Food and Agriculture Organization of the United Nations

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

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

FMD 2024 JAN FEB MAR Quarterly Report

2024 Foot-and-mouth disease quarterly report
January - February - March

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

2023-2027 Strategy
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Jammu and Kashmir: *Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.*

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).*

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	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 (Indonesia)
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 Türkiye
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

Welcome to this first quarterly report for 2024, which presents data from the WRLFMD together with global FMD intelligence from other sources. During this period, the WRLFMD has reported test results for samples received from Algeria, Botswana, Kenya, Malawi, Mozambique, Namibia, Nigeria, Tunisia and Zimbabwe. There have also been new sequence submissions from Algeria (ANSES, France), Indonesia (Pusvetma) and Libya (IZSLER, Italy). Regular readers will recognise a common theme of these reports characterised by unexpected long-distance movements of FMDV to cause outbreaks in new geographical locations. Recent outbreaks in Algeria (first detected in December 2023) represent the first reported outbreaks of SAT 2 serotype in the Maghreb. The emergence of SAT 2 in the region is not completely unexpected, since regional meetings have previously discussed the potential for the SAT2/VII topotype to be introduced from West Africa following similar pathways to serotype O and A. However, the identification of SAT2/V as the causative virus is surprising, since this topotype has not been detected anywhere since 1991. Work is now underway to understand the source of this virus, as well as to provide advice about the suitability of FMD vaccines to control the further spread of this topotype. Elsewhere in North Africa, a new incursion of O/EA-3 has been recorded during February 2024 in Libya where sequence data shared by IZSLER, Italy indicates that these cases are genetically distinct to the serotype O outbreaks reported in Tunisia (during December 2023). Altogether, since 2017 there have now been ~9 separate incursions of FMDV into North Africa (O/EA-3, A/AFRICA/G-IV and SAT2/V); events that inevitably raise the risks for FMD free countries in southern Europe.

Samples received from Kenya represent four FMD serotypes (O, A, SAT1 and SAT2) that are representative of core viral lineages in East Africa; although none of these sequences share close genetic identity to the viruses that have caused recent FMD outbreaks in the Gulf States of the Middle East. Testing is underway for further sample shipments from Ethiopia and Uganda which will help to define the current FMD situation in East Africa. Elsewhere in Africa, further SAT 1 cases have been recorded for Comoros and in South Africa new FMD outbreaks due to serotype SAT 1 and SAT 3 have been reported.

In Asia, new FMDV sequences shared by the FMD NRL in Indonesia (Pusvetma) highlight the continued spread and evolution of the O/ME-SA/Ind-2001e lineage from 2022-24, while a new paper (https://doi.org/10.3389/fvets.2024.1378769) reports FMD outbreaks due to this lineage in South Korea in 2023 that were previously reported.

Don King, Pirbright, April 2024

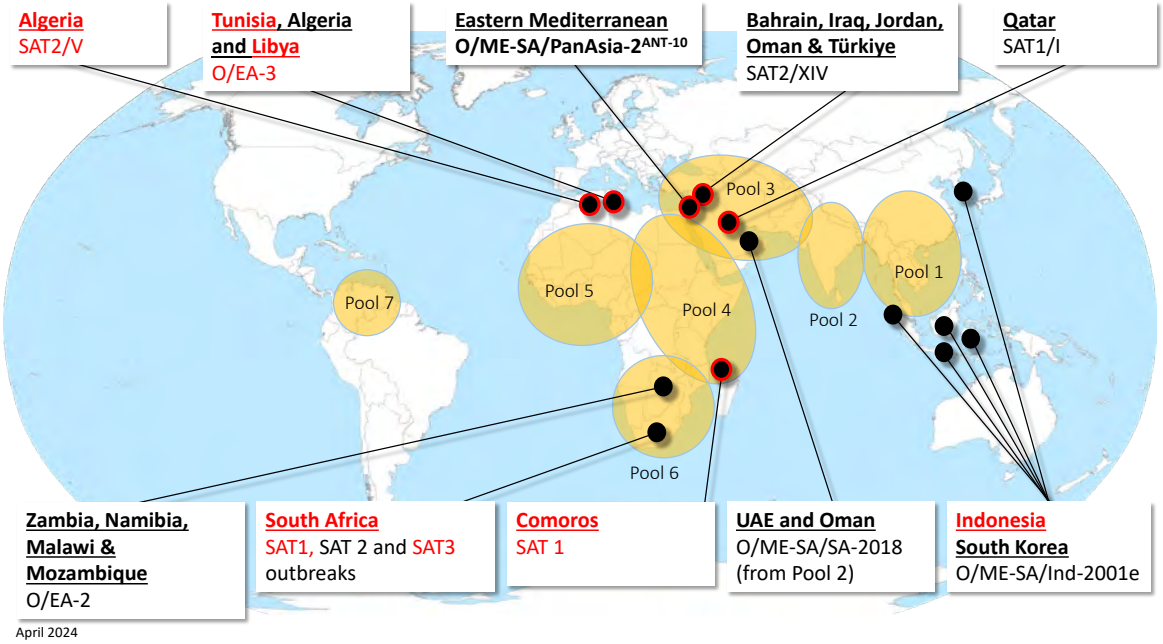


Figure 1: Recent FMD global outbreaks

Note: New headline events reported January to March 2024 are highlighted in red with FMD endemic pools highlighted in orange.
Source: WRLFMD. Map conforms to the United Nations World Map, June 2020.

2. General overview

Endemic Pools comprise separate ecosystems that maintain independently circulating and evolving foot-and-mouth disease virus (FMDV) genotypes. In the absence of specific reports, it should be assumed that the serotypes indicated below are continuously circulating in parts of these pools 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, Asia1 and O
2	**SOUTH ASIA** Bangladesh, Bhutan, India, Mauritius[1], Nepal, Sri Lanka	A, Asia1 and O
3	**WEST EURASIA & NEAR 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, Türkiye, Turkmenistan, United Arab Emirates, Uzbekistan	A, Asia1 and O (SAT2)
4	**EASTERN AFRICA** Burundi, Comoros, Djibouti, Egypt[3], Eritrea, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan, Uganda, United Republic of Tanzania, Yemen	O, A, SAT1, SAT2 and SAT3
	NORTH AFRICA[2] Algeria, Libya, Morocco, Tunisia	A and O
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, SAT1 and SAT2
6	**SOUTHERN AFRICA** Angola, Botswana, Malawi, Mozambique, Namibia, South Africa, Zambia, Zimbabwe	SAT1, SAT2 and SAT3 (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 Near East (Pool 3). NB: Serotypes SAT1 and SAT3 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. Overview of reports

The location of information provided 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.

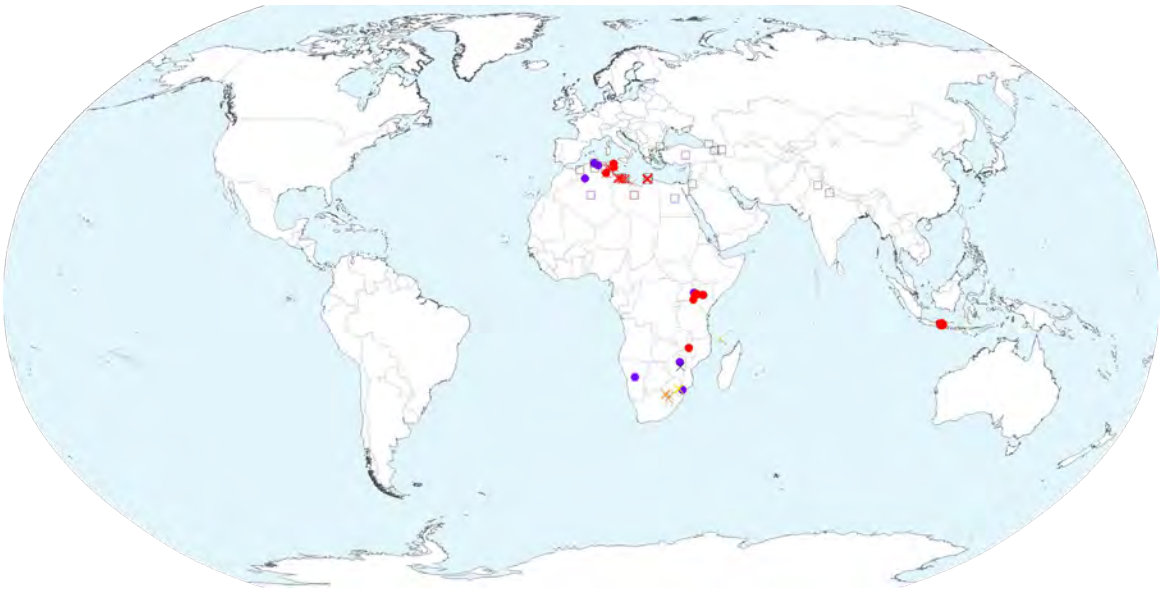
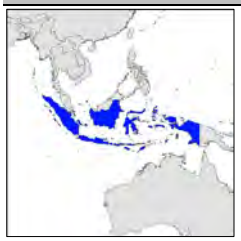


Figure 2: Samples tested by WRLFMD or reported in this quarter. ● indicates samples analysed; × indicates outbreaks reported/updated to the WOAH this quarter; □ indicates reports of FMD from other sources. Shape colours define the serotype detected ●O; ●A; ●C; ●Asia1, ●SAT1, ●SAT2, ●SAT3, ○ FMD not detected,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

The Republic of Indonesia



Nine **FMD type O** VP1 sequences were received from Pusvetma, Indonesia. They were obtained from samples collected from cattle in January 2023 (n=5) and cattle (n=3) and a goat in January 2024 from various locations in Jawa Timur (East Java) Province. Genotyping showed that they all to belong to O/ME-SA/Ind-2001e lineage (see below).

3.3. Pool 2 (South Asia)

No new outbreaks of FMD were reported in South Asia.

3.4. Pool 3 (West Eurasia and Near East)

Armenia

A spring vaccination campaign has been approved, but not yet started. The FMD vaccine will contain the following antigens: A/Iran05, A/G-VII, O/PanAsia2, Asia-1/Sindh 08 and SAT 2.

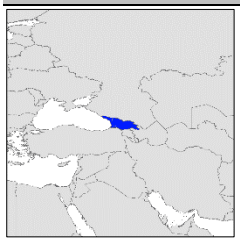
EuFMD FAST Report

The Republic of Azerbaijan

Almost 555,000 cattle and small ruminants were vaccinated in January and February 2024. Samples collected for sero-monitoring after the autumn vaccination campaign have been tested (results to be presented later).

EuFMD FAST Report

Georgia



12,000 large ruminants have been vaccinated during this quarter and a sero-surveillance campaign is being initiated.

EuFMD FAST Report

The Hashemite Kingdom of Jordan

In this quarter, over 260,000 sheep, goats and cattle have been vaccinated. A small scale sero-survey has been completed with only 11 out of 126 sheep and goats testing antibody positive.

EuFMD FAST Report

Türkiye

In this quarter, 44 new outbreaks were detected, 28 due to serotype SAT 2. To eradicate SAT 2, the vaccination strategy for large ruminants has been changed to three times a year, with emergency and pre-shipment vaccination continuing as before.

A Risk Based Surveillance Program has been initiated in the Thrace region for early detection of any outbreaks and to maintain confidence in absence of the disease, while clinical surveillance is occurring in the buffer zone along the Southeastern and Eastern borders of Anatolia.

EuFMD FAST Report

3.5. Pool 4 (North and Eastern Africa)

The People's Democratic Republic of Algeria

On 17 January 2024, a batch of 6 samples was received. They had been collected on 3 and 12 December 2023 from cattle in Sétif and Tizi Ouzou provinces. **FMD type SAT 2** was isolated from all samples and genotyping revealed that they all belonged to topotype V (see below).

Five **FMD type SAT 2** VP1 sequences were received from ANSES, France associated with the cases described above (see below).

A tender is ongoing for the purchase of SAT 2 vaccines, which are not currently included in current vaccination campaign in the country.

EuFMD FAST Report

The Arab Republic of Egypt

Two FMD serotype A and an untyped outbreak were reported this quarter. Clinical surveillance has been conducted, visiting over 12,000 households/farms and detecting one suspected FMD case. During this quarter, over 500,000 animals have been vaccinated.

EuFMD FAST Report

The State of Libya

An outbreak of **FMD type O** was confirmed on 16 January 2024. To date, 5807 cases, causing 1195 deaths, have been reported in cattle, goats and sheep from across the north of the country.

WOAH World Animal Health Information System (event ID: 5499)

During this quarter, 66 new outbreaks have been reported, with O/EA-3 being detected. A two-month FMD vaccination campaign is due to be launched in mid-July.

EuFMD FAST Report

The Republic of Kenya

On 10 January 2024, a batch of 20 samples was received as part of an on-going WOAH twinning project between Embakasi and the WRLFMD. Samples were collected from various locations across Kenya between January 2021 and October 2023 from cattle (n=19) and a pig. They were identified as **FMD type O** (n=8), **FMD type A** (n=2), **FMD SAT 1** (n=3), **FMD type SAT 2** (n=5) and four as **FMDV-GD** (genome detected) [with one animal being detected as positive for types O and SAT 1 and a second animal with types SAT 1 and SAT 2]. Genotyping characterised these viruses as belonging to the O/EA-2 topotype, the A/AFRICA/G-I genotype, the SAT 1/I(NWZ) topotype and the SAT 2/IV topotype.

The Republic of Tunisia

On 17 January 2024, a batch of 3 samples was received (via ANSES). They were collected on 12 March 2023 from cattle in Monastir, Nabeul and Tozeur Governates. All three samples were identified as **FMD type O**, and genotyping revealed that they were from the O/EA-3 topotype.

A further 180 cases of **FMD type O** affecting sheep, goats and cattle have been reported from Kassérine, Le Kef, Monastir, Sidi Bou Zid & Tozeur Governorates through January and February.

WOAH World Animal Health Information System (event ID: 5379)

New FMD outbreaks have been reported this quarter, with O/EA-3 being detected. A high rate of morbidity in large ruminants and clinical signs in small ruminants has been reported. Vaccination in Tunisia is with a trivalent FMD vaccine for large ruminants and bivalent FMD vaccine for small ruminants. In both cases the SAT 2 serotype is included.

EuFMD FAST Report

3.6. Pool 5 (West/Central Africa)

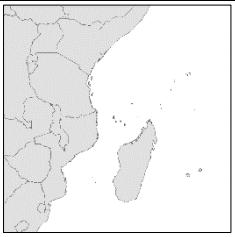
No new outbreaks of FMD were reported in West or Central Africa.

3.7. Pool 6 (Southern Africa)

The Republic of Botswana

On 12 November 2023, a batch of 4 samples was received, they were collected on 10 May 2022. One sample was identified as as **FMDV-GD** (genome detected), the other three samples were classified as **NGD** (No Genome Detected). No genotyping was attempted on the FMDV-GD sample.

The Union of the Comoros



Four new cases of **FMD type SAT 1** (3 in cattle, 1 in goat) were reported on 28 February 2024. These are the first cases reported since the initial report of SAT 1 in Comoros in May 2023.

WOAH World Animal Health Information System (event ID: 5036)

The Republic of Malawi

On 12 November 2023, a batch of 2 samples was received (from BVI). They were collected on 4 January 2022 from cattle in Lilongwe District. Both samples were identified as **FMD type O**, and genotyping revealed that they were from the O/EA-2 topotype.

The Republic of Mozambique

On 12 November 2023, a sample was received (from BVI). It was collected on 27 August 2022 from a bovine in Maputo Province. It was identified as **FMD type SAT 2**, and genotyping revealed that it was from the SAT 2/II topotype.

The Republic of Namibia

On 12 November 2023, a batch of 2 samples was received (from BVI). They were collected on 13 October 2022 from cattle in Zibungo. Both samples were identified as FMD type SAT 2, and genotyping revealed that they were from the SAT 2/III topotype.

The Republic of South Africa

A new outbreak of **FMD type SAT 1** from City of Mbombela, Mpumalanga Province was reported on 12 January 2024. While the outbreak has affected 132 cattle, no deaths have been reported.

On 25 March 2024, 59 new cases of **FMD type SAT 3** were reported vias WAHIS from the province of Gauteng. While 14 new cases of **FMD type SAT 3** were reported from North West Province in February and March.

No new cases have been reported from the on-going FMD SAT 2 outbreak this quarter.

An outbreak of **FMD** affecting 4 cattle was reported on 23 February 2024. The serotype causing this has yet to be determined.

WOAH World Animal Health Information System (event IDs: 3738, 4368, 5487 & 5567)

The Republic of Zimbabwe

On 12 November 2023, a sample was received (from BVI). It was collected on 7 August 2022 from a bovine in Maputo Province. It was identified as **FMD type SAT 2**, and genotyping revealed that it was from the SAT 2/III topotype.

Cases of **FMD** were reported from dip tank locations in Manicaland (31 cases) and Mashonaland East (24 cases) on 24 March 2024. The serotype causing this has yet to be determined.

WOAH World Animal Health Information System (event ID: 5593)

3.8. Pool 7 (South America)

No new outbreaks of FMD were reported in South America.

3.9. Extent of global surveillance

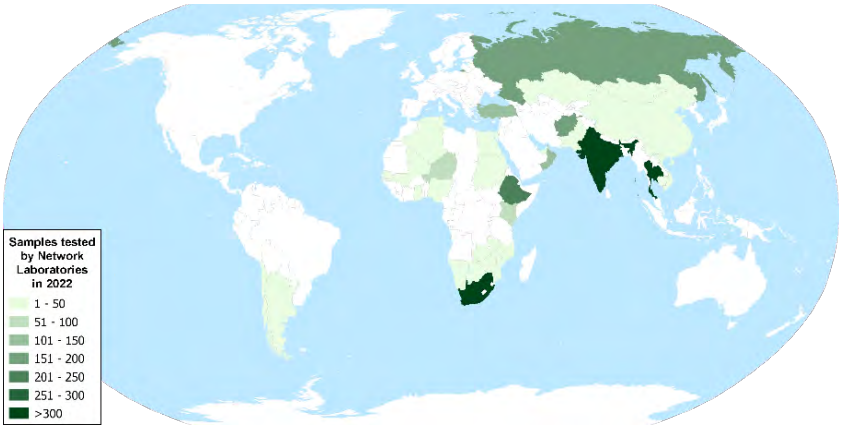


Figure 3: Samples received during 2022 from FMD outbreaks (routine surveillance that is undertaken in countries that are FMD-free without vaccination is not shown). Data from presentations given at the WOAH/FAO FMD reference laboratory network annual meeting (https://www.foot-and-mouth.org/Ref-Lab-Network/Network-Annual-Meeting).
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: Proposed changes to the conjectured relative prevalence of circulating FMD viral lineages in each Pool.

Lineage	Southeast/ Central / East Asia [Pool 1]	South Asia [Pool 2]	West Eurasia & Near 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			**30**					
O ME-SA PanAsia	10							
O SEA Mya-98	**21.5**							
O ME-SA Ind2001	**40**	**76**[1]	**5.5**[1]	**0**				
O EA or O WA			**1.5**	**60**	**53.5**	**69**	16	
O EURO-SA								**90**
O CATHAY	10.5							
A ASIA Sea-97	**18**							
A ASIA Iran-05	0		**28**					
A ASIA G-VII		**20**	**5**					
A AFRICA				**30**	**17**	**15**		
A EURO-SA								**10**
Asia1	**0**	4	**10**					
SAT 1			**1**	0	**15**	**1**	**16**	
SAT 2			**19**	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 Pools 2 and 3.

Note: 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 October 2023) 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**. NB: In response to the FMD cases due to SAT2/XIV, risks in Pool 3 were reviewed and revised in April 2023.

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-2024.

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 - March 2024 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 - March 2024.

WRLFMD Batch No.	Date received	Country	Total No. samples	Serotype	No. of samples	No. of sequences	Sequencing status
WRLFMD/2023/000105	12/11/2023	Botswana	4	FMDV-GD	1	0	Finished
				NVD	3	0	Finished
WRLFMD/2023/000106	12/11/2023	Malawi	2	O	2	2	Finished
WRLFMD/2023/000107	12/11/2023	Mozambique	1	SAT 2	1	1	Finished Finished
WRLFMD/2023/000108	12/11/2023	Namibia	2	SAT 2	2	2	Finished
WRLFMD/2023/000109	12/11/2023	Zimbabwe	1	SAT 2	1	1	Finished
WRLFMD/2024/000001	10/01/2024	Kenya	20	A	2	2	Finished
				O	8	8	
				SAT 1	3	3	
				SAT 2	5	5	
				FMDV-GD	4	0	
WRLFMD/2024/000002	17/01/2024	Algeria	6	SAT 2	6	6	Finished
WRLFMD/2024/000003	17/01/2024	Tunisia	3	O	3	3	Finished
Totals			**39**		**41**	**33**	

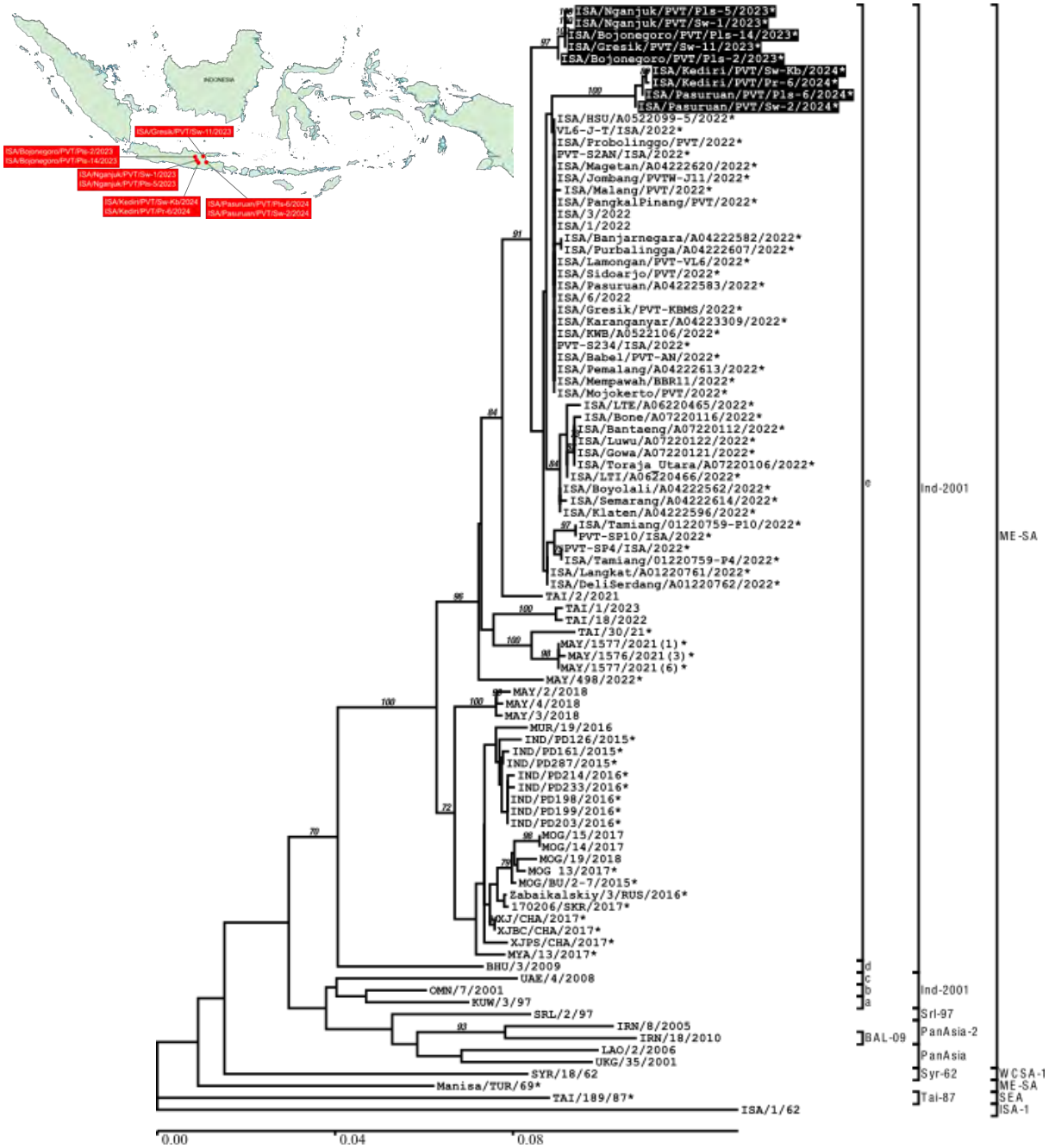
Table 3: VP1 sequences submitted by other FMD laboratories to the WRLFMD from January - March 2024.

WRLFMD Batch No.	Date received	Country	Serotype	Date Collected	No. of sequences	Submitting laboratory
WRLMEG/2024/000001	8/1/24	Algeria	SAT 2	2023	5	ANSES
WRLMEG/2024/000003	11/3/24	Indonesia	O	2023	9	Pusvetma
				Total	**14**	

4. Detailed analysis

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

The Republic of Indonesia	
Batch:	WRLMEG/2024/000003
Sequences Provided By:	Pusvetma, Indonesia
Date Received:	11/3/24
Number Of Sequences:	9
O (O/Me-SA/Ind-2001e):	9



4.2. Pool 2 (South Asia)

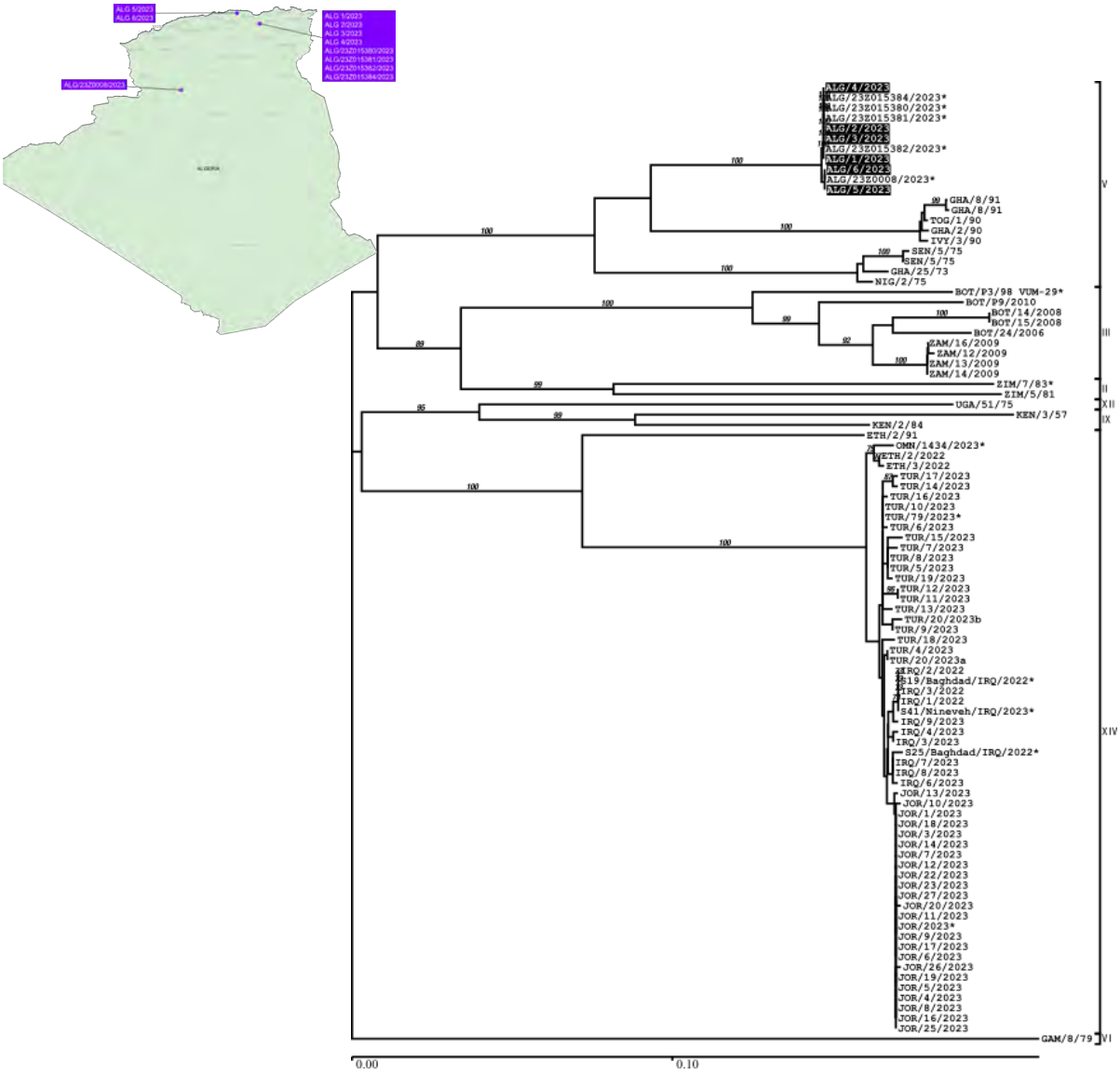
No samples/sequences received.

4.3. Pool 3 (West Eurasia and Near East)

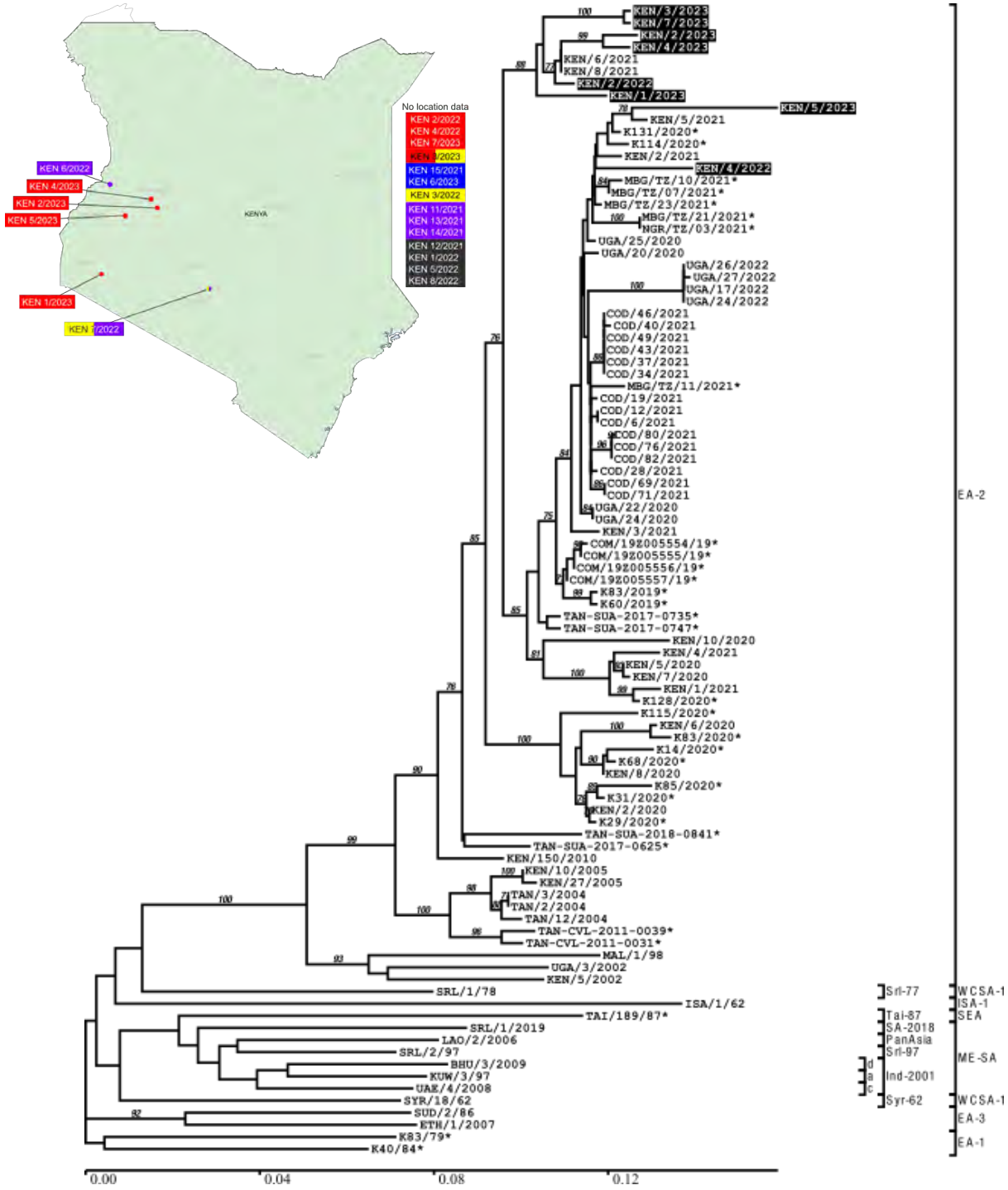
No samples/sequences received.

4.4. Pool 4 (North and East Africa)

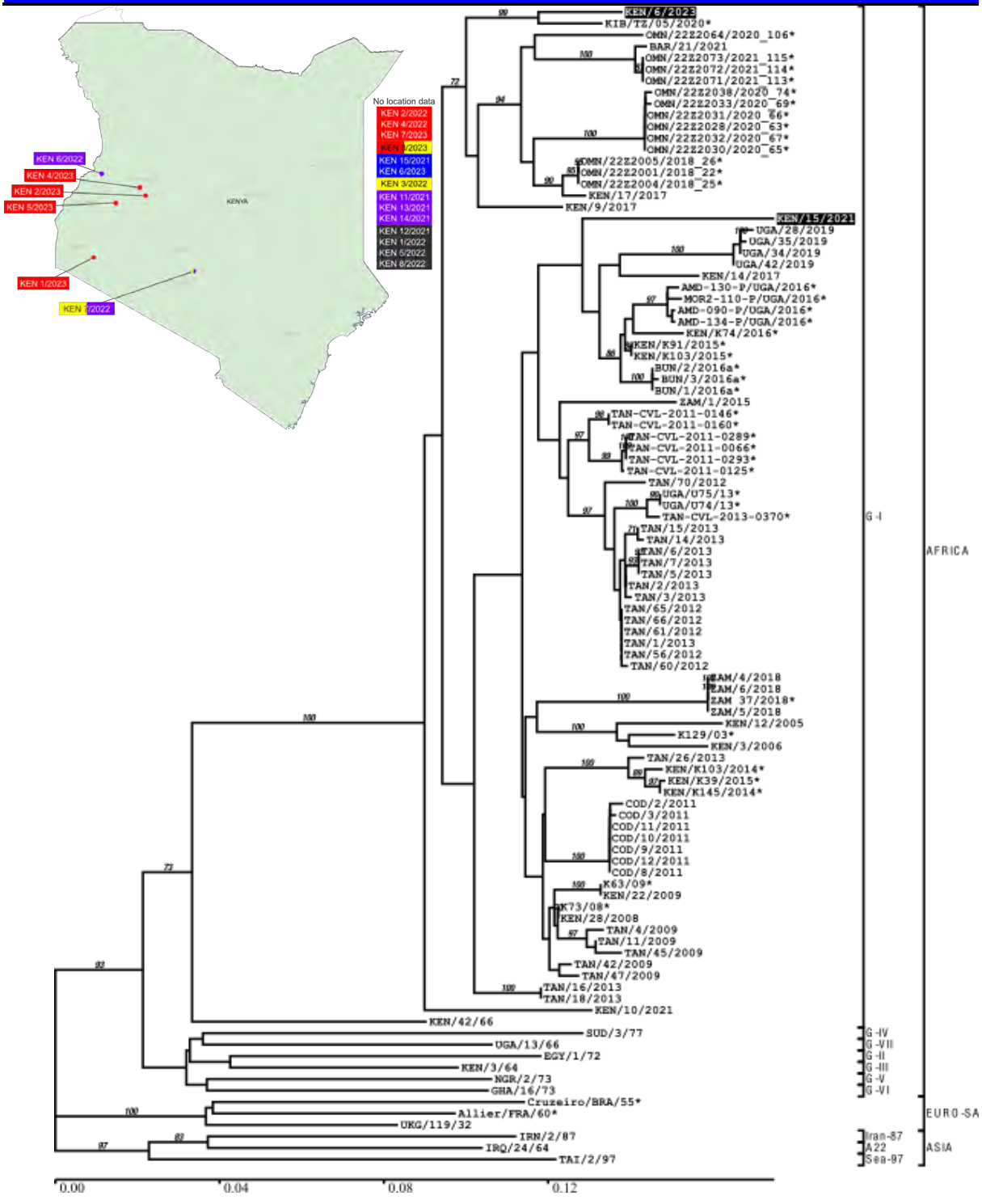
The People's Democratic Republic of Algeria	
Batch:	WRLFMD/2024/000002
Samples/sequences provided by:	ANSES
Date Received:	17 January 2024
Number Of Samples:	6
SAT 2 (SAT 2/V)	6



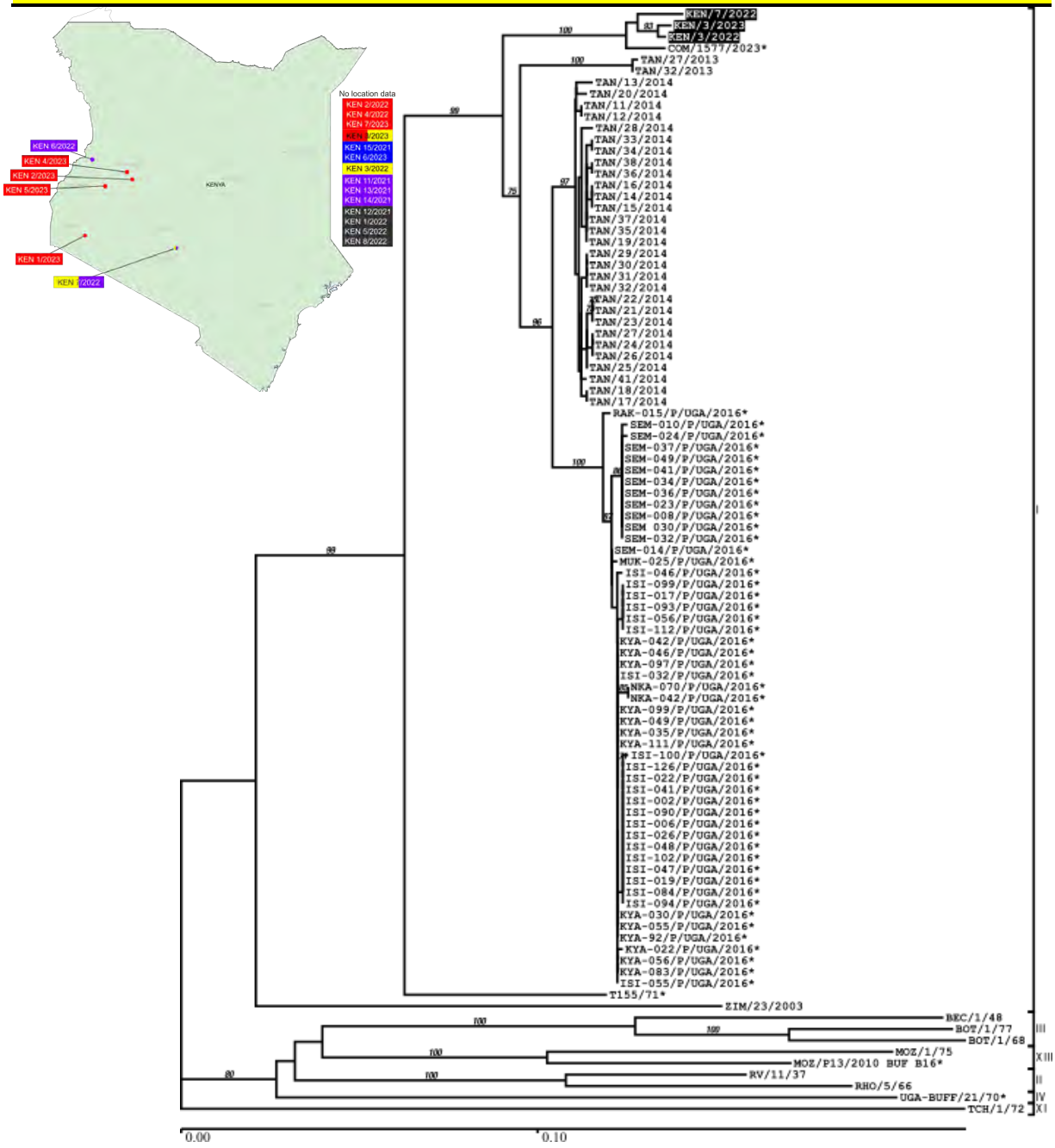
The Republic of Kenya	
Batch:	WRLFMD/2024/000001
Samples Provided by:	FMD Laboratory Embakasi
Date Received:	10 January 2024
Number Of Samples:	20
O (O/EA-2)	8



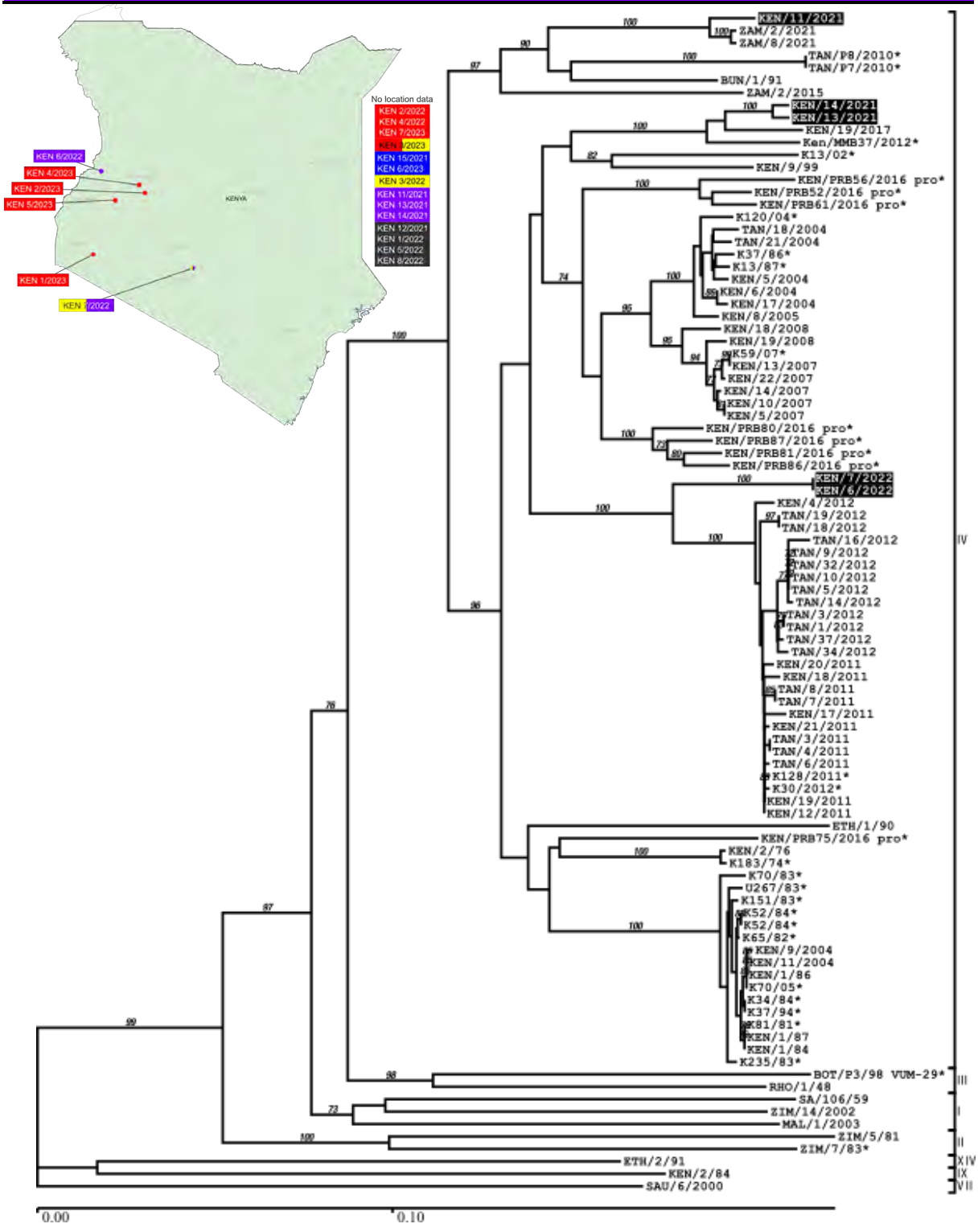
The Republic of Kenya	
Batch:	WRLFMD/2024/000001
Samples Provided by:	FMD Laboratory Embakasi
Date Received:	10 January 2024
Number Of Samples:	20
A (A/Africa/G-I)	2



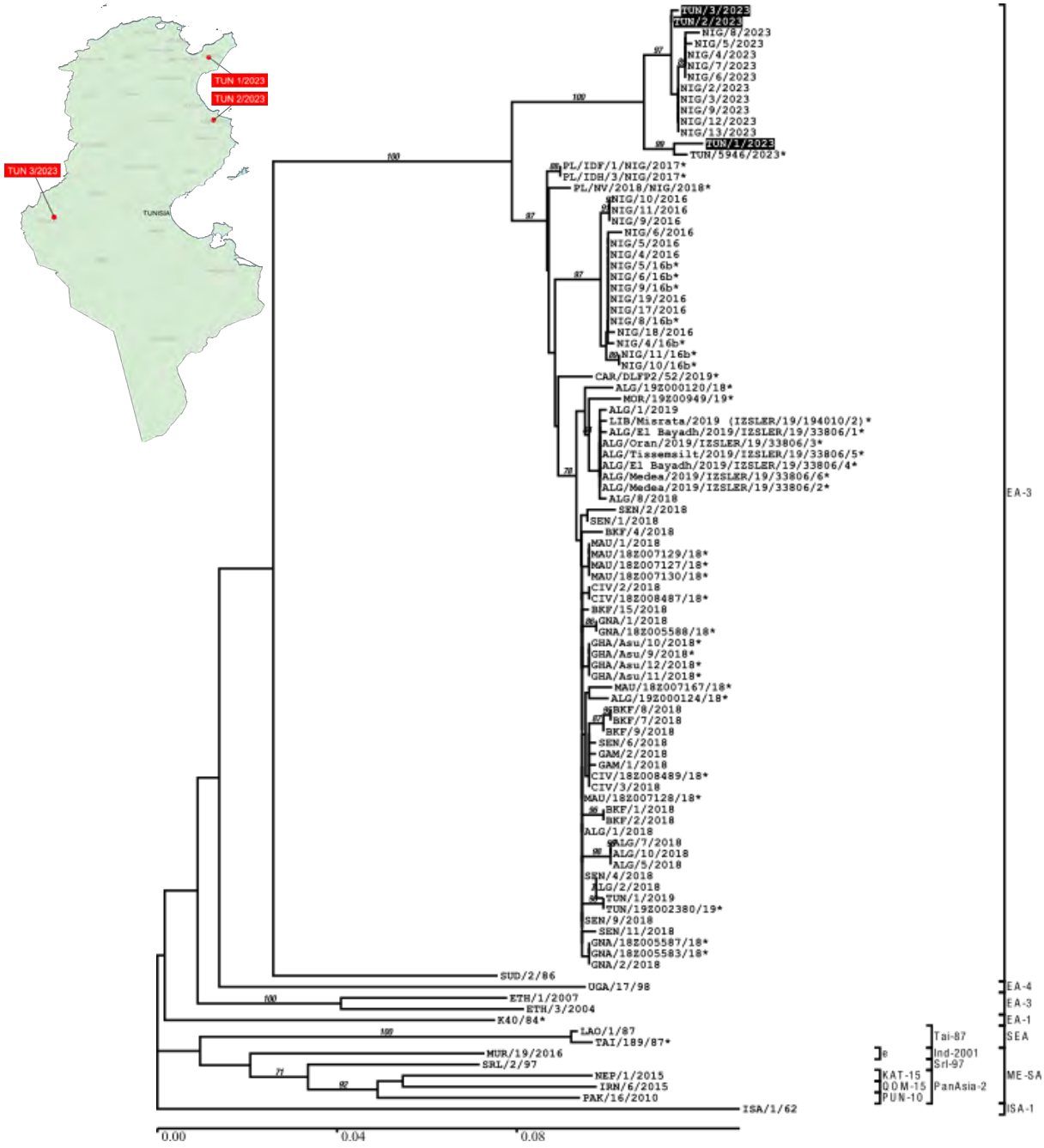
The Republic of Kenya	
Batch:	WRLFMD/2024/000001
Samples Provided by:	FMD Laboratory Embakasi
Date Received:	10 January 2024
Number Of Samples:	20
SAT 1 (SAT 1/I)	3



The Republic of Kenya	
Batch:	WRLFMD/2024/000001
Samples Provided by:	FMD Laboratory Embakasi
Date Received:	10 January 2024
Number Of Samples:	20
SAT 2 (SAT 2/IV)	5



The Republic of Tunisia	
Batch:	WRLFMD/2024/000003
Samples Provided by:	ANSES
Date Received:	17 January 2024
Number Of Samples:	3
O (O/EA-3)	3

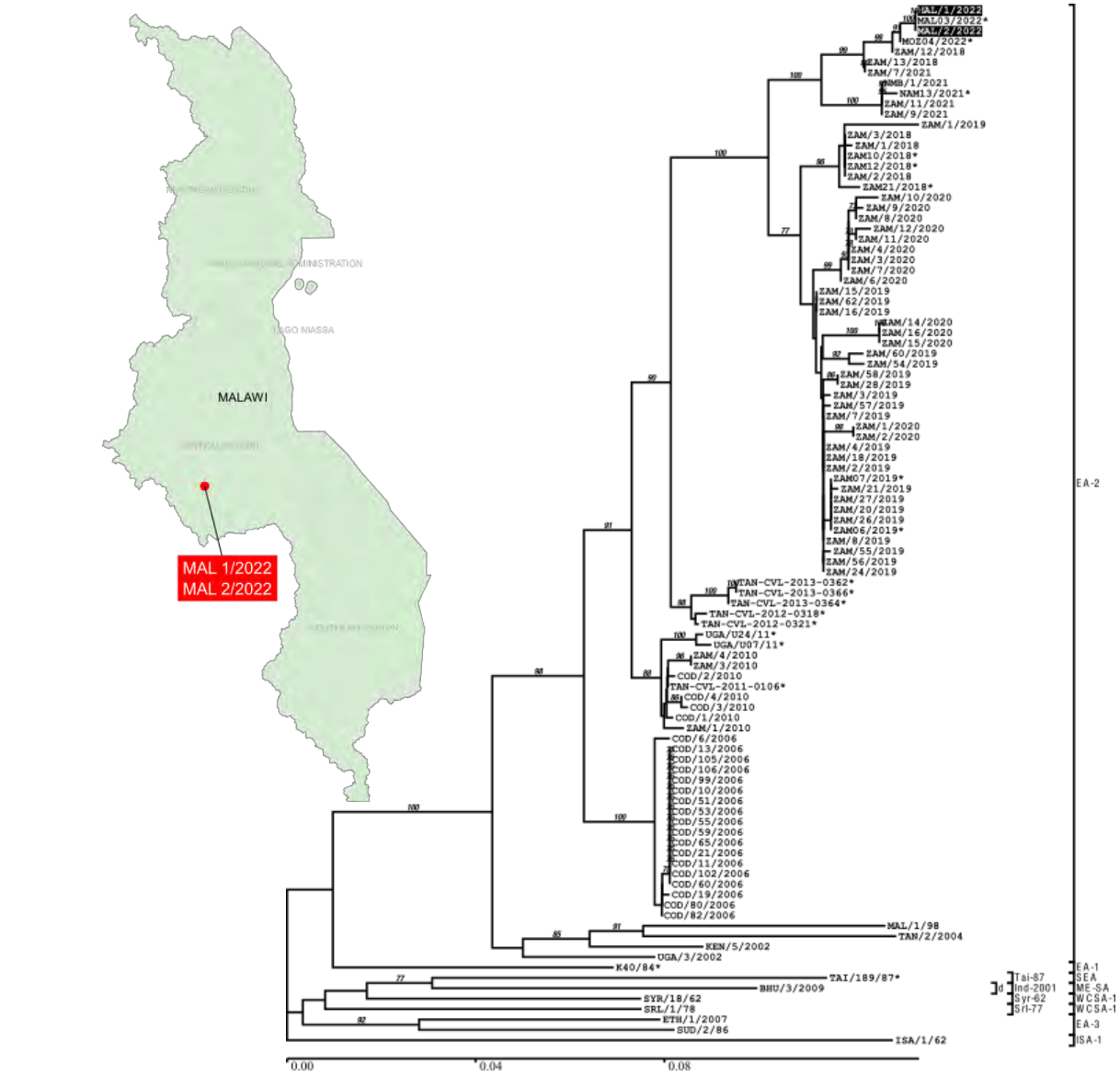


4.5. Pool 5 (West/Central Africa)

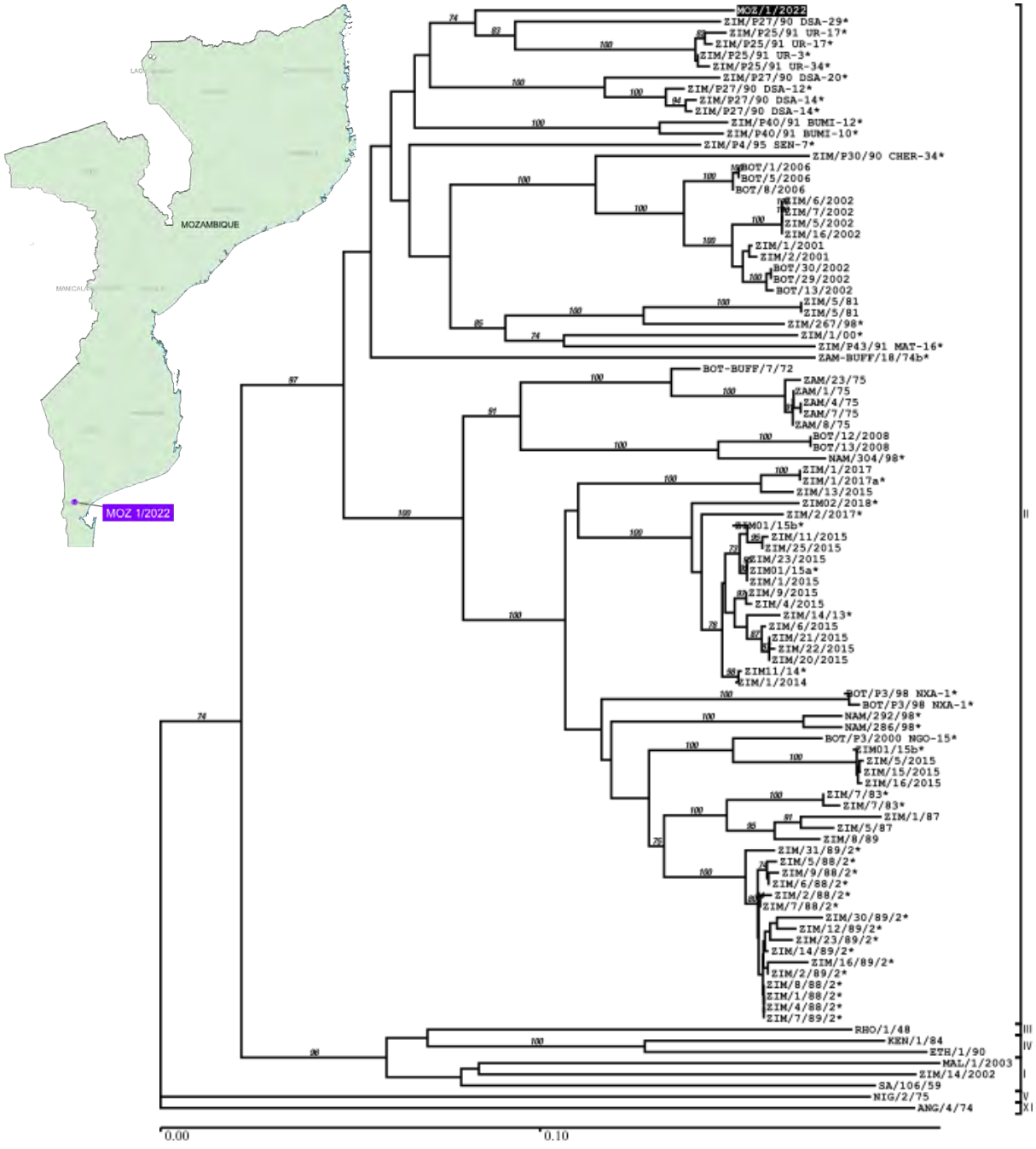
No samples/sequences received.

4.6. Pool 6 (Southern Africa)

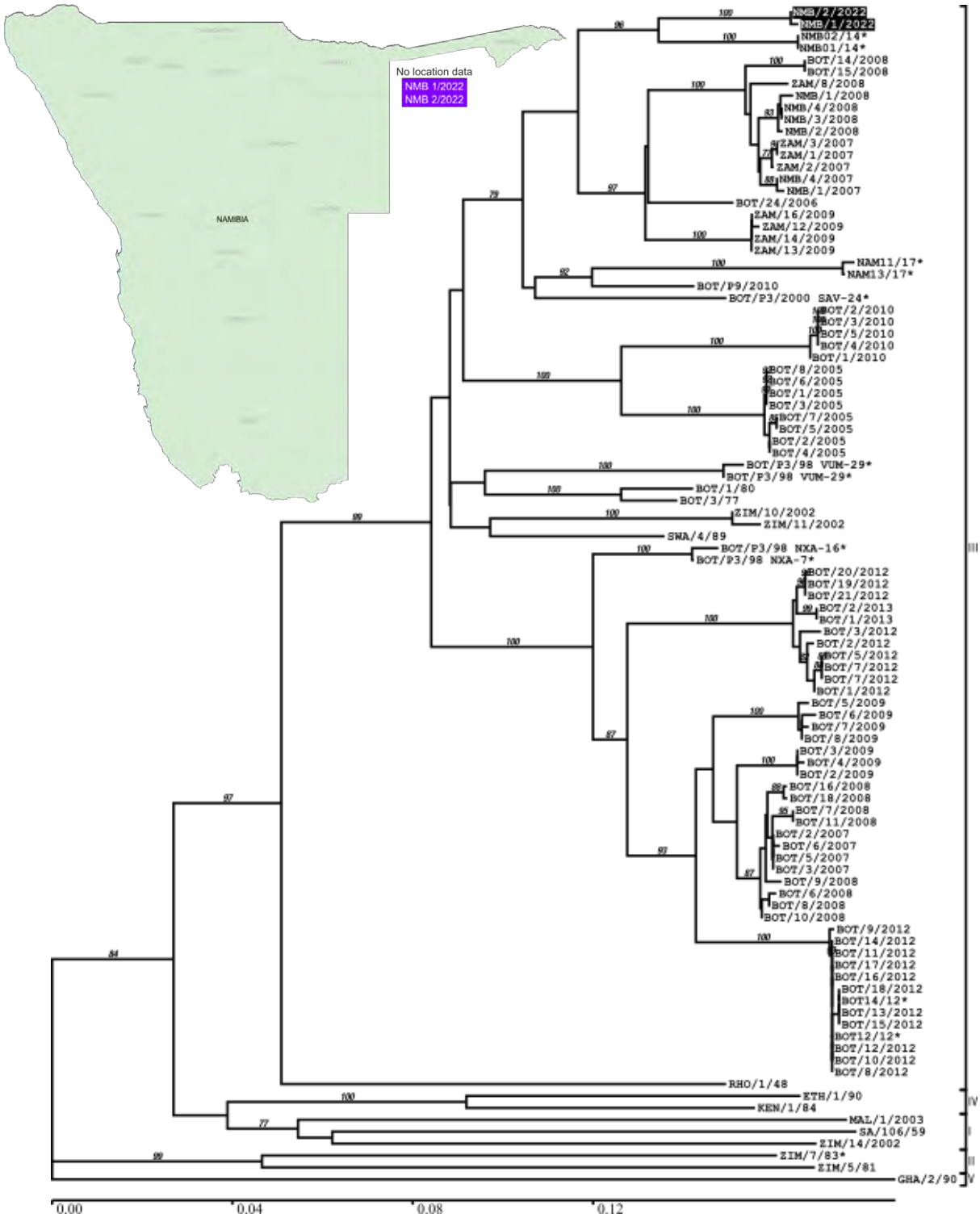
The Republic of Malawi	
Batch:	WRLFMD/2023/000106
Sequences Provided By:	BVI
Date Received:	12 November 2023
Number Of Sequences:	2
O (O/EA-2)	2



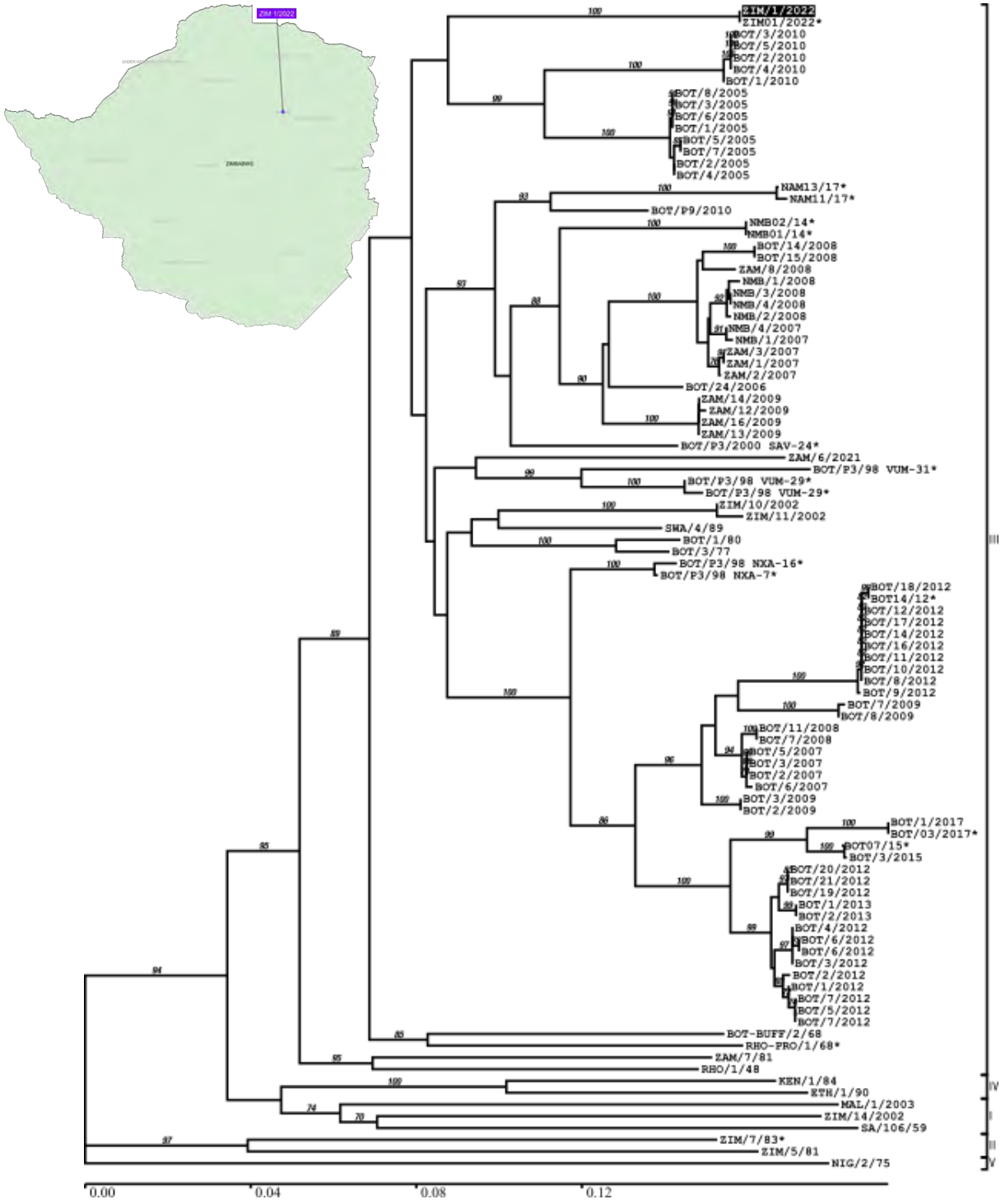
The Republic of Mozambique	
Batch:	WRLFMD/2023/000107
Sequences Provided By:	BVI
Date Received:	12 November 2023
Number Of Sequences:	1
SAT 2 (SAT 2/II)	1



The Republic of Namibia	
Batch:	WRLFMD/2023/000108
Sequences Provided By:	BVI
Date Received:	12 November 2023
Number Of Sequences:	2
SAT 2 (SAT 2/III)	2



The Republic of Zimbabwe	
Batch:	WRLFMD/2023/000109
Sequences Provided By:	BVI
Date Received:	12 November 2023
Number Of Sequences:	1
SAT 2 (SAT 2/III)	1



4.7. Pool 7 (South America)

No samples/sequences received.

4.8. Vaccine matching

Antigenic characterisation of FMD field isolates by matching with vaccine strains by 2dmVNT from January - March 2024.

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
Mozambique	-	-	-	-	-	1	-
Tunisia	3	-	-	-	-	-	-
Zimbabwe	-	-	-	-	-	1	-
Total	**3**	**0**	**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*
O/TUN/1/2023	EA-3	-	0.90	*1.86*	0.47	*2.11*	0.98	*2.76*	0.93	*2.22*	0.42	*2.11*	0.62	*2.24*
O/TUN/2/2023	EA-3	-	0.63	*1.71*	0.32	*1.93*	0.66	*2.59*	0.45	*1.91*	0.31	*1.98*	0.39	*2.03*
O/TUN/3/2023	EA-3	-	0.77	*1.79*	0.32	*1.93*	0.78	*2.66*	0.54	*1.98*	0.32	*1.99*	0.46	*2.11*

Table 6: 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*
SAT2/ MOZ 1/2022	II	-	0.50	*1.70*	0.21	*1.97*
SAT2/ ZIM 1/2022	III	-	0.36	*1.56*	0.19	*1.93*

Annex 1: Sample data

Summary of submissions

Table 7: Summary of samples collected and received to WRLFMD January - March 2024

Country	Nº of samples	Virus isolation in cell culture/ELISA								RT-PCR for FMD	
		FMD virus serotypes							No Virus Isolated		
		O	*A*	*C*	*SAT 1*	*SAT 2*	*SAT 3*	*ASIA1*		*Positive*	*Negative*
Algeria	6	-	-	-	-	6	-	-	-	6	-
Botswana	4	-	-	-	-	-	-	-	4	1	3
Kenya	20	8	2	-	3	5	-	-	4	20	-
Malawi	2	2	-	-	-	-	-	-	-	2	-
Mozambique	1	-	-	-	-	1	-	-	-	1	-
Namibia	2	-	-	-	-	2	-	-	-	2	-
Tunisa	3	3	-	-	-	-	-	-	-	3	-
Zimbabwe	1	-	-	-	-	1	-	-	-	1	-
TOTAL	**39**	**13**	**2**	**0**	**3**	**15**	**0**	**0**	**8**	**36**	**3**

Clinical samples

Table 8: Clinical sample diagnostics made by the WRLFMD January - March 2024

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
Botswana	11 Dec 2023	13 Feb 2024	BOT 2/2022	N/A	05 Oct 2022	NVD	FMDV GD	FMDV GD
			BOT 3/2022	N/A	05 Oct 2022	NVD	FMDV NGD	NVD
			BOT 4/2022	N/A	05 Oct 2022	NVD	FMDV NGD	NVD
			BOT 5/2022	N/A	05 Oct 2022	NVD	FMDV NGD	NVD
Malawi	11 Dec 2023	13 Feb 2024	MAL 1/2022	CATTLE	01 Apr 2022	O	FMDV GD	O
			MAL 2/2022	CATTLE	01 Apr 2022	O	FMDV GD	O
Mozambique	11 Dec 2023	13 Feb 2024	MOZ 1/2022	CATTLE	27 Aug 2022	SAT2	FMDV GD	SAT2
Namibia	11 Dec 2023	13 Feb 2024	NMB 1/2022	CATTLE	13 Oct 2022	SAT2	FMDV GD	SAT2
			NMB 2/2022	CATTLE	13 Oct 2022	SAT2	FMDV GD	SAT2
Zimbabwe	11 Dec 2023	13 Feb 2024	ZIM 1/2022	CATTLE	08 Jul 2022	SAT2	FMDV GD	SAT2
Kenya	10 Jan 2024	20 Feb 2024	KEN 11/2021	CATTLE	01 Jul 2021	SAT2	FMDV GD	SAT2
			KEN 12/2021	CATTLE	23 Jul 2021	NVD	FMDV GD	FMDV GD

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
			KEN 13/2021	CATTLE	12 Aug 2021	SAT2	FMDV GD	SAT2
			KEN 14/2021	CATTLE	30 Aug 2021	SAT2	FMDV GD	SAT2
			KEN 15/2021	CATTLE	10 Nov 2021	A	FMDV GD	A
			KEN 1/2022	CATTLE	15 Feb 2022	NVD	FMDV GD	FMDV GD
			KEN 2/2022	CATTLE	29 Mar 2022	O	FMDV GD	O
			KEN 3/2022	CATTLE	20 Jun 2022	SAT1	FMDV GD	SAT1
			KEN 4/2022	CATTLE	25 Jul 2022	O	FMDV GD	O
			KEN 5/2022	CATTLE	24 Aug 2022	NVD	FMDV GD	FMDV GD
			KEN 6/2022	CATTLE	15 Sep 2022	SAT 2	FMDV GD	SAT 2
			KEN 7/2022	PIG	11 Oct 2022	SAT1 & SAT2	FMDV GD	SAT1 & SAT2
			KEN 8/2022	CATTLE	26 Oct 2022	NVD	FMDV GD	FMDV GD
			KEN 1/2023	CATTLE	10 Jan 2023	O	FMDV GD	O
			KEN 2/2023	CATTLE	01 Feb 2023	O	FMDV GD	O
			KEN 3/2023	CATTLE	06 Feb 2023	SAT1 & O	FMDV GD	SAT1 & O
			KEN 4/2023	CATTLE	07 Feb 2023	O	FMDV GD	O
			KEN 5/2023	CATTLE	30 Jun 2023	O	FMDV GD	O
			KEN 6/2023	CATTLE	26 Jul 2023	A	FMDV GD	A
			KEN 7/2023	CATTLE	28 Jul 2023	O	FMDV GD	O
Algeria	17 Jan 2024	16 Feb 2024	ALG 1/2023	CATTLE	03 Dec 2023	SAT2	FMDV GD	SAT2
			ALG 2/2023	CATTLE	03 Dec 2023	SAT2	FMDV GD	SAT2
			ALG 3/2023	CATTLE	03 Dec 2023	SAT2	FMDV GD	SAT2
			ALG 4/2023	CATTLE	03 Dec 2023	SAT2	FMDV GD	SAT2
			ALG 5/2023	CATTLE	12 Dec 2023	SAT2	FMDV GD	SAT2
			ALG 6/2023	CATTLE	12 Dec 2023	SAT2	FMDV GD	SAT2
Tunisia	17 Jan 2024	04 Mar 2024	TUN 1/2023	CATTLE	03 Dec 2023	O	FMDV GD	O
			TUN 2/2023	CATTLE	03 Dec 2023	O	FMDV GD	O
			TUN 3/2023	CATTLE	03 Dec 2023	O	FMDV GD	O
TOTAL					**39**			

Annex 2: FMD publications

Recent FMD Publications January - March 2024 cited by Web of Science.

1. Abd-Ellatieff, H.A., A.A. Hegazy, A.R.A. AbouRawash, H.G. Tohamy, M. Al-Shehri, E.K. Bazh, H. Hassan, and B.H. Essa (2023). Pathological and genetic characterization of foot-and-mouth disease viruses collected from cattle and water buffalo in Egypt. *PLoS One*, **18**(10): 19. DOI: 10.1371/journal.pone.0291970.
2. Al-Rawahi, W.A., E.I. Elshafie, S. Baqir, A. Al-Ansari, J. Wadsworth, H.M. Hicks, N.J. Knowles, A. Di Nardo, D.P. King, S. Zientara, F. Al Salloom, A. Sangula, C. Bernelin-Cottet, L. Bakkali-Kassimi, and B. Al Riyami (2024). Detection of foot-and-mouth disease viruses from the A/AFRICA/G-I genotype in the Sultanate of Oman. *Preventive Veterinary Medicine*, **223**: 8. DOI: 10.1016/j.prevetmed.2023.106113.
3. Banda, F., A.B. Ludi, G. Wilsden, C. Browning, H.L. Kangwa, L. Mooya, M. Ngoma, G.M. Muuka, C. Mundia, P. Fandamu, D.J. Paton, D.P. King, and M.L.Y. Quan (2023). The immunogenicity of a *Foot-and-mouth disease virus* serotype O vaccine in commercial and subsistence cattle herds in Zambia. *Vaccines*, **11**(12): 8. DOI: 10.3390/vaccines11121818.
4. Chen, C., N. Zhang, M.L. Li, A.L. Guo, Y.F. Zheng, F. Humak, P. Qian, and P. Tao (2024). Recombinant bacteriophage T4 displaying key epitopes of the *Foot-and-mouth disease virus* as a novel nanoparticle vaccine. *International Journal of Biological Macromolecules*, **258**: 7. DOI: 10.1016/j.ijbiomac.2023.128837.
5. Costa, M., F. Mansilla, J.M. Sala, A. Saravia, D. Ubios, P. Lores, A.V. Capozzo, and T. Freire (2024). *Fasciola hepatica* infection modifies IgG1 specific immune response to *Foot-and-mouth disease virus* induced by vaccination. *Vaccine*, **42**(3): 541-547. DOI: 10.1016/j.vaccine.2023.12.067.
6. Das, S., S. Pal, S.S. Rautaray, J.K. Mohapatra, S. Subramaniam, M. Rout, S.N. Rai, and R.P. Singh (2023). Estimation of *Foot-and-mouth disease virus* sero-prevalence rates using novel computational approach for the susceptible bovine population in India during the period 2008-2021. *Scientific Reports*, **13**(1): 17. DOI: 10.1038/s41598-023-48459-w.
7. Das, S., S. Pal, S. Mahapatra, J.K. Biswal, S.K. Pradhan, A.P. Sahoo, and R.P. Singh (2024). FMDVSerPred: A novel computational solution for *Foot-and-mouth disease virus* classification and serotype prediction prevalent in Asia using VP1 nucleotide sequence data. *Current Bioinformatics*: 15. DOI: 10.2174/0115748936278851231213110653.
8. Dhakal, S.P., K. Pandey, M. Upadhyaya, S. Karki, N. Ramdam, S. Vandyk, and S. Premashthira (2023). Spatiotemporal distribution of foot-and-mouth disease in Nepal between 2019 and 2021. *Animal Diseases*, **3**(1): 10. DOI: 10.1186/s44149-023-00104-9.
9. El-Ansary, R.E., S. Kasem, M.A.M. El-Tabakh, Y. Badr, and A.S. Abdel-Moneim (2023). Isolation, molecular characterization, and genetic diversity of recently isolated *Foot-and-mouth disease virus* serotype A in Egypt. *PLOS One*, **18**(12): 13. DOI: 10.1371/journal.pone.0295319.
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12. Gadir, M., S.M. Azimi, N. Harzandi, B. Hemati, and N. Eskandarzade (2023). Whole-genome sequencing of *Foot-and-mouth disease virus* serotype O/PanAsia-2/QOM-15 and comparison of its VP1-encoding region with two vaccine strains. *Veterinary Research Forum*, **14**(11): 615-623. DOI: 10.30466/vrf.2023.1978294.3704.
13. Ghorbani, A., A.A. Sadeghi, P. Shawrang, M. Chamani, and F. Foroudi (2023). The effect of different sources of unsaturated fatty acids on the expression of IL-1β and TNFα genes and blood factors in Sangesari lambs vaccinated against foot-and-mouth disease. *Russian Journal of Genetics*, **59**(SUPPL 2): S145-S153. DOI: 10.1134/s1022795423140041.
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15. Han, D., B. Ahn, and K.D. Min (2024). Exploring preventive factors against insufficient antibody positivity rate for foot-and-mouth disease in pig farms in South Korea: a preliminary ecological study. *Journal of Veterinary Science*, **25**(1): 9. DOI: 10.4142/jvs.23185.
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28. Kim, Y., E. Pool, E. Kim, C.S. Dampalla, H.N. Nguyen, D.K. Johnson, S. Lovell, W.C. Groutas, and K.O. Chang (2024). Potent small molecule inhibitors against the 3C protease of *Foot-and-mouth disease virus*. *Microbiology Spectrum*: 15. DOI: 10.1128/spectrum.03372-23.

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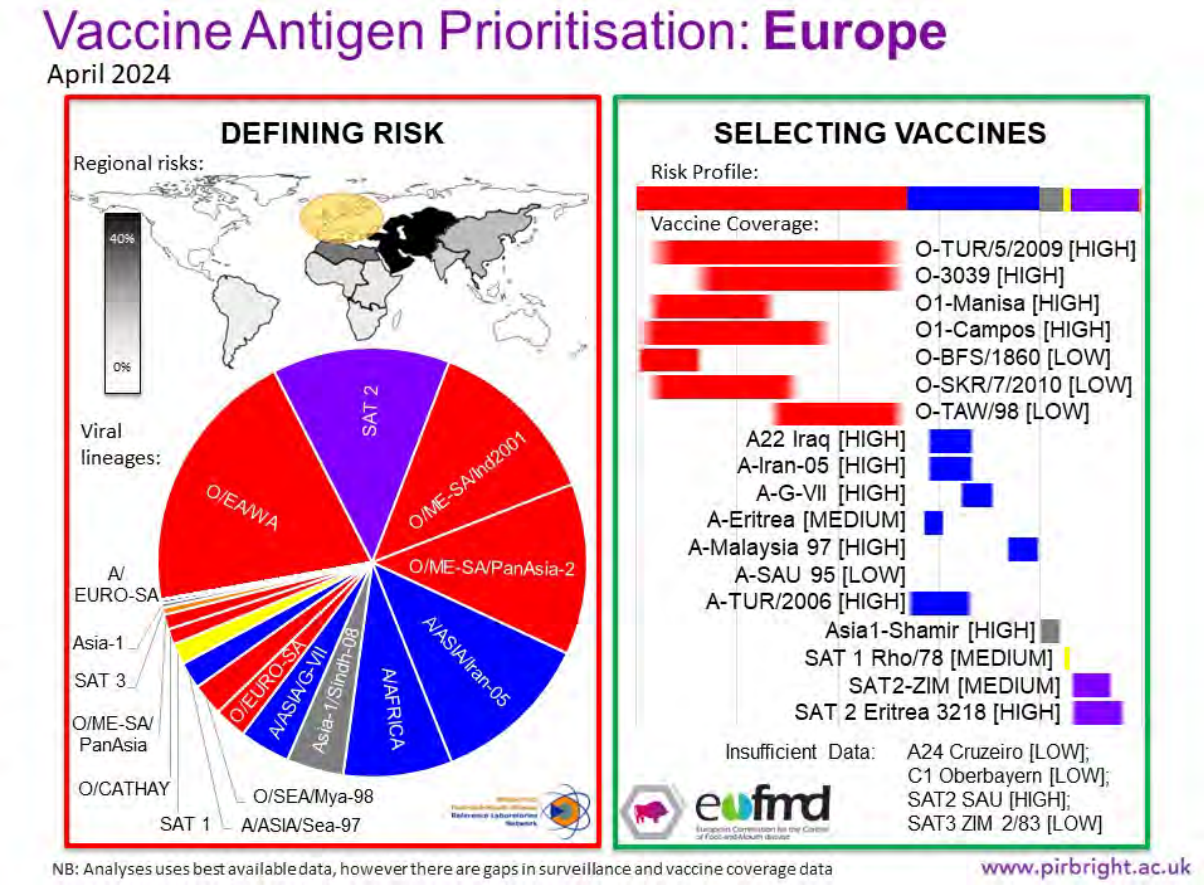
Annex 3: Vaccine recommendations

This report provides recommendations of FMDV vaccines to be included in antigen banks. These outputs are generated with a 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



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 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 WRLFMD will host a two-week practical training course in FMD Diagnostic methods (https://www.pirbright.ac.uk/instructor-led-training/diagnosis-foot-and-mouth-disease) during May 2024.
- A second practical course will be offered at Pirbright during May 2024 to cover FMD post-vaccination monitoring through VNT and ELISA (https://www.pirbright.ac.uk/instructor-led-training/fmd-post-vaccination-monitoring-through-vnt-and-elisa).
- 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.
- **Risk mapping for early detection and control of foot-and-mouth and other similar transboundary animal diseases and Statement of Intention/Early Warning Surveillance workshops** from 23 to 24 April 2024 in Tiblisi, Georgia.
- **Virtual Real-Time Training (vRTT) Australia** from 29 April to 10 June 2024, online.

- **Passive surveillance for FAST diseases** from 10 to 28 June 2024, online.
- **RTC4 - Real-Time training** from 8 to 11 July 2024 in Nakuru, Kenya
- **Progressive Control Pathway for foot-and-mouth disease (PCP-FMD) workshop** from 12 to 13 July 2024 in Naivasha, Kenya

Podcasts

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

- 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** – 15 May 2024
- **104th Executive Committee of the EuFMD** - 26 September 2024
- **Open Session of the Standing Technical Committee of the EuFMD - OS24 in Madrid, Spain** - 29 to 31 October 2024
- **105th Executive Committee of the EuFMD** - 12 March 2025
- **46th General Session of the EuFMD** - 6 to 7 May 2025

Proficiency test scheme organised by WRLFMD

Results for the FMD PTS (Phase XXXV, supported with funding from EuFMD and UK Defra) are currently being analysed. Participating laboratories should have received feedback letters and we hope to circulate a final report for this scheme in the next Quarter. Any laboratories interested in participating in future exercises should contract the WRLFMD for further information. The progress of this PTS will be described in future quarterly reports.

FAO four betters. Better life, better environment, better nutrition, better production.

EuFMD's programme, tools and initiatives

FAST
Foot-and-mouth And Similar Transboundary animal diseases

Dt
EuFMD digital transformation

Tom
EuFMD training management system

Microlearning
EuFMD micro learning

Vlearning
EuFMD virtual learning

SimExOn
Simulation exercises online

Get prepared
Emergency preparedness toolbox

Risk Comms
EuFMD risk communications

RMT-FAST
Risk monitoring tool for foot-and-mouth and similar transboundary animal diseases

Pragmatist
Prioritization of antigen management with international surveillance tool

EuFMDiS
European foot-and-mouth disease spread model

Vademos
FMD vaccine demand estimation model

GVS
Global vaccine security

PQv
Vaccine prequalification

PCP
Progressive control pathway

PSO
Pcp practitioner officers

PPP
Public private partnership

PROTECT
RESPOND
CONTROL

MOVE FAST

FAST, Foot-and-mouth
And Similar Transboundary
animal diseases.

EuFMD structure

Secretariat, Executive Committee, Standing Technical Committee (STC), Special Committee on Risk Monitoring, Integrated Surveillance and Applied Research (SCRISAR), Special Committee on Biorisk Management (SCBRM), Regional Groups for FAST Coordination, Standing Committee on Prequalification of Vaccines against FAST diseases (SCPQv), Steering Committee TOM (SCTOM).

EuFMD Secretariat

Animal Production and Health Division, (NSA) / European Commission for the Control of Foot-and-Mouth Disease (EuFMD)

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