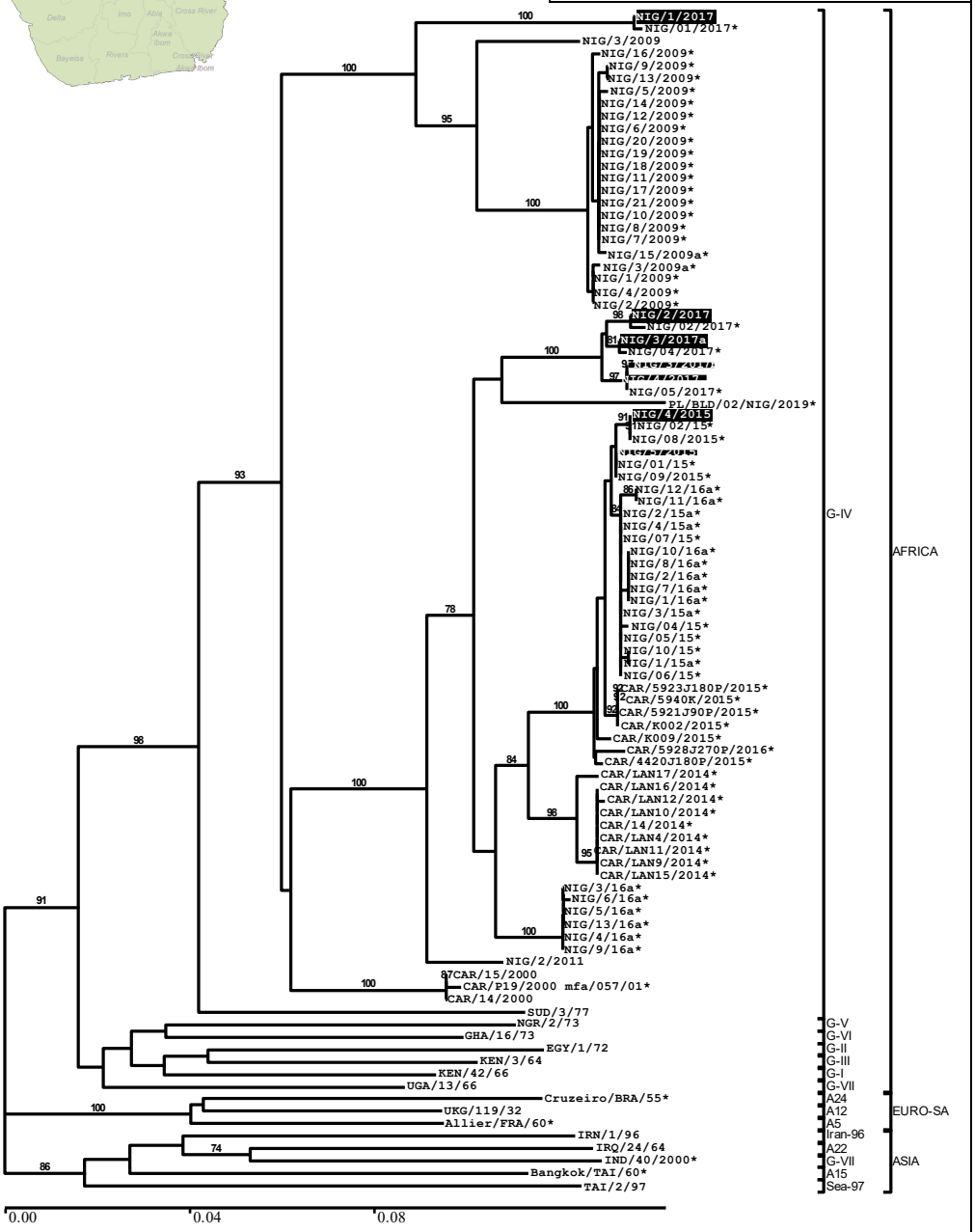
No. of samples: 12

SAT2 (VII/Lib-12): 6

FMDV-GD: 2

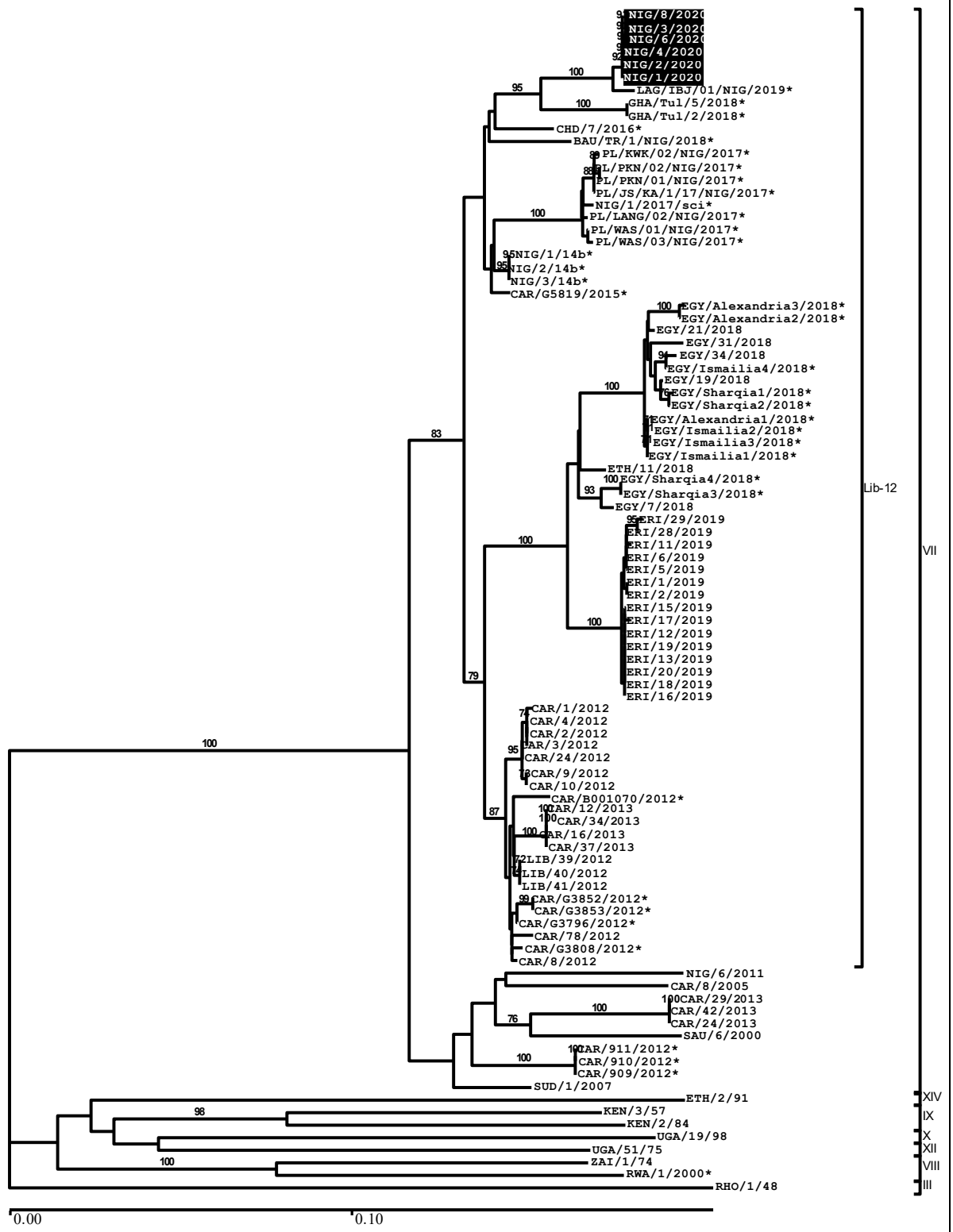
NVD: 4



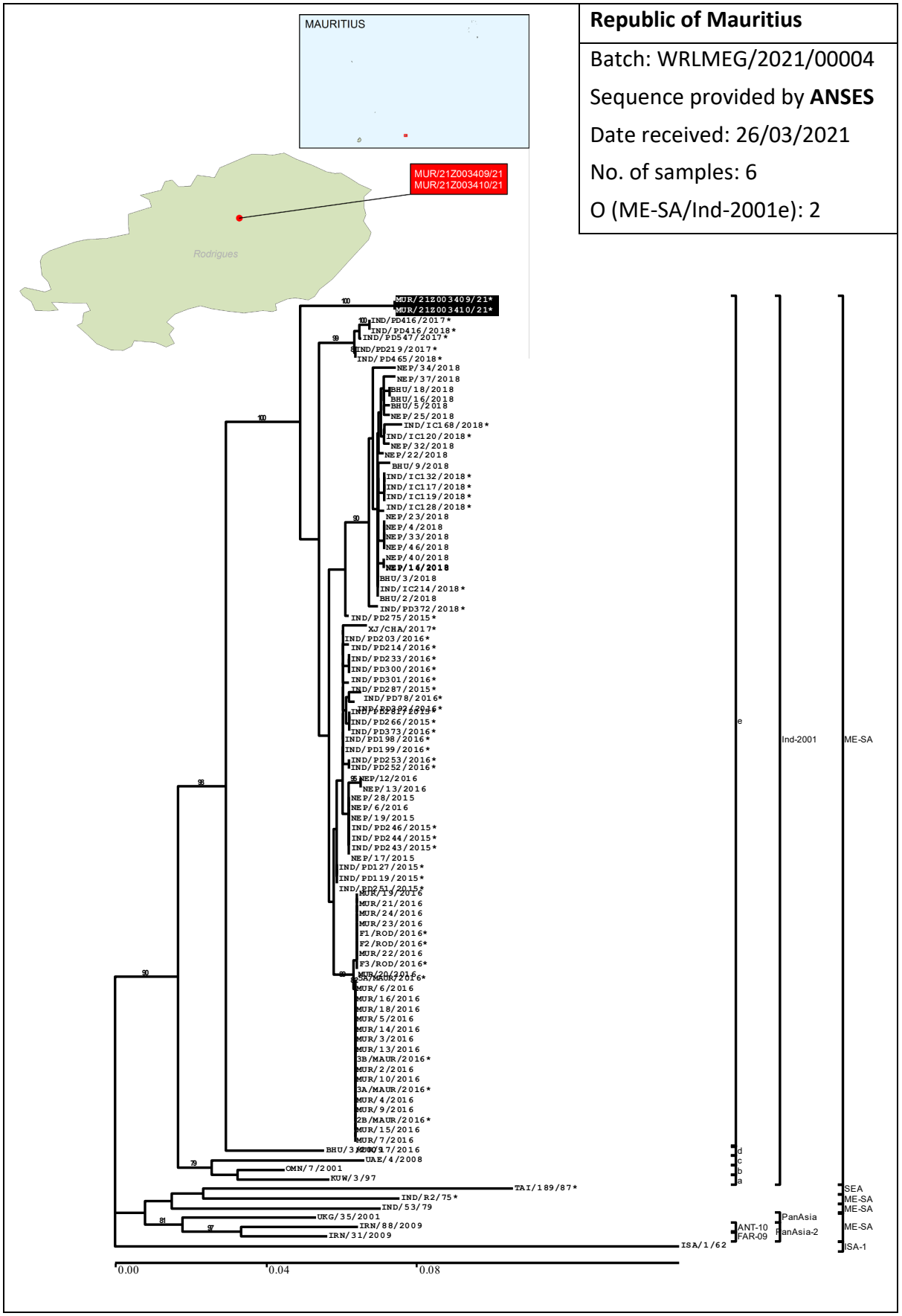


Nigeria continued on next page

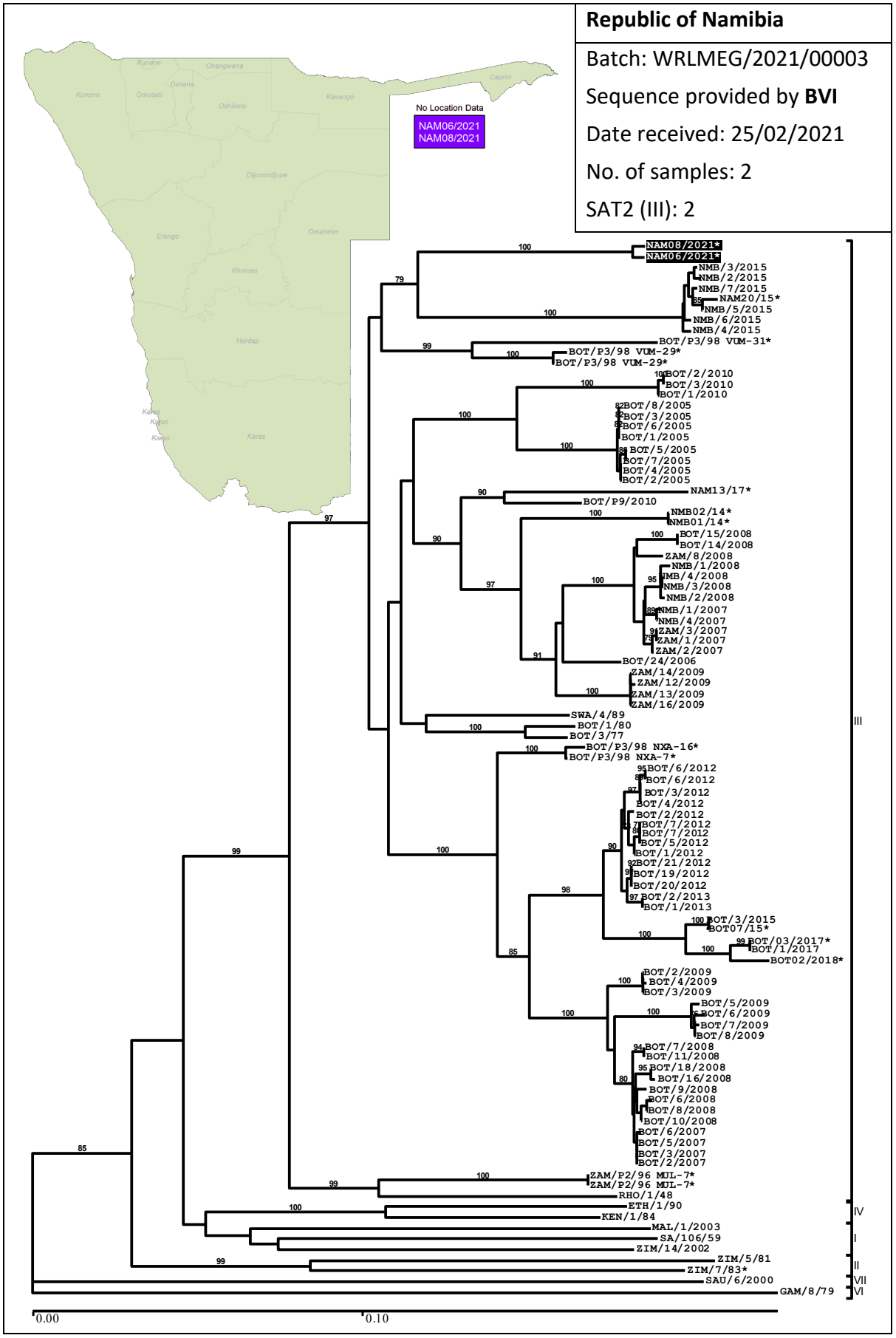
Nigeria continued



4.4. Pool 6 (Southern Africa)



Republic of Mauritius
Batch: WRLMEG/2021/00004
Sequence provided by **ANSES**
Date received: 26/03/2021
No. of samples: 6
O (ME-SA/Ind-2001e): 2


Republic of Namibia
Batch: WRLMEG/2021/00003
Sequence provided by BVI
Date received: 25/02/2021
No. of samples: 2
SAT2 (III): 2
No Location Data
NAM06/2021
NAM08/2021
Kunene
Ohangwena
Oshana
Omusati
Oshikoto
Kavango
Caprivi
Otjozondjupa
Erongo
Omaheke
Khomas
Hardap
Karas
NAM08/2021*
NAM06/2021*
NMB/3/2015
NMB/2/2015
NMB/7/2015
NAM20/15*
NMB/5/2015
NMB/6/2015
NMB/4/2015
BOT/P3/98 VUM-31*
BOT/P3/98 VUM-29*
BOT/P3/98 VUM-29*
BOT/2/2010
BOT/3/2010
BOT/1/2010
BOT/8/2005
BOT/3/2005
BOT/6/2005
BOT/1/2005
BOT/5/2005
BOT/7/2005
BOT/4/2005
BOT/2/2005
NAM13/17*
BOT/P9/2010
NMB02/14*
NMB01/14*
BOT/15/2008
BOT/14/2008
ZAM/8/2008
NMB/1/2008
NMB/4/2008
NMB/3/2008
NMB/2/2008
NMB/1/2007
NMB/4/2007
ZAM/3/2007
ZAM/1/2007
ZAM/2/2007
BOT/24/2006
ZAM/14/2009
ZAM/12/2009
ZAM/13/2009
ZAM/16/2009
SWA/4/89
BOT/1/80
BOT/3/77
BOT/P3/98 NXA-16*
BOT/P3/98 NXA-7*
BOT/6/2012
BOT/6/2012
BOT/3/2012
BOT/4/2012
BOT/2/2012
BOT/7/2012
BOT/7/2012
BOT/5/2012
BOT/1/2012
BOT/21/2012
BOT/19/2012
BOT/20/2012
BOT/2/2013
BOT/1/2013
BOT/3/2015
BOT07/15*
BOT/03/2017*
BOT/1/2017
BOT02/2018*
BOT/2/2009
BOT/4/2009
BOT/3/2009
BOT/5/2009
BOT/6/2009
BOT/7/2009
BOT/8/2009
BOT/7/2008
BOT/11/2008
BOT/18/2008
BOT/16/2008
BOT/9/2008
BOT/6/2008
BOT/8/2008
BOT/10/2008
BOT/6/2007
BOT/5/2007
BOT/3/2007
BOT/2/2007
ZAM/P2/96 MUL-7*
ZAM/P2/96 MUL-7*
RHO/1/48
ETH/1/90
KEN/1/84
MAL/1/2003
SA/106/59
ZIM/14/2002
ZIM/5/81
ZIM/7/83*
SAU/6/2000
GAM/8/79
III
IV
I
II
VII
VI
0.00
0.10

4.5. Vaccine matching

Antigenic characterisation of FMD field isolates by matching with vaccine strains by 2dmVNT from January to March 2021.

NOTES:

1. Vaccine efficacy is influenced by vaccine potency, antigenic match and vaccination regime. Therefore, it is possible that a less than perfect antigenic match of a particular antigen may be compensated by using a high potency vaccine and by administering more than one vaccine dose at suitable intervals. 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 and is administered under a regime to maximise host antibody responses (Brehm, 2008).
2. Vaccine matching data generated in this report only considers antibody responses in cattle after a single vaccination (typically 21 days after vaccination). The long-term performance of FMD vaccines after a second or multiple doses of vaccine should be monitored using post-vaccination serological testing.

Table 4: Summary of samples tested by vaccine matching

Serotype	O	A	C	Asia-1	SAT 1	SAT 2	SAT 3
Nigeria	-	3	-	-	-	-	-
Israel*	3	-	-	-	-	-	-
Total	**3**	**3**	**0**	**0**	**0**	**0**	**0**

* Supplementary vaccine matching reports including O1 Campos from Biogénesis Bagó

Abbreviations used in tables

For each field isolate the r1 value is shown followed by the heterologous neutralisation titre (r1-value / titre). The r1 values shown below, represent the one-way serological match between vaccine strain and field isolate, calculated from the comparative reactivity of antisera raised against the vaccine in question. Heterologous neutralisation titres for vaccine sera with the field isolates are included as an indicator of cross-protection.

M	**Vaccine Match** *r_1 = ≥ 0.3 - suggests that there is a close antigenic relationship between field isolate and vaccine strain. A potent vaccine containing the vaccine strain is likely to confer protection.*
N	**No Vaccine Match** *r_1 = < 0.3* - suggest that the field isolate is antigenically different to the vaccine strain. Where there is no alternative, the use of this vaccine should carefully consider vaccine potency, the possibility to use additional booster doses and monitoring of vaccinated animals for heterologous responses.
NT	**Not tested against this vaccine**

NOTE: A "0" in the neutralisation columns indicates that for that particular field virus no neutralisation was observed at a virus dose of a 100 $TCID_{50}$.

NOTE: This report includes the source of the vaccine virus and bovine vaccinal serum. Vaccines from different manufactures may perform differently and caution should be taken when comparing the data.

Table 5: Vaccine matching studies for A FMDV

Isolate	**Serotype A**		**A Iran 05** Boehringer Ingelheim		**A Saudi 95** Boehringer Ingelheim		**A/TUR/20/06** MSD Animal Health		**A Malaysia 97** Boehringer Ingelheim		**A22 Iraq** Boehringer Ingelheim	
	Topotype	*Lineage*	r_1	*Titre*	r_1	*Titre*	r_1	*Titre*	r_1	*Titre*	r_1	*Titre*
NIG/1/2017	Africa	G-IV	0.00	0.00	0.16	1.72	0.15	1.00	0.12	1.44	0.18	1.75
NIG/3/2017	Africa	G-IV	0.04	1.11	0.37	2.08	0.21	1.15	0.17	1.58	0.23	1.86
NIG/5/2015	Africa	G-IV	0.05	1.17	0.35	2.05	0.20	1.13	0.19	1.63	0.30	1.98

Table 6: Supplementary vaccine matching studies for O1 Campos (Biogénesis Bagó)

Isolate	**Serotype 0**		**O1 Campos** Biogénesis Bagó	
	Topotype	*Lineage*	r_1	*Titre*
ISR/15/2017	EA-3	-	0.21	2.13
ISR/12/2019	ME-SA	PanAsia-2^{QOM-15}	0.29	2.28
ISR/27/2019	ME-SA	PanAsia-2^{QOM-15}	0.42	2.25

Annex 1: Sample data

Summary of submissions

Table 6: Summary of samples collected and received to WRLFMD (January to March 2021)

Country	Nº of samples	Virus isolation in cell culture/ELISA								RT-PCR for FMD	
		FMD virus serotypes							No Virus Detected		
		O	*A*	*C*	*SAT 1*	*SAT 2*	*SAT 3*	*ASIA-1*		*Positive*	*Negative*
BAHRAIN	40	3	1	-	-	-	-	-	36	5	35
CAMBODIA	9	9	-	-	-	-	-	-	-	9	-
ISRAEL	6	6	-	-	-	-	-	-	-	6	-
LAOS	5	5	-	-	-	-	-	-	-	5	-
NIGERIA	18	-	6	-	-	6	-	-	6	14	4
THAILAND	16	12	4	-	-	-	-	-	-	16	-
UGANDA	11	-	-	-	-	-	-	-	11	9	2
TOTAL	**105**	**35**	**11**	**0**	**0**	**6**	**0**	**0**	**53**	**64**	**41**

Clinical samples

Table 7: Clinical sample diagnostics made by the WRLFMD® January to March 2021

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
BAHRAIN	09-Mar-21	23-Mar-21	BAR 1/2021	Goat	01-Feb-21	NEG	NEG	NVD
			BAR 2/2021	Goat	01-Feb-21	NEG	NEG	NVD
			BAR 3/2021	Cattle	01-Feb-21	NEG	NEG	NVD
			BAR 4/2021	Cattle	01-Feb-21	NEG	NEG	NVD
			BAR 5/2021	Cattle	01-Feb-21	NEG	NEG	NVD
			BAR 6/2021	Cattle	01-Feb-21	NEG	NEG	NVD
			BAR 7/2021	Cattle	01-Feb-21	NEG	NEG	NVD
			BAR 8/2021	Cattle	01-Feb-21	NEG	NEG	NVD
			BAR 9/2021	Cattle	01-Feb-21	NEG	NEG	NVD
			BAR 10/2021	Cattle	01-Feb-21	NEG	NEG	NVD
			BAR 11/2021	Cattle	01-Feb-21	NEG	NEG	NVD
			BAR 12/2021	Sheep	01-Feb-21	NEG	NEG	NVD
			BAR 13/2021	Sheep	01-Feb-21	NEG	NEG	NVD

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
			BAR 14/2021	Cattle	01-Feb-21	NEG	NEG	NVD
			BAR 15/2021	Cattle	01-Feb-21	NEG	NEG	NVD
			BAR 16/2021	Cattle	01-Feb-21	NEG	NEG	NVD
			BAR 17/2021	Cattle	02-Feb-21	O	POS	O
			BAR 18/2021	Cattle	02-Feb-21	O	POS	O
			BAR 19/2021	Cattle	02-Feb-21	NEG	POS	FMDV GD
			BAR 20/2021	Cattle	02-Feb-21	O	POS	O
			BAR 21/2021	Cattle	02-Feb-21	A	POS	A
			BAR 22/2021	Sheep	09-Feb-21	NEG	NEG	NVD
			BAR 23/2021	Sheep	09-Feb-21	NEG	NEG	NVD
			BAR 24/2021	Sheep	09-Feb-21	NEG	NEG	NVD
			BAR 25/2021	Sheep	09-Feb-21	NEG	NEG	NVD
			BAR 26/2021	Sheep	09-Feb-21	NEG	NEG	NVD
			BAR 27/2021	Sheep	09-Feb-21	NEG	NEG	NVD
			BAR 28/2021	Sheep	09-Feb-21	NEG	NEG	NVD
			BAR 29/2021	Sheep	09-Feb-21	NEG	NEG	NVD
			BAR 30/2021	Sheep	09-Feb-21	NEG	NEG	NVD
			BAR 31/2021	Cattle	09-Feb-21	NEG	NEG	NVD
			BAR 32/2021	Cattle	09-Feb-21	NEG	NEG	NVD
			BAR 33/2021	Cattle	09-Feb-21	NEG	NEG	NVD
			BAR 34/2021	Cattle	09-Feb-21	NEG	NEG	NVD
			BAR 35/2021	Cattle	09-Feb-21	NEG	NEG	NVD
			BAR 36/2021	Cattle	09-Feb-21	NEG	NEG	NVD
			BAR 37/2021	Cattle	09-Feb-21	NEG	NEG	NVD
			BAR 38/2021	Cattle	09-Feb-21	NEG	NEG	NVD
			BAR 39/2021	Cattle	09-Feb-21	NEG	NEG	NVD
			BAR 40/2021	Cattle	09-Feb-21	NEG	NEG	NVD
CAMBODIA	22-Dec-20	29-Jan-21	CAM 1/2018	Cattle	01-Jan-18	O	POS	O
			CAM 2/2018	Cattle	03-May-18	O	POS	O
			CAM 3/2018	Cattle	17-May-18	O	POS	O
			CAM 4/2018	Cattle	30-May-18	O	POS	O
			CAM 5/2018	Cattle	10-Aug-18	O	POS	O
			CAM 6/2018	Buffalo	10-Aug-18	O	POS	O
			CAM 7/2018	Cattle	15-Aug-18	O	POS	O
			CAM 8/2018	Cattle	05-Sep-18	O	POS	O
			CAM 9/2018	Cattle	14-Sep-18	O	POS	O
ISRAEL	01-Mar-21	08-Mar-21	ISR 1/2021	Goat	03-Jan-21	O	POS	O
			ISR 2/2021	Goat	05-Jan-21	O	POS	O
			ISR 3/2021	Cattle	03-Jan-21	O	POS	O
			ISR 4/2021	Cattle	04-Jan-21	O	POS	O
			ISR 5/2021	Cattle	05-Jan-21	O	POS	O

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
			ISR 6/2021	Cattle	06-Jan-21	O	POS	O
LAOS	22-Dec-20	29-Jan-21	LAO 1/2020	Cattle	30-Jan-20	O	POS	O
			LAO 2/2020	Cattle	30-Jan-20	O	POS	O
			LAO 3/2020	Cattle	30-Jan-20	O	POS	O
			LAO 4/2020	Cattle	30-Jan-20	O	POS	O
			LAO 5/2020	Cattle	30-Jan-20	O	POS	O
NIGERIA	28-Jan-21	09-Feb-21	NIG 4/2015	Cattle	11-Sep-15	A	POS	A
			NIG 5/2015	Cattle	11-Sep-15	A	POS	A
			NIG 1/2017	Cattle	22-Mar-17	A	POS	A
			NIG 2/2017	Cattle	29-May-17	A	POS	A
			NIG 3/2017	Cattle	04-Jul-17	A	POS	A
			NIG 4/2017	Cattle	21-Sep-17	A	POS	A
	24-Feb-21	08-Mar-21	NIG 1/2020	Cattle	11-Jan-20	SAT 2	POS	SAT 2
			NIG 2/2020	Cattle	11-Jan-20	SAT 2	POS	SAT 2
			NIG 3/2020	Cattle	11-Jan-20	SAT 2	POS	SAT 2
			NIG 4/2020	Cattle	11-Jan-20	SAT 2	POS	SAT 2
			NIG 5/2020	Cattle	11-Jan-20	NEG	NEG	NVD
			NIG 6/2020	Cattle	11-Jan-20	SAT 2	POS	SAT 2
			NIG 7/2020	Cattle	11-Jan-20	NEG	POS	FMDV GD
			NIG 8/2020	Cattle	11-Jan-20	SAT 2	POS	SAT 2
			NIG 9/2020	Cattle	11-Jan-20	NEG	NEG	NVD
			NIG 10/2020	Cattle	11-Jan-20	NEG	NEG	NVD
			NIG 11/2020	Cattle	11-Jan-20	NEG	POS	FMDV GD
			NIG 12/2020	Cattle	11-Jan-20	NEG	NEG	NVD
THAILAND	22-Dec-20	29-Jan-21	TAI 9/2019	Cattle	23-Jan-19	A	POS	A
			TAI 10/2019	Cattle	04-Mar-19	A	POS	A
			TAI 11/2019	Cattle	28-Mar-19	A	POS	A
			TAI 12/2019	Cattle	30-Jul-19	A	POS	A
			TAI 1/2020	Cattle	07-Jan-20	O	POS	O
			TAI 2/2020	Cattle	23-Jan-20	O	POS	O
			TAI 3/2020	Cattle	31-Jan-20	O	POS	O
			TAI 4/2020	Cattle	05-Feb-20	O	POS	O
			TAI 5/2020	Cattle	07-Feb-20	O	POS	O
			TAI 6/2020	Cattle	18-Feb-20	O	POS	O
			TAI 7/2020	Cattle	05-Mar-20	O	POS	O
			TAI 8/2020	Cattle	09-Mar-20	O	POS	O
			TAI 9/2020	Cattle	07-Apr-20	O	POS	O
			TAI 10/2020	Cattle	15-Apr-20	O	POS	O
			TAI 11/2020	Cattle	20-Apr-20	O	POS	O
			TAI 12/2020	Cattle	20-Apr-20	O	POS	O
UGANDA	16-Dec-20	29-Jan-21	UGA 1/2020	Cattle	13-Feb-20	NEG	POS	FMDV GD

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
			UGA 2/2020	Cattle	13-Feb-20	NEG	POS	FMDV GD
			UGA 3/2020	Cattle	02-Jul-20	NEG	POS	FMDV GD
			UGA 4/2020	Cattle	02-Jul-20	NEG	NEG	NVD
			UGA 5/2020	Cattle	02-Jul-20	NEG	NEG	NVD
			UGA 6/2020	Cattle	02-Jul-20	NEG	POS	FMDV GD
			UGA 7/2020	Cattle	02-Jul-20	NEG	POS	FMDV GD
			UGA 8/2020	Cattle	10-Jul-20	NEG	POS	FMDV GD
			UGA 9/2020	Cattle	10-Jul-20	NEG	POS	FMDV GD
			UGA 10/2020	Cattle	10-Jul-20	NEG	POS	FMDV GD
			UGA 11/2020	Cattle	10-Jul-20	NEG	POS	FMDV GD
TOTAL					**105**			

14. Fukai, K., K. Inoue, A. Takeuchi, and M. Yamakawa (2021). New possibilities for egg white lysozyme: heat-denatured lysozyme partially inactivates select *Foot-and-mouth disease virus* strains. *Scientific Reports*, **11**(1): 5. DOI: 10.1038/s41598-020-80239-8.
15. Gashirai, T.B., S.D. Hove-Musekwa, and S. Mushayabasa (2021). Dynamical analysis of a fractional-order Foot-and-mouth disease model. *Mathematical Sciences*, **15**(1): 65-82. DOI: 10.1007/s40096-020-00372-3.
16. Hao, J.H., C.C. Shen, N.N. Wei, M.H. Yan, X.G. Zhang, G.W. Xu, D. Zhang, J. Hou, W.J. Cao, Y. Jin, K.S. Zhang, H.X. Zheng, and X.T. Liu (2021). *Foot-and-mouth disease virus* Capsid Protein VP1 capsid protein vp1 antagonizes TPL2-mediated activation of the IRF3/IFN-β signaling pathway to facilitate the virus replication. *Frontiers in Immunology*, **11**: 14. DOI: 10.3389/fimmu.2020.580334.
17. Jo, H., B.Y. Kim, S.H. Park, H.M. Kim, S.H. Shin, S.Y. Hwang, S.M. Kim, B. Kim, J.H. Park, and M.J. Lee (2021). The HSP70-fused foot-and-mouth disease epitope elicits cellular and humoral immunity and drives broad-spectrum protective efficacy. *NPJ Vaccines*, **6**(1): 14. DOI: 10.1038/s41541-021-00304-9.
18. Khan, M.Z., X.W. Gao, X.L. Fan, L.Y. Song, M.U.R. Memon, D.H. Kalhoro, I. Bano, S.A. Fazilani, Y.J. Li, Y.G. Xu, and L.J. Tang (2020). Comparative study on the potency of trivalent vaccine of Foot-and-mouth disease in different cattle breeds and triggered immune response signaling pathway. *Large Animal Review*, **26**(6): 321-328.
19. Kim, A.Y., H. Kim, S.Y. Park, S.H. Park, J.M. Lee, J.S. Kim, J.W. Park, C.K. Park, J.H. Park, and Y.J. Ko. Investigation of the optimal medium and application strategy for Foot-and-mouth disease vaccine antigen production. *Journal of Applied Microbiology*: 10. DOI: 10.1111/jam.15024.
20. Kim, A.Y., H. Kim, S.Y. Park, S.H. Park, J.S. Kim, J.W. Park, J.H. Park, and Y.J. Ko (2021). Development of a potent stabilizer for long-term storage of Foot-and-mouth disease vaccine antigens. *Vaccines*, **9**(3): 10. DOI: 10.3390/vaccines9030252.
21. Kim, H., A.Y. Kim, J. Choi, S.Y. Park, S.H. Park, J.S. Kim, S.I. Lee, J.H. Park, C.K. Park, and Y.J. Ko (2021). *Foot-and-mouth disease virus* evades innate immune response by 3C-targeting of MDA5. *Cells*, **10**(2): 13. DOI: 10.3390/cells10020271.
22. Ko, M.K., J.H. Park, H.E. Jo, J.H. Choi, S.H. You, S.H. Shin, S.Y. Hwang, H. Jo, H.M. Kim, M.J. Lee, S.M. Kim, and B. Kim (2021). Efficient protection against Asia1 type Foot-and-mouth disease using a chimeric vaccine strain suitable for East Asia. *Veterinary Microbiology*, **253**: 7. DOI: 10.1016/j.vetmic.2020.108975.
23. Krishnaswamy, N., S. Jeyakumar, R.P.T. Selvan, G.R. Gowane, P. Mahadappa, U. Vijayapillai, H.J. Dechamma, B.H.M. Patel, P. Saravanan, K.P. Ramesha, and A. Sanyal (2021). Short-term effect of foot-and-mouth disease (FMD) vaccination on the milk yield in the Deoni and crossbred cows. *Tropical Animal Health and Production*, **53**(2): 6. DOI: 10.1007/s11250-021-02653-y.
24. Kushwaha, A., S. Behera, M. Saminathan, K. Sreedharan, S. Basagoudanavar, G.B.M. Reddy, and M. Hosamani (2021). Monoclonal antibodies against *Foot-and-mouth disease virus* RNA polymerase for detection of virus infection. *Microbiology and Immunology*, **65**(2): 95-98. DOI: 10.1111/1348-0421.12860.
25. Lalzampuia, H., V.K. Ganji, S. Elango, N. Krishnaswamy, V. Umapathi, G.R. Reddy, A. Sanyal, and H.J. Dechamma (2021). Expression of *Foot-and-mouth disease virus* non-structural protein 3A upregulates the expression of autophagy and immune response genes *in vitro*. *Virus Research*, **292**: 6. DOI: 10.1016/j.viruses.2020.198247.
26. Lee, J.H., W. Yun, H.J. Oh, J.S. An, Y.G. Kim, C.G. Lee, J.H. Cho, and F. Miglior (2020). Effects of dietary silicate levels on growth performance, nutrient digestibility, fecal microflora, odorous gas emissions, blood characteristics, and Foot-and-mouth disease antibodies in weaning to finishing pigs. *Canadian Journal of Animal Science*, **100**(4): 640-649. DOI: 10.1139/cjas-2019-0200.

27. Li, C., J.B. Shi, H.W. Wang, E.E. Rivera-Serrano, D.C. Yang, G.H. Zhou, C. Sun, C.E. Cameron, and L. Yu (2021). Polymerase fidelity contributes to *Foot-and-mouth disease virus* pathogenicity and transmissibility *in vivo*. *Journal of Virology*, **95**(1): 11. DOI: 10.1128/jvi.01569-20.
28. Li, K.L., C.C. Wang, F. Yang, W.J. Cao, Z.X. Zhu, and H.X. Zheng (2021). Virus-host interactions in *Foot-and-mouth disease virus* infection. *Frontiers in Immunology*, **12**: 18. DOI: 10.3389/fimmu.2021.571509.
29. Liu, H.S., Q. Xue, Z.X. Zhu, F. Yang, W.J. Cao, X.T. Liu, and H.X. Zheng. *Foot-and-mouth disease virus* inhibits RIP2 protein expression to promote vral replication. *Virologica Sinica*: 15. DOI: 10.1007/s12250-020-00322-2.
30. Liu, W., J.J. Shao, G.L. Zhang, Y.Y. Chang, S.D. Ge, Y. Sun, Z. Gao, and H.Y. Chang (2021). Development of an indirect chemiluminescence immunoassay using a multiepitope recombinant protein to specifically detect antibodies against Foot-and-mouth disease virus serotype O in swine. *Journal of Clinical Microbiology*, **59**(3): 12. DOI: 10.1128/jcm.02464-20.
31. MacPhillamy, I., J. Young, F. Earp, S. Khounsy, P. Windsor, J.A. Toribio, and R. Bush. Foot-and-mouth disease seroprevalence and reporting behaviours in nine northern provinces in Lao PDR: The current situation and challenges for control. *Transboundary and Emerging Diseases*: 15. DOI: 10.1111/tbed.14031.
32. Mansuroglu, B., S. Derman, K. Kizilbey, S.C. Ates, and Z.M. Akdeste (2020). Synthetic peptide vaccine for Foot-and-Mouth Disease: synthesis, characterization and immunogenicity. *Turkish Journal of Biochemistry-Turk Biyokimya Dergisi*, **45**(6): 859-868. DOI: 10.1515/tjb-2020-0110.
33. Manyweathers, J., Y. Maru, L. Hayes, B. Loechel, H. Kruger, A. Mankad, G. Xie, R. Woodgate, and M. Hernandez-Jover (2021). The goat industry in Australia: Using Bayesian network analysis to understand vulnerability to a Foot-and-mouth disease outbreak. *Preventive Veterinary Medicine*, **187**: 8. DOI: 10.1016/j.prevetmed.2020.105236.
34. Marschik, T., I. Kopacka, S. Stockreiter, F. Schmoll, J. Hiesel, A. Hoflechner-Poltl, A. Kasbohrer, and B. Pinior (2021). The epidemiological and economic impact of a potential Foot-and-mouth disease outbreak in Austria. *Frontiers in Veterinary Science*, **7**: 13. DOI: 10.3389/fvets.2020.594753.
35. Meecham, A. and J. Marshall. Harnessing the power of *Foot-and-mouth-disease virus* for targeting integrin α-v β-6 for the therapy of cancer. *Expert Opinion on Drug Discovery*: 8. DOI: 10.1080/17460441.2021.1878143.
36. Neiffer, D., J. Hewlett, P. Buss, L. Rossouw, G. Hausler, L.M. DeKlerk-Lorist, E. Roos, F. Olea-Popelka, B. Lubisi, L. Heath, and M. Miller (2021). Antibody prevalence to *African swine fever virus*, *Mycobacterium bovis*, *Foot-and-mouth disease virus*, *Rift Valley fever virus*, *Influenza A virus*, and *Brucella* and *Leptospira* spp. In free-ranging warthog (*Phacochoerus africanus*) populations in South Africa. *Journal of Wildlife Diseases*, **57**(1): 60-70. DOI: 10.7589/jwd-d-20-00011.
37. Nishi, T., K. Morioka, R. Kawaguchi, M. Yamada, M. Ikezawa, and K. Fukai (2021). Quantitative analysis of infection dynamics of *Foot-and-mouth disease virus* strain O/CATHAY in pigs and cattle. *Plos One*, **16**(1): 10. DOI: 10.1371/journal.pone.0245781.
38. Olufemi, O.T., A.W. Adanu, Y.S. Wungak, J.A. Nwuku, H. Emmanuel, P.A. Shinggu, A.A. Dzikwi-Emennaa, G.R. Otolorin, Y.O. Adedeji, V.O. Ameh, T.D. Jatau, E.B.T. Baba-Onoja, D. Esonu, and D.G. Alford (2020). Serological evidence of *Foot-and-mouth disease virus* among apparently healthy Pigs in Wukari, Taraba State, Nigeria. *International Journal of Infectious Diseases*, **101**: 542-542. DOI: 10.1016/j.ijid.2020.09.1406.
39. Osmani, A., I.D. Robertson, and I. Habib. Seroprevalence and risk factors for Foot-and-mouth disease in cattle in Baghlan Province, Afghanistan. *Veterinary Medicine and Science*: 13. DOI: 10.1002/vms3.477.

40. Ranjitha, H.B., V. Ammanathan, N. Guleria, M. Hosamani, B.P. Sreenivasa, V.V. Dhanesh, R. Santhoshkumar, B.K.C. Sagar, B.P. Mishra, R.K. Singh, A. Sanyal, R. Manjithaya, and S.H. Basagoudanavar (2021). *Foot-and-mouth disease virus* induces PERK-mediated autophagy to suppress the antiviral interferon response. *Journal of Cell Science*, **134**(5): 10. DOI: 10.1242/jcs.240622.
41. Ren, H.R., M.T. Li, Y.M. Wang, Z. Jin, and J. Zhang (2021). The risk factor assessment of the spread of Foot-and-mouth disease in mainland China. *Journal of Theoretical Biology*, **512**: 11. DOI: 10.1016/j.jtbi.2020.110558.
42. Ren, T.T., H.T. Chen, X.S. Liu, Y.X. Wang, A.X. Fan, L.L. Qi, L. Pan, W.L. Bai, Y.G. Zhang, and Y.F. Sun. ID1 inhibits *Foot-and-mouth disease virus* replication via targeting of interferon pathways. *FEBS Journal*: 18. DOI: 10.1111/febs.15725.
43. Rodriguez-Habibe, I., C. Celis-Giraldo, M.E. Patarroyo, C. Avendano, and M.A. Patarroyo (2020). A comprehensive review of the immunological response against *Foot-and-mouth disease virus* infection and its evasion mechanisms. *Vaccines*, **8**(4): 19. DOI: 10.3390/vaccines8040764.
44. Russell, J. (2021). Marking 20 years since FMD 2001. *Veterinary Record*, **188**(5): 197-197.
45. Sahu, T.K., A.K.S. Gurjar, P.K. Meher, C. Varghese, S. Marwaha, G.P. Rao, A. Rai, N. Guleria, S.H. Basagoudanavar, A. Sanyal, and A.R. Rao (2020). Computational insights into RNAi-based therapeutics for Foot-and-mouth disease of *Bos taurus*. *Scientific Reports*, **10**(1): 13. DOI: 10.1038/s41598-020-78541-6.
46. Saiz, M. and E. Martinez-Salas. Uncovering targets of the Leader protease: Linking RNA-mediated pathways and antiviral defense. *Wiley Interdisciplinary Reviews-Rna*: 14. DOI: 10.1002/wrna.1645.
47. Salem, R., A.A. El-Kholy, F.R. Waly, R. Khaled, and W. Elmenofy. Removal of 3C protease from the 3ABC improves expression, solubility, and purification of the recombinant 3AB of *Foot-and-mouth disease virus*. *Virus Genes*: 11. DOI: 10.1007/s11262-020-01815-8.
48. Salem, R., A.A. El-Kholy, F.R. Waly, R. Khaled, and W. Elmenofy (2021). Removal of 3C protease from the 3ABC improves expression, solubility, and purification of the recombinant 3AB of *Foot-and-mouth disease virus*. *Virus Genes*, **57**(1): 72-82. DOI: 10.1007/s11262-020-01815-8.
49. Sangrat, W., W. Thanapongtharm, and C. Poolkhet (2020). Identification of risk areas for foot-and-mouth disease in Thailand using a geographic information system-based multi-criteria decision analysis. *Preventive Veterinary Medicine*, **185**: 8. DOI: 10.1016/j.prevetmed.2020.105183.
50. Sansamur, C., A. Wiratsudakul, A. Charoenpanyanet, and V. Punyapornwithaya (2021). Estimating the number of farms experienced foot-and-mouth disease outbreaks using capture-recapture methods. *Tropical Animal Health and Production*, **53**(1): 9. DOI: 10.1007/s11250-020-02452-x.
51. Shmeiger, Z., M. Miculitzki, B. Gelman, I. Vaxman, and T. Goshen (2021). The effect of Foot-and-mouth disease morbidity influencing periparturient diseases and culling on Nir Yitzhak dairy cattle farm. *Israel Journal of Veterinary Medicine*, **76**(1): 27-34.
52. Simmons, J. (2021). We need to ensure FMD precautions last. *Veterinary Record*, **188**(6): 232-232.
53. Song, Y.M., Y.L. Yang, X. Lin, Q.Z. Zhao, Z.J. Li, G.H. Ma, Z.G. Su, and S.P. Zhang (2021). On-line separation and quantification of virus antigens of different serotypes in multivalent vaccines by capillary zone electrophoresis: A case study for quality control of *Foot-and-mouth disease virus* vaccines. *Journal of Chromatography A*, **1637**: 8. DOI: 10.1016/j.chroma.2020.461834.
54. Swanepoel, H., J. Crafford, and M. Quan (2021). A scoping review of viral diseases in African ungulates. *Veterinary Sciences*, **8**(2): 32. DOI: 10.3390/vetsci8020017.
55. Taylor, N. (2021). Remembering that terrible FMD spring. *Veterinary Record*, **188**(4): 294-294.

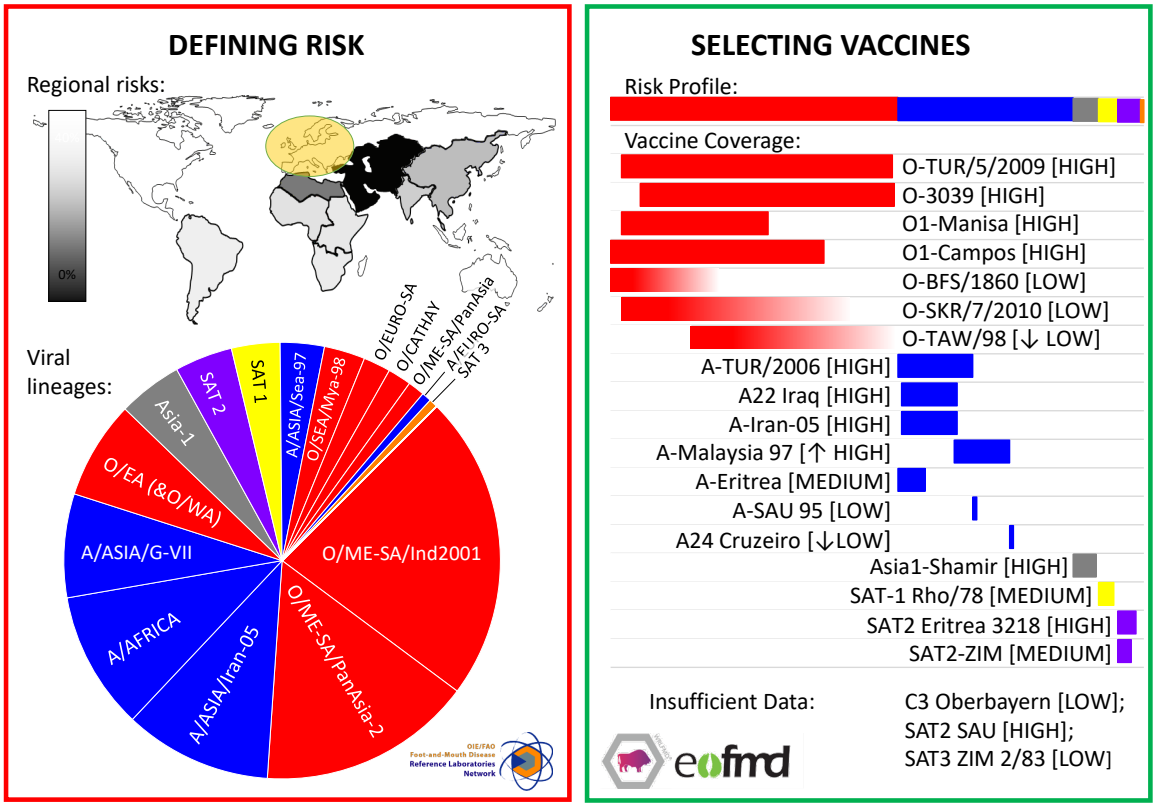
56. Wang, X.Y. and J.Y. Yang (2021). Dynamics of a nonlocal dispersal Foot-and-mouth disease model in a spatially heterogeneous environment. *Acta Mathematica Scientia*, **41**(2): 552-572. DOI: 10.1007/s10473-021-0217-y.
57. Wataradee, S., T. Boonserm, C. Sangaprakhon, K. Ajariyakhajorn, and C. Inchaisri (2021). Use of an automatic needle-free injection device for foot-and-mouth disease vaccination in dairy heifers. *Veterinarni Medicina*, **66**(3): 87-93. DOI: 10.17221/4/2020-vetmed.
58. Waters, R.A., J. Wadsworth, V. Mioulet, A.E. Shaw, N.J. Knowles, D. Abdollahi, R. Hassanzadeh, K. Sumption, and D.P. King (2021). *Foot-and-mouth disease virus* infection in the domestic dog (*Canis lupus familiaris*), Iran. *BMC Veterinary Research*, **17**(1): 5. DOI: 10.1186/s12917-021-02769-1.
59. Wu, P., Y.Y. Rodriguez, B.J. Hershey, Y. Tadassa, K.A. Dodd, and W. Jia (2021). Validation of a binary ethylenimine (BEI) inactivation procedure for biosafety treatment of foot-and-mouth disease viruses (FMDV), vesicular stomatitis viruses (VSV), and swine vesicular disease virus (SVDV). *Veterinary Microbiology*, **252**: 6. DOI: 10.1016/j.vetmic.2020.108928.
60. Xiao, Y., S.L. Zhang, H. Yan, X.L. Geng, Y.W. Wang, X. Xu, M.Y. Wang, H.H. Zhang, B.C. Huang, W.Q. Pang, M. Yang, and K.G. Tian (2021). The high immunity induced by the virus-like particles of *Foot-and-mouth disease virus* serotype O. *Frontiers in Veterinary Science*, **8**: 10. DOI: 10.3389/fvets.2021.633706.
61. Xu, G.W., S.X. Xu, X.J. Shi, C.C. Shen, D.J. Zhang, T. Zhang, J. Hou, K.S. Zhang, H.X. Zheng, and X.T. Liu (2020). *Foot-and-mouth disease virus* degrades Rab27a to suppress the exosome-mediated antiviral immune response. *Veterinary Microbiology*, **251**: 11. DOI: 10.1016/j.vetmic.2020.108889.
62. Xu, W.H. and M. Yang (2021). Genetic variation and evolution of *Foot-and-mouth disease virus* serotype A in relation to vaccine matching. *Vaccine*, **39**(9): 1420-1427. DOI: 10.1016/j.vaccine.2021.01.042.
63. Zhang, A.L., X.L. Ba, X. Weng, B. Zhao, D.Y. Wang, H. Cao, and J. Huang (2021). Immunological activities of the aqueous extracts of *Cistanche deserticola* as a polysaccharide adjuvant for inactivated foot-and-mouth disease vaccines. *Food and Agricultural Immunology*, **32**(1): 126-142. DOI: 10.1080/09540105.2021.1880551.
64. Zhang, Z.D., R. Waters, and Y.M. Li (2021). Pathogenesis of non-epithelial foot-and-mouth disease in neonatal animals. *Veterinary Microbiology*, **254**: 6. DOI: 10.1016/j.vetmic.2020.108961.
65. Zhi, Y., H.J. Ji, H.C. Guo, J.H. Lim, E.B. Byun, W.S. Kim, and H.S. Seo (2021). Salmonella vaccine vector system for *Foot-and-mouth disease virus* and evaluation of Its efficacy with virus-like particles. *Vaccines*, **9**(1): 17. DOI: 10.3390/vaccines9010022.

Annex 3: Vaccine recommendations

This report provides recommendations of FMDV vaccines to be included in antigen banks. These outputs are generated with a new tool (called PRAGMATIST) that has been developed in partnership between WRLFMD and EuFMD (http://www.fao.org/3/cb1799en/cb1799en.pdf). These analyses accommodate the latest epidemiological data collected by the OIE FAO FMD Laboratory Network regarding FMDV lineages that are present in different *source regions* (see Table 1 in Section 3.9, above), as well as available *in vitro, in vivo* and field data to score the ability of vaccines to protect against these FMDV lineages.

Vaccine Antigen Prioritisation: **Europe**

March 2021



NB: Analyses uses best available data, however there are gaps in surveillance and vaccine coverage data

Please contact WRLFMD or 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.

Annex 4: Brief round-up of EuFMD and WRLFMD activities

Courses

- The EuFMD Virtual Learning platform provides convenient self-paced training which you may study anytime, anywhere, free of charge. Open access courses currently offered are:
  - Simulation Exercises for Animal Disease Emergencies aiming at building your understanding of simulation exercises and their value as part of the emergency preparedness cycle.
  - Introduction to the Risk-Based Strategic Plan introducing the Risk-Based Strategic Plan (RBSP).
  - What is the Progressive Control Pathway providing an overview of the Progressive Control Pathway for Foot-and-Mouth Disease (PCP-FMD), the tool used to FMD control under the GF-TADs Global Strategy.
  - For anyone who is new to the PCP-FMD, a short e-learning module is also available in Arabic.
  - Introduction to FMD course, available in English and French, introducing foot-and-mouth disease (FMD), its importance, diagnosis, outbreak investigation and the control measure that might apply in a previously free country experiencing an outbreak.
  - Introduction to Lumpy Skin Disease , a short open-access module made available to support countries in Asia and the Pacific face this rapidly emerging threat.
  - Public Private Partnerships in the Veterinary Domain course, developed in partnership with the World Organisation for Animal Health OIE, applying public-private partnerships to the control of FMD and similar transboundary animal diseases.
- The WRLFMD residential training course on FMD diagnostic methods (https://www.pirbright.ac.uk/instructor-led-training/diagnosis-foot-and-mouth-disease) scheduled for May 2021 has been postponed.

Other resources

We have a constantly updated series of short **podcasts** relating to the FAST world, available here: http://www.fao.org/eufmd/resources/podcasts/en/

Emergency Preparedness Network http://www.fao.org/eufmd/network/en/

The Emergency Preparedness Network is a forum for emergency preparedness experts to share information and experience. You will regularly receive the latest information on topics related to prevention and control of foot-and-mouth and other similar transboundary animal diseases ("FAST" diseases).

Meetings

- A Meeting of Laboratory and Epidemiology Networks for the West Eurasia Region is planned for June 2021 (virtual).
- The 4th Regional Roadmap Meeting on PCP-FMD for SAARC Member States is planned for July 2021 (virtual) and will also include a meeting of the Laboratory and Epidemiology networks.

Proficiency test scheme organised by WRLFMD

Sample panels for the Phase XXXII exercise have shipped to international laboratories; however, this is still ongoing as the disruption to air travel continues. Results have been received from laboratories and feedback has been sent out to those laboratories that have submitted results (see table below for a summary of the current status of the exercise).

Status	Number of Labs
Invitations	75*
Declined to take part	21
PTS shipped	37
Destroyed in transit	1
Results returned	33
Feedback returned	30

* This table includes self-funded countries.

We will write to inform participating laboratories about any other changes that may be required to accommodate these events, and please feel free to contact WRLFMD if you have any questions.