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control of foot-and-mouth disease

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

WRLFMD

Foot-and-Mouth Disease

October-December 2022

Quarterly report

FAST Reports

Foot-and-mouth And Similar Transboundary animal diseases

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

This report is version 1

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Sudan and South Sudan: *Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined.*

Abyei: *Final status of the Abyei area is not yet determined.*

Falkland Islands (Malvinas): *A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).*

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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	Lanzhou Veterinary Research Institute
MEVAC	International Facility for Veterinary Vaccines Production (Egypt)
MNFMDL	Malaysian National Foot-and-Mouth Disease Laboratory
NT	not tested
NVD	no virus detected
PIADC	Plum Island Animal Disease Center
Pusvetma	Pusat Veteriner Farma
rRT-PCR	real-time reverse transcription polymerase chain reaction
SAARC	South Asian Association for Regional Cooperation
SADC	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 WOAH)
WOAH	World Organisation for Animal Health
WRLFMD	World Reference Laboratory for Foot-and-Mouth Disease

1. Highlights and headlines

Thank you for reading this last quarterly report for 2022 covering FMD activities for October-December. Life after COVID-19 is now starting to return to normal and the recent EuFMD OS-22 (https://www.eufmd.info/os22) and the Annual Meeting of the WOAH/FAO FMD Network provided welcome opportunities to finally meet colleagues in a face-to-face format after two years of virtual communication. These meetings reviewed global FMD events that include:

(i) circulation of a new clade within O/ME-SA/PanAsia-2^{ANT-10} in Eastern Mediterranean countries. These FMD viruses appear to have supplanted O/ME-SA/PanAsia-2^{QOM-15} viruses that were previously dominant in this region. [NB: New FMD cases due to serotype O have been reported to WOAH (Israel in September, and Palestine in November and December)].

(ii) incursions of the O/ME-SA/Ind-2001e lineage into Indonesia, where the WRLFMD has recently co-authored a paper to describe the genome of the FMDV responsible (see: https://doi.org/10.1128/mra.01081-22).

(iii) emergence of a new lineage called O/ME-SA/SA-2018 from South Asia into the Gulf States. In India, this lineage is now responsible for approx. 40 percent of serotype O cases and new sequence data analysed in this report demonstrate that the lineage is present in Bangladesh.

(iv) reports of FMD cases in Egypt with a South American origin. These unexpected outbreaks need to be monitored closely since there is potential for onward spread of these viruses into other countries in North Africa and the Eastern Mediterranean. A shipment of samples from Egypt was received to WRLFMD at the end of the year (results to be reported in Q1 2023).

During this period, the WRLFMD has reported test results for samples received from Sudan and there have also been new sequence submissions from Bangladesh, Israel (KVI), Malaysia (MNFMDL), Mongolia (ARRIAH/GenBank) and Turkey (FMDI). Individual laboratory reports can be retrieved from http://www.wrlfmd.org/ and further information is provided in this report.

I take this opportunity to wish you all the best for the New Year.

Don King, Pirbright, January 2023

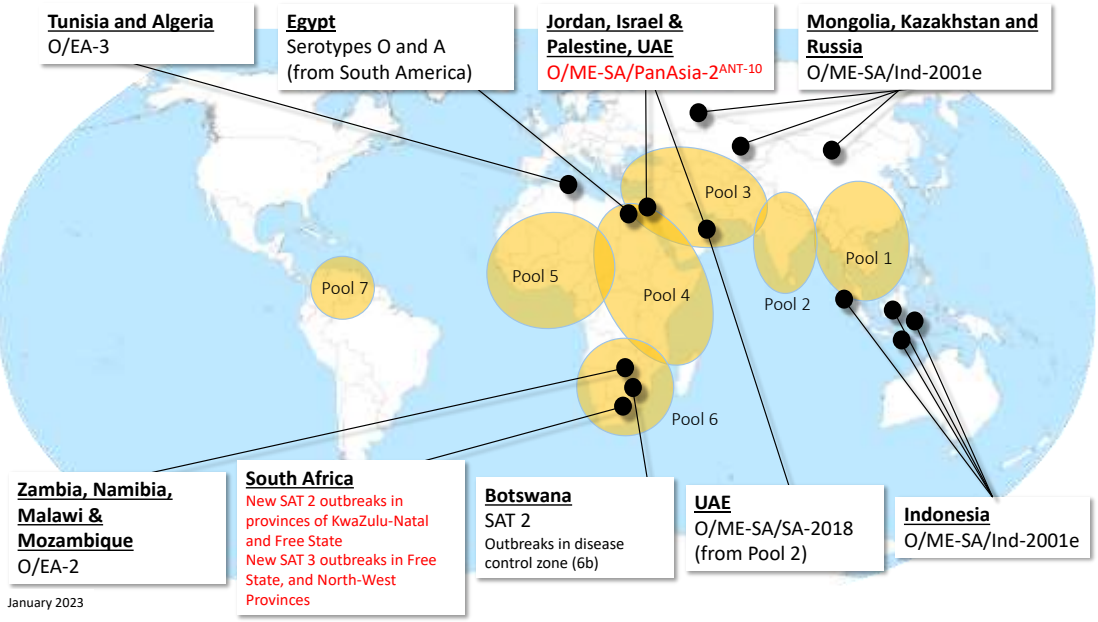


Figure 1: Recent FMD global outbreaks (new headline events reported October to December 2022 are highlighted in red) with endemic pools highlighted in orange. Source: WRLFMD. Map conforms to the United Nations World Map, June 2020.

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, Indonesia, 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[1], 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	**EASTERN AFRICA** Burundi, Comoros, Djibouti, Egypt[3], Eritrea, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan, Uganda, United Republic of Tanzania, Yemen	O, A, SAT 1, SAT 2 and SAT 3
	NORTH AFRICA[2] Algeria, Libya, Morocco, Tunisia	A, O and SAT 2
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[4], A)
7	**SOUTH AMERICA** Venezuela (Bolivarian Republic of)	O and A

[1]FMD outbreaks in 2016/21 due to O/ME-SA/Ind-2001 demonstrate close epidemiological links between Pool 2 and Mauritius.

[2]Long-term maintenance of FMDV lineages has not been documented in the Maghreb countries of North Africa and therefore this region does not constitute an Endemic Pool, but data is segregated here since FMD circulation in this region poses a specific risk to FMD-free countries in Southern Europe.

[3]Egypt represents a crossroads between East African Pool 4 and the Middle East (Pool 3). NB: Serotypes SAT 1 and SAT 3 have not been detected in this country.

[4]Detection of O/EA-2 in southern/western Zambia (2018-2021), Namibia (2021), Malawi (2022) and Mozambique (2022) represent a new incursion into Pool 6.

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.

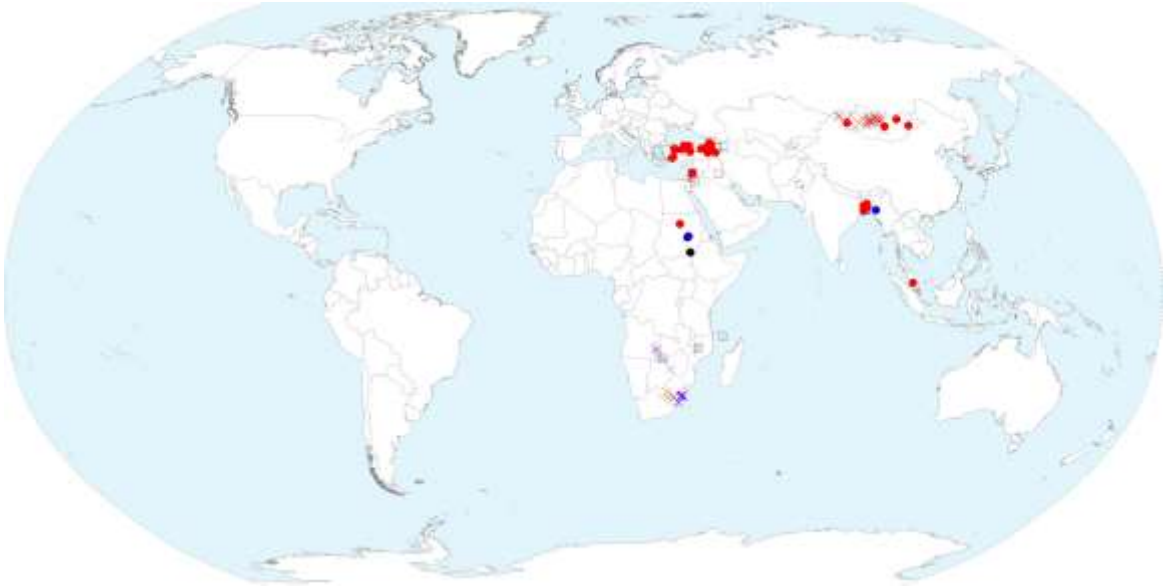
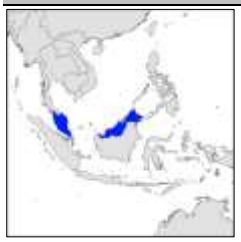


Figure 2: Samples tested by WRLFMD or reported in this quarter. ● indicates samples analysed; × indicates outbreaks reported/updated to the WOAH this quarter; □ indicates reports of FMD from other sources. Shape colours define the serotype detected ●O; ●A; ●C; ●Asia1, ●SAT1, ●SAT2, ●SAT3, ○ FMD not detected, ● 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)

Malaysia



On 17 October 2022, a single **FMD type O** VP1 sequence was received from the Malaysian National Foot and Mouth Disease Laboratory (MNFMDL). It was obtained from a sample collected during 2022 from cattle at Jempol, Negeri Sembilan. Genotyping showed that it belonged to the O/ME-SA/Ind-2001e sublineage (see below).

Mongolia

Further outbreaks, due to **FMD type O**, were reported in cattle, sheep and goats during the reporting period in the provinces of Arhangay, Bayan-Ölgiy, Bayanhongor, Bulgan, Dzavhan, Hovd and Töv.

Five **FMD type O** VP1 sequences, determined by the FGBI ARRIAH (Vladimir, Russia), were retrieved from GenBank. They were obtained from samples collected in 2018 and 2021 and genotyping showed that they all belonged to the O/ME-SA/Ind-2001e sublineage (see below).

3.3. Pool 2 (South Asia)

The People's Republic of Bangladesh

On 9 November 2022, 16 **FMD type O** complete VP1 sequences were retrieved from GenBank. They had been submitted by the University of Dhaka, Bangladesh along with 28 partial VP1 sequences (23 type O and 5 type A). Four of the complete VP1 sequences belonged to the O/ME-SA/SA-2018 lineage, while the remaining 12 belonged to the O/ME-SA/Ind-2001e sublineage (see below). The type O partial VP1 sequences also belonged to the O/ME-SA/Ind-2001e sublineage, while the type A partial VP1 sequences belonged to the A/ASIA/G-VII lineage (data not shown).

The Republic of India

On 10 November 2022, a single **FMD type A** VP1 sequence was retrieved from GenBank. It had been determined by the Central Agricultural University (CAU), Mizoram, India from a sample collected from cattle on 12 May 2020 in Mizoram state. Genotyping revealed that it belonged to the A/ASIA/G-VII lineage (see below).

3.4. Pool 3 (West Eurasia and Middle East)

The Republic of Armenia

Passive surveillance is being used in Armenia where serology in large and small ruminants has been undertaken by testing for NSP antibodies (4 400 samples) and and SP antibodies (991 samples). A total of 865 324 large ruminants and 3 649 small ruminants have been vaccinated.

FAO Eu-FMD FAST report Oct-Dec 2022

The Republic of Azerbaijan

Active and passive surveillance is being used in Armenia. During this quarter, 28.7 percent of the large ruminant and 24.8 percent of the small ruminant populations were vaccinated and 1 524 samples were collected for the sero-monitoring campaign.

FAO Eu-FMD FAST report Oct-Dec 2022

Georgia

Samples for the NSP sero-surveillance programme have been taken and are being tested. An autumn vaccination campaign has reached 30.2 percent of the large ruminant and 50.3 percent of the small ruminant populations.

FAO Eu-FMD FAST report Oct-Dec 2022

The Islamic Republic of Iran

Twenty-one outbreaks have been reported in this quarter. The circulating FMDV strains are O/ME-SA/PanAsia-2^{ANT-10} and A/ASIA/Iran-05^{FAR-11}.

Passive and risk-based active surveillance activities are on-going.

A trivalent vaccine (O, A & Asia-1) has been used to vaccinate 24.8 percent of the large ruminant and 21.4 percent of the small ruminant populations.

FAO Eu-FMD FAST report Oct-Dec 2022

The Republic of Iraq

Thirty-two outbreaks of FMD, serotypes O and A, were reported (not all confirmed by laboratory analysis). Most cases were in buffalo and cattle.

FAO Eu-FMD FAST report Oct-Dec 2022

The State of Israel

An outbreak due to **FMD type O** was reported in cattle at Lahavot Habashan, HaZafon, in September 2022. A VP1 sequence was received from the Kimron Veterinary Institute and genotyping showed it to belong to the O/ME-SA/Ind-2001e sublineage (see below). The outbreak at Lehavot Habashan is similar to O/ME-SA/Panasia-2^{ANT-10}, which was active in the region last year.

ProMED post: 20221012.8706096

The Hashemite Kingdom of Jordan

The first national FMD vaccination campaign commenced in October 2022. More than 75 percent of the large ruminant and 95 percent of the small ruminant population have been vaccinated. A post-vaccination monitoring study is also being undertaken.

FAO Eu-FMD FAST report Oct-Dec 2022

The State of Palestine

Outbreaks of **FMD type O** were reported in cattle, sheep and goats in the West Bank during November and December 2022.

Eighty-three deaths from FMD across 414 outbreaks have been reported in 2022.

FAO Eu-FMD FAST report Oct-Dec 2022

The Islamic Republic of Pakistan

One hundred and three outbreaks were reported from Punjab, Khyber Pakhtunkhwa and Sindh provinces. Serotypes O, A and Asia-1 were identified in 73 of the outbreaks.

FAO Eu-FMD FAST report Oct-Dec 2022

The Republic of Türkiye

On 1 December 2022, 30 **FMD type O** VP1 sequences were received from the FMD Institute (FMDI) in Ankara. They were derived from samples collected from sheep and cattle in various provinces during 2022. Genotyping revealed that 25 belonged to the O/ME-SA/PanAsia-2QOM-15 sublineage and five belonged to the O/ME-SA/PanAsia-2ANT-10 sublineage (see below).

During this quarter there were 26 outbreaks of FMD in the Anatolia region. Most typed as O/ME-SA/PanAsia-2^{QOM-15}, only two was O/ME-SA/PanAsia-2^{ANT-10}.

Clinical surveillance (26 960 animals) was achieved in >85 percent epi-units in the buffer zone area and the autumn vaccination campaign was completed using a quadrivalent vaccine.

FAO Eu-FMD FAST report Oct-Dec 2022

3.5. Pool 4 (North and Eastern Africa)

The Republic of the Sudan

A batch of 40 samples, collected from cattle between January 2019 and March 2022 in the Khartoum, Blue Nile and Northern States, was received on 27/06/2022. **FMD type O** was detected in 11 samples, **FMDV type A** in nine samples, while FMDV genome was detected in a further 14 samples. Six samples were No Virus Detected (NVD). VP1 genotyping

revealed all the type O viruses belonged to the O/EA-3 topotype while the type A viruses belonged to the A/AFRICA/G-IV lineage (see below).

3.6. Pool 5 (West/Central Africa)

No new outbreaks of FMD were reported in West/Central Africa.

3.7. Pool 6 (Southern Africa)

The Union of the Comoros

FMD as been identified in Ngazidja (Grand Comore). It is believed to have arrived with imported oxen & goats from Tanzania and/or Kenya.

ProMED post: 20221227.8707478

The Republic of Mozambique

An outbreak of FMD was reported in October 2022 in cattle at Nakoma, Chiuta, Mecanhelas District, Niassa Province, adjacent to the border with Malawi, however, no samples were collected.

WOAH World Animal Health Information System (event ID: 4654)

ProMED post: 20221020.8706251

The Republic of Namibia

Two outbreaks of FMD type SAT 2 were reported in cattle in Kabe, Zambezi Region, during October 2022.

The areas of Kabbe South and North constituencies have been declared FMD-infected areas, while the entire Zambezi region is declared a disease management area (DMA). Movement controls have been put into place and vaccination will start.

WOAH World Animal Health Information System (event ID: 4650)

ProMED post: 20221019.8706250

The Republic of South Africa

Outbreaks (n=28) due to **FMD SAT 2** have been reported in cattle, sheep and Cape buffalo in KwaZulu-Natal province (Zululand and eThekwini) and a further 35 outbreaks in the Free State province (Thabo Mofutsanyane). Outbreaks of **FMD SAT 3** have been reported during September 2022 in cattle and sheep in the Free State and the North West provinces.

WOAH World Animal Health Information System (event ID: 3738 & 4368)

3.8. Pool 7 (South America)

No new outbreaks of FMD were reported in South America.

3.9. Extent of global surveillance

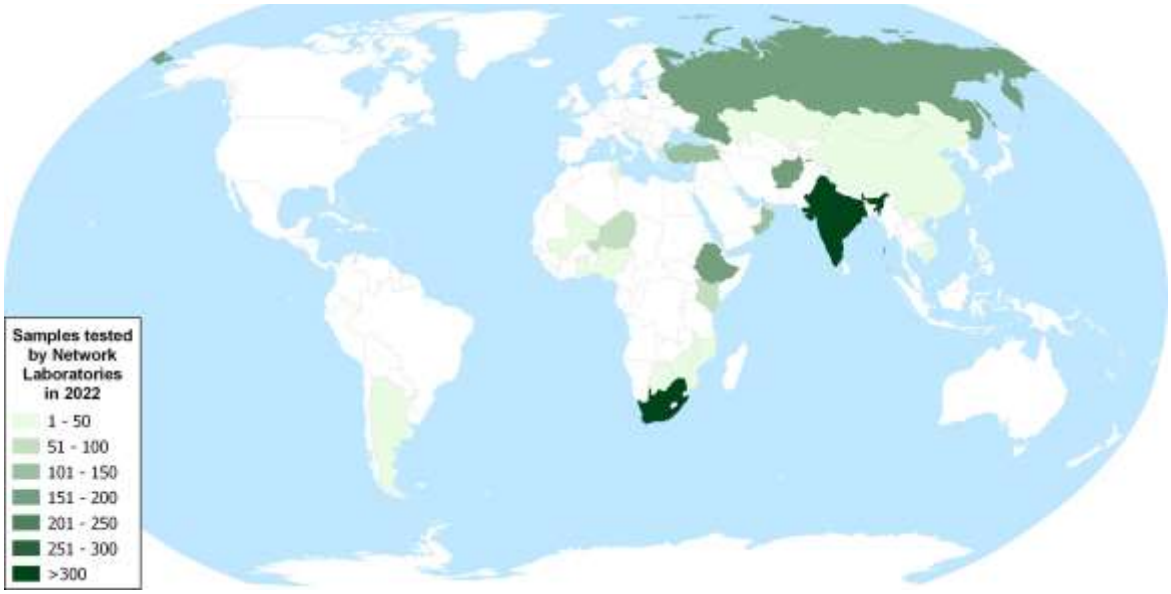


Figure 3: Samples received during 2022 from FMD outbreaks (routine surveillance that is undertaken in countries that are FMD-free without vaccination is not shown). Data from presentations given at the WOAH/FAO FMD reference laboratory network annual meeting (https://www.foot-and-mouth.org/Ref-Lab-Network/Network-Annual-Meeting). Source: WRLFMD. Map conforms to the United Nations World map, June 2020.

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 region (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 [percent] of total FMD cases that occur in domesticated hosts). These scores (reviewed at the WOAH/FAO FMD reference laboratory network meeting in December 2021) 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	21.5							
O ME-SA Ind2001	40	86[1]	7	2				
O EA or O WA			3	55	55.5	65	16	
O EURO-SA								90
O CATHAY	10.5							
A ASIA Sea-97	18							
A ASIA Iran-05	0		32					
A ASIA G-VII		10	10					
A AFRICA				33	22	17		

A EURO-SA								10
Asia-1	0	4	12.5					
SAT 1				0	8	3	16	
SAT 2			0.5	10	14	15	52	
SAT 3					0.5		16	
C								

[1] Includes cases due to the emerging O/ME-SA/SA-18 lineage that has been recently detected in Pool 2.

A number of outbreaks have occurred where samples have not been sent to the WRLFMD or other laboratories in the WOAH/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-2021.

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 October to December 2022 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 October to December 2022.

WRLFMD Batch No.	Date received	Country	Total No. samples	Serotype	No. of samples	No. of sequences	Sequencing status
WRLFMD/2022/0000039	27/06/2022	Sudan	40	O A	11 9	11 9	Finished
Totals			**40**		**20**	**20**	

Table 3: VP1 sequences submitted by other FMD Network laboratories to the WRLFMD from October to December 2022.

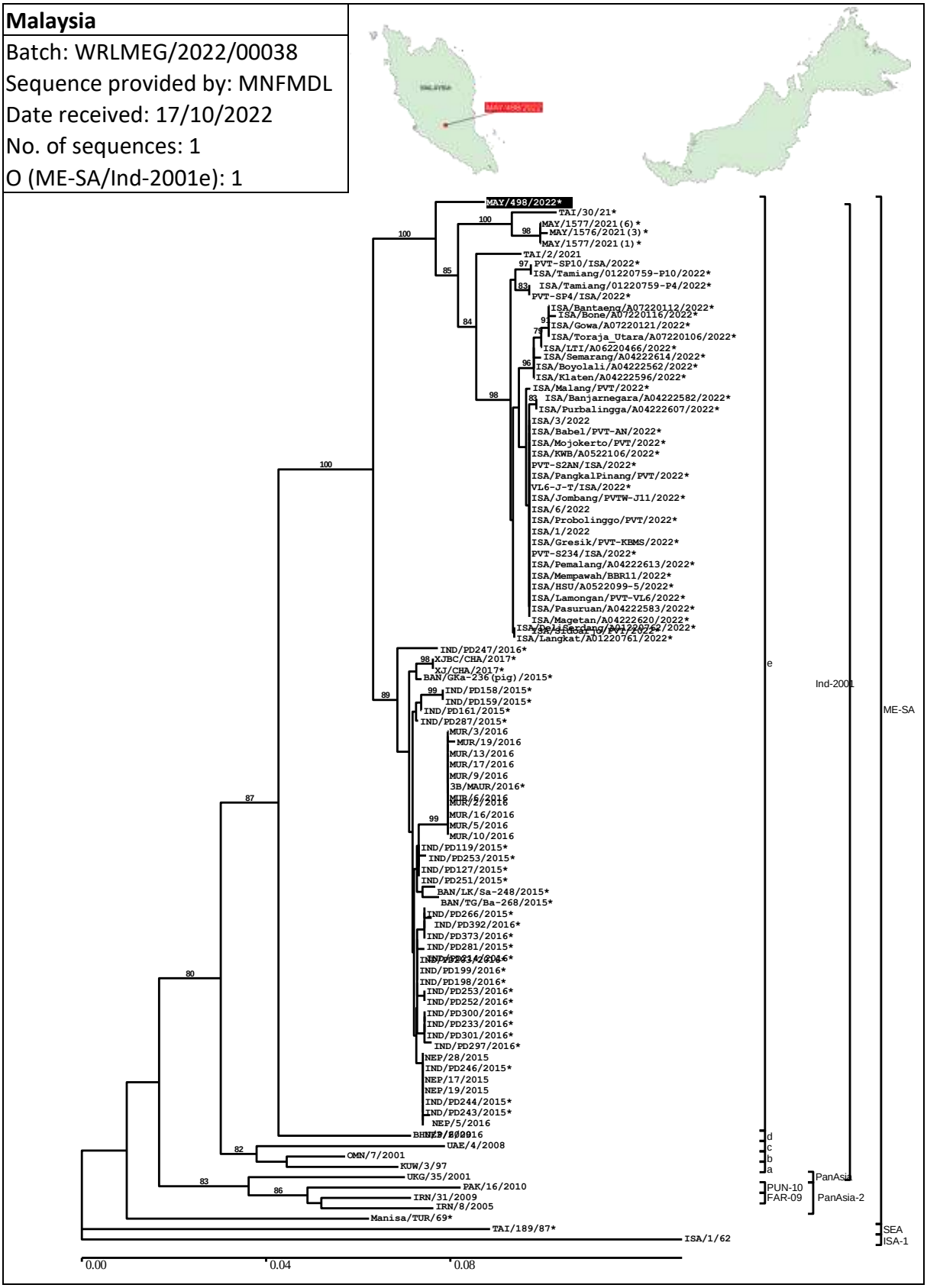
WRLFMD Batch No.	Date received	Country	Serotype	Date Collected	No. of sequences	Submitting laboratory
WRLMEG/2022/00036	05/10/2022	Mongolia	O	2018, 2021	5	ARRIAH (GenBank)
WRLMEG/2022/00038	17/10/2022	Malaysia	O	2022	1	MNFMDL
WRLMEG/2022/00039	31/10/2022	Israel	O	2022	1	KVI
WRLMEG/2022/00040	09/11/2022	Bangladesh	O	2019-2021 2021	12 4	UNIV-DHAKA (GenBank)
WRLMEG/2022/00041	10/11/2022	India	A	2020	1	CAU-MIZORAM (GenBank)
WRLMEG/2022/00042	01/12/2022	Turkey	O	2022 2022	25 5	FMDI-Ankara

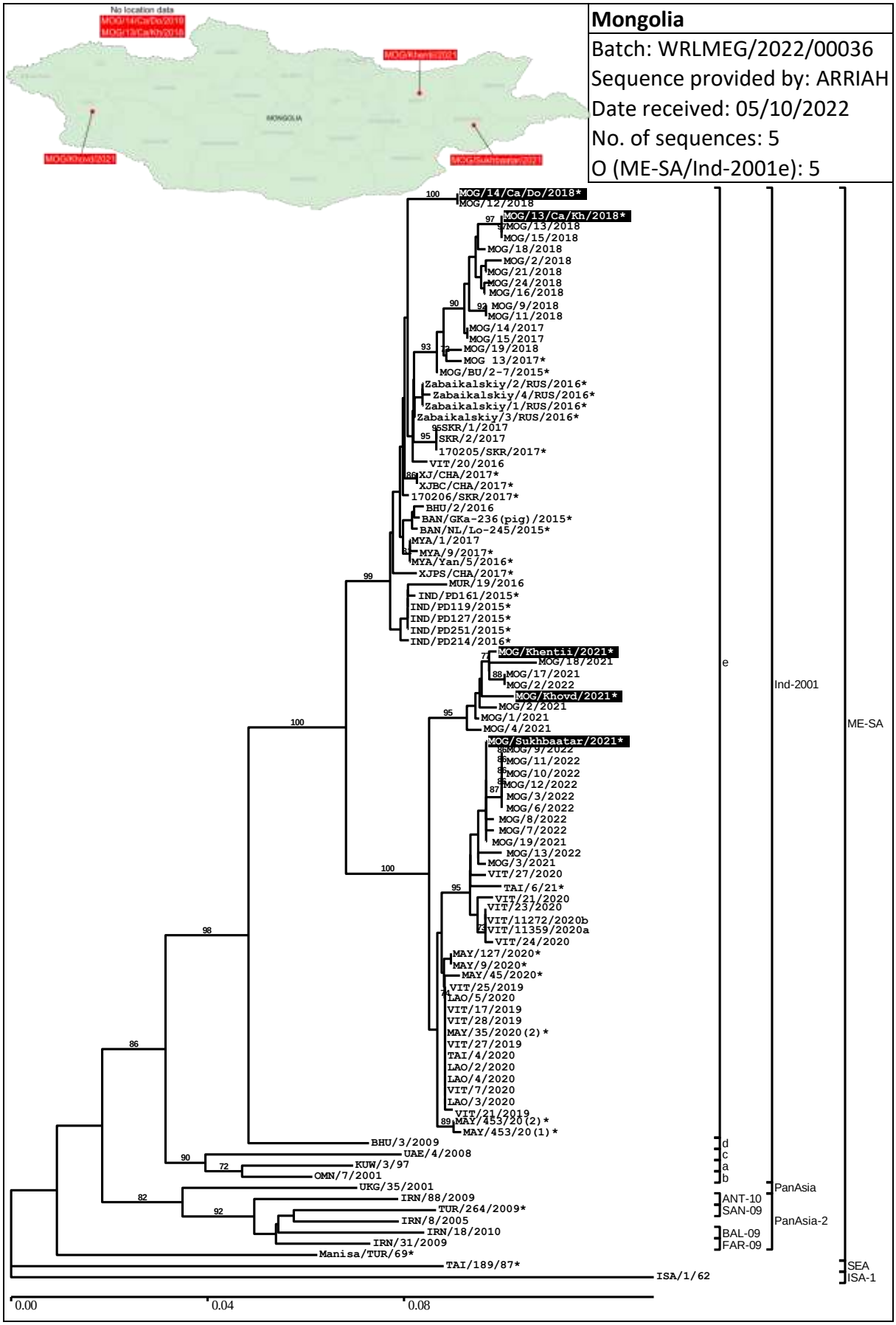
WRLFMD Batch No.	Date received	Country	Serotype	Date Collected	No. of sequences	Submitting laboratory
				Total	54	

4. Detailed analysis

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

Malaysia
Batch: WRLMEG/2022/00038
Sequence provided by: MNFMDL
Date received: 17/10/2022
No. of sequences: 1
O (ME-SA/Ind-2001e): 1

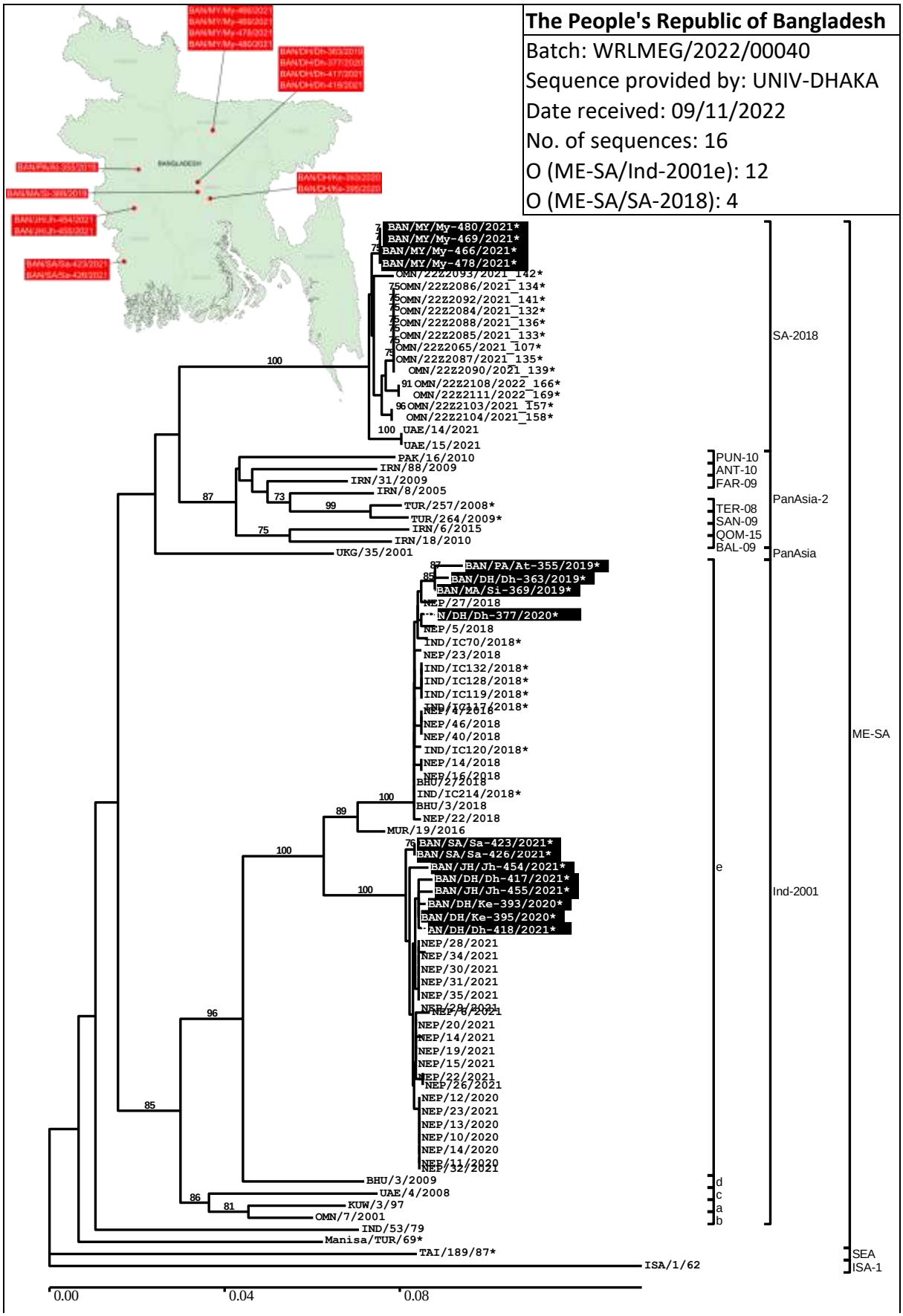


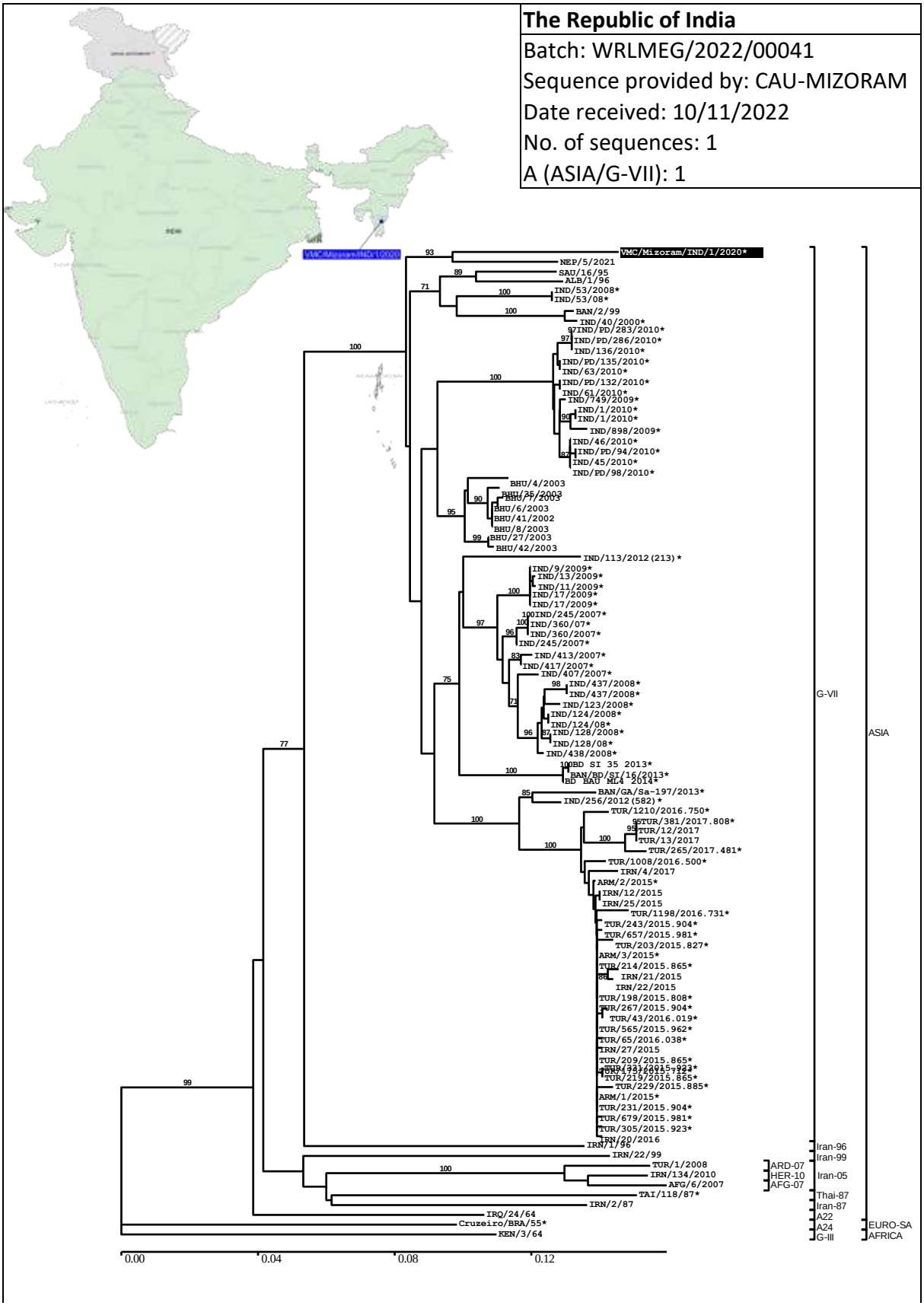


Mongolia

Batch: WRLMEG/2022/00036
Sequence provided by: ARRIAH
Date received: 05/10/2022
No. of sequences: 5
O (ME-SA/Ind-2001e): 5

4.2. Pool 2 (South Asia)




The Republic of India
Batch: WRLMEG/2022/00041
Sequence provided by: CAU-MIZORAM
Date received: 10/11/2022
No. of sequences: 1
A (ASIA/G-VII): 1
VMC/Mizoram/IND/1/2020*
NEP/5/2021
SAU/16/95
ALB/1/96
IND/53/2008*
IND/53/08*
BAN/2/99
IND/40/2000*
IND/PD/283/2010*
IND/PD/286/2010*
IND/136/2010*
IND/PD/135/2010*
IND/63/2010*
IND/PD/132/2010*
IND/61/2010*
IND/749/2009*
IND/1/2010*
IND/1/2010*
IND/898/2009*
IND/46/2010*
IND/PD/94/2010*
IND/45/2010*
IND/PD/98/2010*
BHU/4/2003
BHU/35/2003
BHU/7/2003
BHU/6/2003
BHU/41/2002
BHU/8/2003
BHU/27/2003
BHU/42/2003
IND/113/2012(213)*
IND/9/2009*
IND/13/2009*
IND/11/2009*
IND/17/2009*
IND/17/2009*
IND/245/2007*
IND/360/07*
IND/360/2007*
IND/245/2007*
IND/413/2007*
IND/417/2007*
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TUR/267/2015.904*
TUR/43/2016.019*
TUR/565/2015.962*
TUR/65/2016.038*
IRN/27/2015
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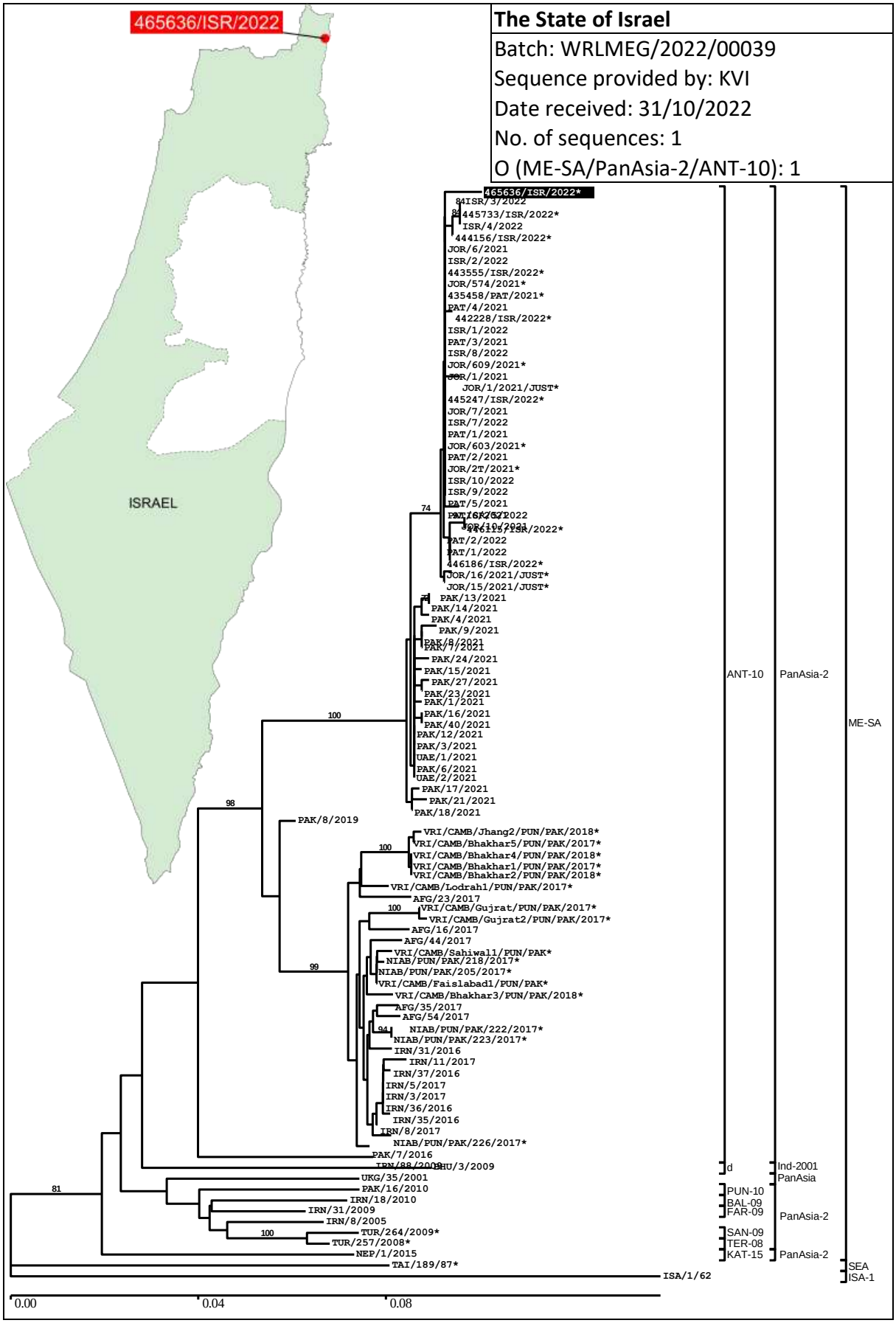
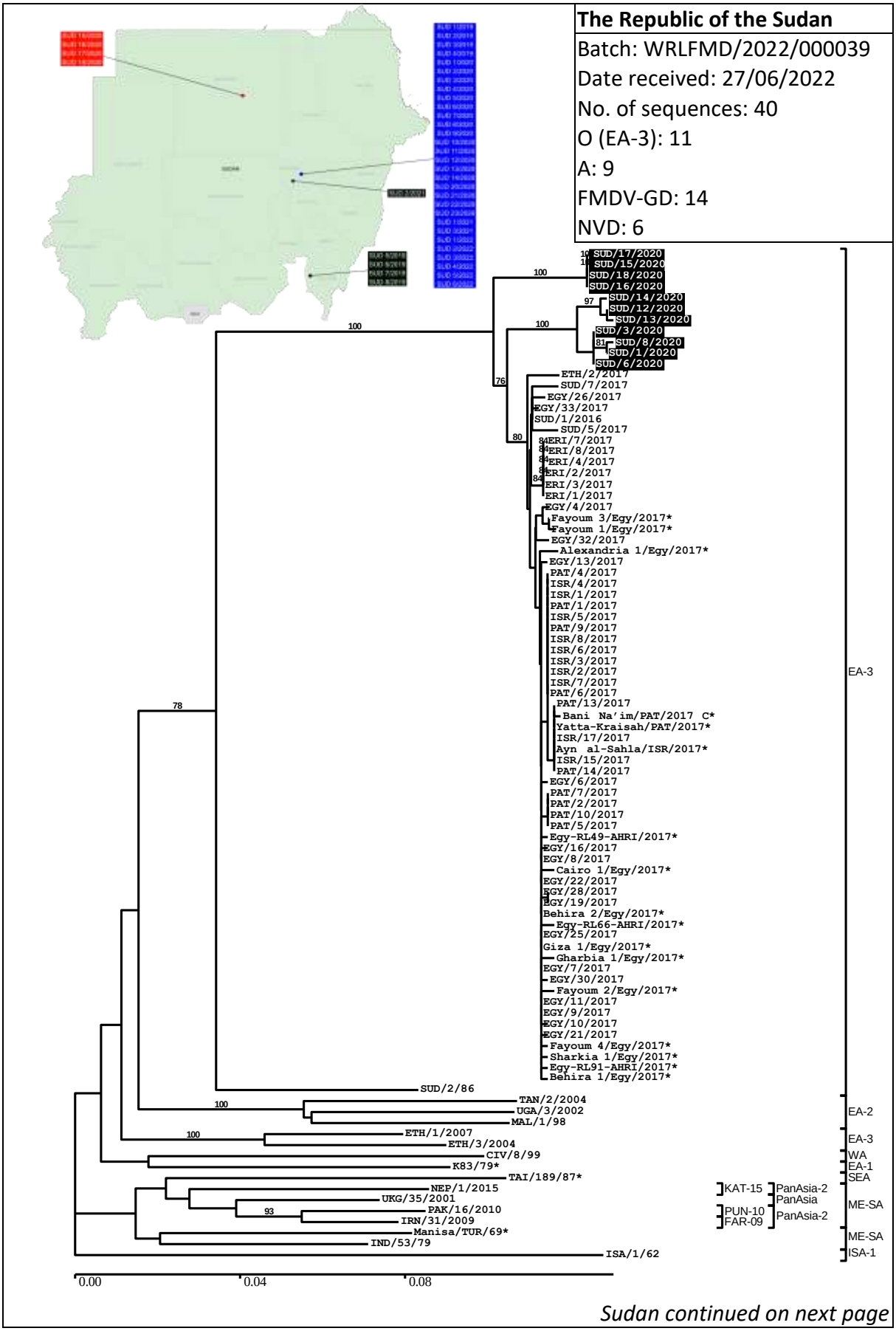
TUR/219/2015.865*
TUR/229/2015.885*
ARM/1/2015*
TUR/231/2015.904*
TUR/679/2015.981*
TUR/305/2015.923*
IRN/20/2016
IRN/1/96
IRN/22/99
TUR/1/2008
IRN/134/2010
AFG/6/2007
TAI/118/87*
IRN/2/87
IRQ/24/64
Cruzeiro/BRA/55*
KEN/3/64
0.00
0.04
0.08
0.12
G-VII
ASIA
Iran-96
Iran-99
ARD-07
HER-10
AFG-07
Iran-05
Thai-87
Iran-87
A22
A24
G-III
EURO-SA
AFRICA

4.3. Pool 3 (West Eurasia and Middle East)



4.4. Pool 4 (North and East Africa)



Sudan continued on next page

Sudan continued

4.5. Pool 6 (Southern Africa)

No samples/sequences received.

4.6. Pool 7 (South America)

No samples/sequences received.

4.7. Vaccine matching

Antigenic characterisation of FMD field isolates by matching with vaccine strains by 2dmVNT from October to December 2022.

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
Ethiopia	4	3	-	-	-	2	-
Sudan	2	3	-	-	-	-	-
Total	**6**	**6**	**0**	**0**	**0**	**2**	**0**

Abbreviations used in tables

For each field isolate the r_1 value is shown followed by the heterologous neutralisation titre (r_1-value / titre). The r_1 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 O FMDV

Isolate	Serotype O		O 3039 *Boehringer Ingelheim*		O Campos *Boehringer Ingelheim*		O_1 Campos *Biogénesis Bagó*		O Manisa *Boehringer Ingelheim*		PanAsia 2 *Boehringer Ingelheim*		O/TUR/5/09 *MSD*	
	Topotype	Lineage	r_1	*titre*	r_1	*titre*	r_1	*titre*	r_1	*titre*	r_1	*titre*	r_1	*titre*
ETH/5/2020	EA-3	-	0.36	*1.67*	0.34	*1.94*	0.63	*2.59*	0.69	*2.1*	0.47	*2.17*	0.52	*2.04*
ETH/5/2021	EA-3	-	0.90	*2.07*	0.74	*2.42*	0.87	*2.73*	0.94	*2.24*	0.60	*2.27*	0.94	*2.31*
ETH/5/2022	EA-3	-	0.39	*1.71*	0.43	*2.18*	0.70	*2.64*	0.4	*2.04*	0.34	*2.03*	0.91	*2.29*
SUD/6/2020	EA-3	-	0.55	*1.86*	0.38	*2.07*	0.64	*2.68*	0.61	*2.27*	0.27	*2.07*	0.69	*2.06*
SUD/17/2020	EA-3	-	0.14	*1.28*	0.45	*2.14*	0.49	*2.56*	0.18	*1.73*	0.26	*2.04*	0.68	*2.05*
ETH/28/2019	EA-4	-	0.47	*1.79*	0.40	*2.05*	0.90	*2.75*	0.36	*2.02*	0.51	*2.20*	1.00	*2.36*

Table 6: Vaccine matching studies for A FMDV

Isolate	Serotype A		A22 Iraq *Boehringer Ingelheim*		A Iran 2005 *Boehringer Ingelheim*		A GVII 2015 *Boehringer Ingelheim*		A Saudi 95 *Boehringer Ingelheim*		A/TUR/20/06 *MSD*		A Eritrea 98 *Boehringer Ingelheim*	
	Topotype	Lineage	r_1	*titre*	r_1	*titre*	r_1	*titre*	r_1	*titre*	r_1	*titre*	r_1	*titre*
ETH/25/2019	AFRICA	G-IV	0.27	*2.01*	0.43	*2.21*	0.04	*0.59*	0.11	*1.67*	0.13	*0.97*	0.23	*2.11*
ETH/1/2020	AFRICA	G-IV	0.22	*1.93*	0.45	*2.23*	0.04	*0.53*	0.06	*1.37*	0.03	*0.57*	0.25	*2.14*
ETH/4/2022	AFRICA	G-IV	0.13	*1.68*	0.05	*1.31*	0.07	*0.83*	0.06	*1.37*	0.13	*0.95*	0.29	*2.21*
SUD/4/2019	AFRICA	G-IV	0.19	*1.99*	0.14	*1.72*	0.06	*0.75*	0.66	*2.19*	0.11	*1.10*	0.26	*2.09*
SUD/1/2021	AFRICA	G-IV	0.07	*1.56*	0.13	*1.71*	0.00	*0.00*	0.63	*2.18*	0.19	*1.34*	0.15	*1.85*
SUD/2/2022	AFRICA	G-IV	0.14	*1.84*	0.37	*2.05*	0.00	*0.00*	0.33	*1.89*	0.01	*0.21*	0.13	*1.78*

Table 7: Vaccine matching studies for SAT 2 FMDV

Isolate	Serotype SAT 2		Eritrea 98 *Boehringer Ingelheim*		SAT2 Zim 83 *Boehringer Ingelheim*	
	Topotype	Lineage	r_1	*titre*	r_1	*titre*
ETH/31/2019	VII	Lib-12	0.76	*1.59*	0.23	*1.80*
ETH/2/2022	XIV	-	0.81	*1.62*	0.54	*2.17*

Annex 1: Sample data

Summary of submissions

Table 7: Summary of samples collected and received to WRLFMD October to December 2022

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*
Sudan	40	10	9	0	0	0	0	0	21	34	6
TOTAL	**40**	**10**	**9**	**0**	**0**	**0**	**0**	**0**	**21**	**34**	**6**

Clinical samples

Table 8: Clinical sample diagnostics made by the WRLFMD October to December 2022

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
Sudan	27/06/2022	21/10/2022	SUD 1/2019	CATTLE	10-Jan-19	A	FMDV GD	A
			SUD 2/2019	CATTLE	24-Jan-19	NVD	NGD	NVD
			SUD 3/2019	CATTLE	24-Jan-19	A	FMDV GD	A
			SUD 4/2019	CATTLE	24-Jan-19	A	FMDV GD	A
			SUD 5/2019	CATTLE	28-Feb-19	NVD	NGD	NVD
			SUD 6/2019	CATTLE	01-Mar-19	NVD	NGD	NVD
			SUD 7/2019	CATTLE	01-Mar-19	NVD	FMDV GD	FMDV GD
			SUD 8/2019	CATTLE	01-Mar-19	NVD	NGD	NVD
			SUD 1/2020	CATTLE	20-Feb-20	NVD	FMDV GD	FMDV GD
			SUD 2/2020	CATTLE	20-Feb-20	NVD	FMDV GD	FMDV GD
			SUD 3/2020	CATTLE	24-Feb-20	O	FMDV GD	O
			SUD 4/2020	CATTLE	24-Feb-20	NVD	FMDV GD	FMDV GD
			SUD 5/2020	CATTLE	24-Feb-20	NVD	FMDV GD	FMDV GD
			SUD 6/2020	CATTLE	26-Feb-20	O	FMDV GD	O
			SUD 7/2020	CATTLE	26-Feb-20	NVD	FMDV GD	FMDV GD
			SUD 8/2020	CATTLE	26-Feb-20	O	FMDV GD	O
			SUD 9/2020	CATTLE	01-Mar-20	NVD	FMDV GD	FMDV GD
			SUD 10/2020	CATTLE	01-Mar-20	NVD	FMDV GD	FMDV GD
			SUD 11/2020	CATTLE	04-Mar-20	NVD	FMDV GD	FMDV GD
			SUD 12/2020	CATTLE	09-Mar-20	O	FMDV GD	O
			SUD 13/2020	CATTLE	09-Mar-20	O	FMDV GD	O

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
			SUD 14/2020	CATTLE	09-Mar-20	O	FMDV GD	O
			SUD 15/2020	CATTLE	27-Apr-20	O	FMDV GD	O
			SUD 16/2020	CATTLE	27-Apr-20	O	FMDV GD	O
			SUD 17/2020	CATTLE	27-Apr-20	O	FMDV GD	O
			SUD 18/2020	CATTLE	27-Apr-20	O	FMDV GD	O
			SUD 19/2020	CATTLE	30-Dec-20	NVD	NGD	NVD
			SUD 20/2020	CATTLE	30-Dec-20	NVD	FMDV GD	FMDV GD
			SUD 21/2020	CATTLE	30-Dec-20	NVD	NGD	NVD
			SUD 22/2020	CATTLE	30-Dec-20	NVD	FMDV GD	FMDV GD
			SUD 23/2020	CATTLE	30-Dec-20	NVD	FMDV GD	FMDV GD
			SUD 1/2021	CATTLE	25-Feb-21	A	FMDV GD	A
			SUD 2/2021	CATTLE	12-Apr-21	NVD	FMDV GD	FMDV GD
			SUD 3/2021	CATTLE	03-Aug-21	NVD	FMDV GD	FMDV GD
			SUD 1/2022	CATTLE	23-Feb-22	A	FMDV GD	A
			SUD 2/2022	CATTLE	01-Mar-22	A	FMDV GD	A
			SUD 3/2022	CATTLE	01-Mar-22	A	FMDV GD	A
			SUD 4/2022	CATTLE	12-Mar-22	A	FMDV GD	A
			SUD 5/2022	CATTLE	12-Mar-22	A	FMDV GD	A
			SUD 6/2022	CATTLE	13-Mar-22	NVD	FMDV GD	FMDV GD
TOTAL					**40**			

Annex 2: FMD publications

Recent FMD Publications October to December 2022 cited by Web of Science.

1. Abdalhamed, A.M., S.M. Naser, A.H. Mohamed, and G.S.G. Zeedan (2022). Development of gold nanoparticles-lateral flow test as a novel field diagnostic assay for detecting foot-and-mouth disease and lumpy skin disease viruses. *Iranian Journal of Microbiology*, **14**(4): 574-586.
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4. Babayani, N.D. and O.I. Thololwane (2022). A qualitative risk assessment indicates moderate risk of foot-and-mouth disease outbreak in cattle in the lower Okavango Delta because of interaction with buffaloes. *Transboundary and Emerging Diseases*, **69**(5): 2840-2855. DOI: 10.1111/tbed.14436.
5. Bayir, T. and I.S. Gurcan (2022). Spatiotemporal distributions of foot-and-mouth disease between 2010-2019 in Turkey. *Acta Veterinaria-Beograd*, **72**(3): 334-347. DOI: 10.2478/acve-2022-0027.
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9. Chanchaidechachai, T., H. Saatkamp, M. de Jong, C. Inchaisri, H. Hogeveen, S. Premashthira, N. Buamitoup, R. Prakotcheo, and B.H.P. van den Borne. Epidemiology of foot-and-mouth disease outbreaks in Thailand from 2011 to 2018. *Transboundary and Emerging Diseases*: 14. DOI: 10.1111/tbed.14754.
10. Chathuranga, W.A.G., C. Hewawaduge, N.A.N. Nethmini, T.H. Kim, J.H. Kim, Y.H. Ahn, I.J. Yoon, S.S. Yoo, J.H. Park, and J.S. Lee (2022). Efficacy of a novel multiepitope vaccine candidate against *Foot-and-mouth disease virus* serotype O and A. *Vaccines*, **10**(12): 22. DOI: 10.3390/vaccines10122181.
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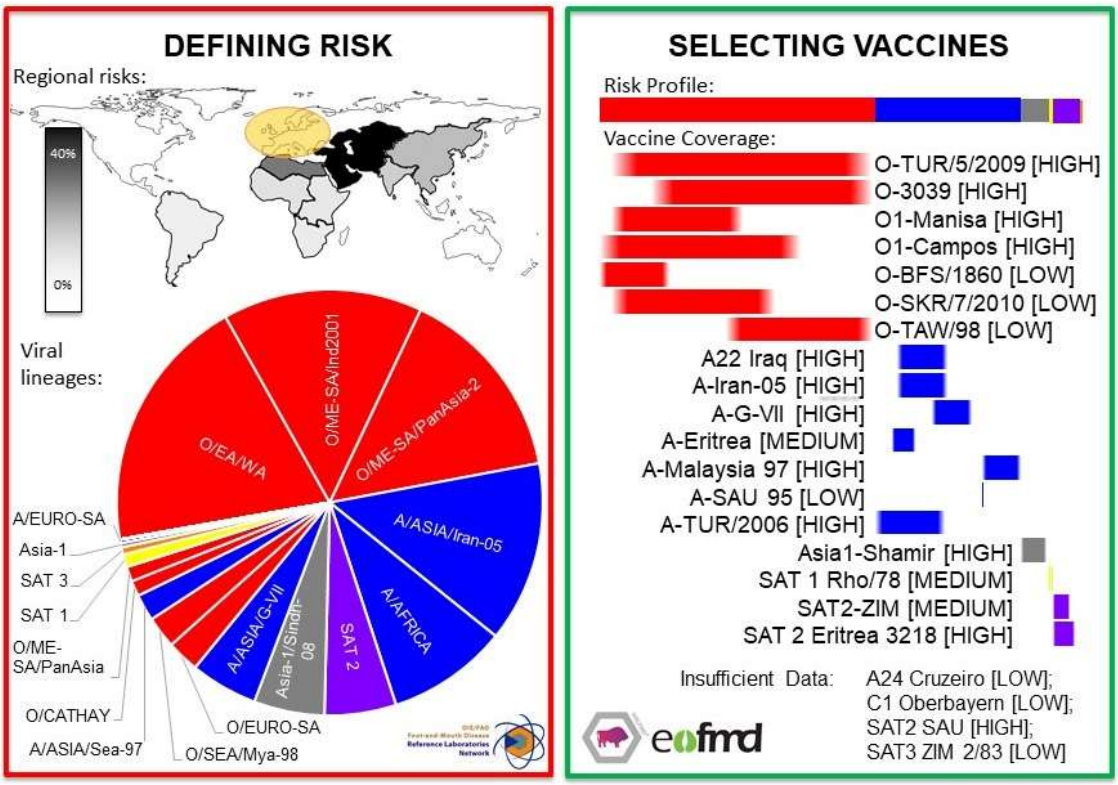
Annex 3: Vaccine recommendations

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 WOAH/FAO FMD reference 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 prioritisation (for Europe): December 2022:



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.

Further information about the PRAGMATIST system has been published recently in *Frontiers in Veterinary Science*-see: https://doi.org/10.3389/fvets.2022.1029075.

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

Courses

- The EuFMD's Open Access Courses provide convenient self-paced training which you may study anytime, anywhere, free of charge. There are currently 8 courses in English and 1 in Arabic:
  - **Introduction to Foot-and-Mouth Disease** (available in English and French), introducing foot-and-mouth disease (FMD), its importance, diagnosis, outbreak investigation and the control measures 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 facing this rapidly emerging threat.
  - **Introduction to Rift Valley Fever** aims to build your understanding of Rift Valley fever diagnosis, surveillance, prevention and control.
  - **What is the Progressive Control Pathway** (available in English and, for anyone who is new to the PCP-FMD, a short e-learning module is also available in Arabic) 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.
  - **Introduction to the Risk-Based Strategic Plan** introducing the Risk-Based Strategic Plan (RBSP).
- **Public Private Partnerships in the Veterinary Domain** course, developed in partnership with the World Organisation for Animal Health (WOAH), applying public-private partnerships to the control of FMD and similar transboundary animal diseases.
- **Simulation Exercises for Animal Disease Emergencies** (available through FAO eLearning academy) aiming at building your understanding of simulation exercises and their value as part of the emergency preparedness cycle.
- A course on **Introduction to the FMD Minimum Biorisk Management Standards** is currently in development. The virtual course will be open access, will target National Competent Authorities, Institute directors for FMD facilities, biorisk managers and laboratory personnel in laboratories handling infectious FMD. The learning objectives will include introduce the importance, implications and responsibilities of implementing the FMD Minimum Biorisk Management Standards.
- The next **WRLFMD residential training course on FMD diagnostic methods** is scheduled for 15-26 May 2023.
- **OutCosT-RUM webinar** (24 January 2023; Online). This webinar will introduce OutCosT - RUM, following its publication on the EuFMD Trello, thus allowing participants to understand the tool, its potential to support country authorities, and the resources and time needed for its implementation.
- **Progressive Control Pathway for Foot-and-Mouth Disease (PCP-FMD) Workshop** (2-3 February 2023; Nakuru, Kenya). EuFMD will organise and deliver training on the application of the PCP-FMD at County level for Kenyan veterinary services.
- **Real-Time Training Europe** (6-9 February 2023; Naivasha, Kenya).

- **VADEMOS - Model for Vaccine Demand Workshop** (28 March 2023; Food and Agriculture Organization of the United Nations HQ).
- **Vaccine Value Chain Workshop** (28 March 2023; Food and Agriculture Organization of the United Nations HQ).
- **FMD Emergency Preparation Course - Spain** (26 April 2023; Spain [To Be Confirmed]). The course helps raise awareness of FMD and on the importance of early detection amongst a wider group of practitioners. It is particularly suitable for field level government and private veterinarians.

Other resources

Podcasts

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

- The EuFMD has opened the Emergency Toolbox.
- A series of videos on foot-and-mouth disease in English, Bulgarian, Greek and Turkish (https://www.fao.org/eufmd/en/).
- Leaflets on FMD in English, Turkish, Bulgarian and Greek, for the Thrace region (https://www.fao.org/publications/card/en/c/CB4903EN).
- Join our Telegram channel to receive EuFMD updates (https://t.me/eufmd).
- Find out who TOM is and why you need him (https://www.eufmd.info/tom-training).

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).

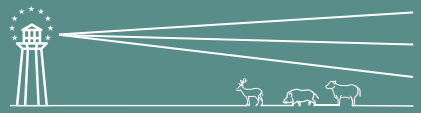
Meetings

- **Standing Technical Committee of the EuFMD** (15 February 2023; Online).
- **Special Committee for Surveillance and Applied Research meeting** (23rd February 2023; Food and Agriculture Organization of the United Nations HQ).
- **Executive Committee of the EuFMD** (8 March 2023; Online).
- **Lumpy Skin Disease symposium** (14-16 March 2023; Food and Agriculture Organization of the United Nations HQ).
- **Standing Committee on Prequalification of vaccines against FAST diseases (SCPQv) meeting** (28 March 2023; Food and Agriculture Organization of the United Nations HQ).
- **45th General Session** of the European Commission for the control Foot-and-Mouth Disease (EuFMD) will be held in Rome, Italy, on 4-5 May 2023.
- **Executive Committee** (18 October 2023; Online)

Proficiency test scheme organised by WRLFMD

Phase XXXIII of the WRLFMD proficiency testing scheme (PTS) has been concluded, and the participating laboratories should have received their feedback letters and the final report.

Invitation letters should have been received for the next exercise (Phase XXXIV) and WRLFMD anticipate that shipments will be organised in the next few months. Any interested laboratories should contract the WRLFMD for further information. Progress of this PTS will be described in future quarterly reports.



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eufmdlearning.works
eufmd.info

eufmd@fao.org

Hold-FAST tools

GET PREPARED, E-learning, FMD-PCP, EuFMDiS, Pragmatist, Impact Risk Calculator, Virtual Learning Center, SMS Disease reporting, Global Vaccine Security, Outbreak Investigation app, PCP-Support Officers, PCP Self-Evaluation tool, AESOP, Telegram, Whatssap, Quarterly Global Reports, Real Time Traning.

EuFMD Committees

Executive Committee, Standing Technical Committee, Special Committee for Surveillance and Applied Research (SCSAR), Special Committee on Biorisk Management (SCBRM), Tripartite Groups.

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