

Foot-and-Mouth Disease

October-December 2021 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 2

The collection date of Cambodian sequences analysed by the WRLFMD (in section 3.2 on page 7) has been corrected from January 2021 to January 2019.

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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).

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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	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 edition of the FMD quarterly report which aims to summarise key global epidemiological events relating to FMD, as well as collate the laboratory testing work that has been undertaken by the WRLFMD at Pirbright. During this reporting period, the WRLFMD has reported results for samples collected from Iran, Kenya, Mongolia, Nepal, Nigeria and Uganda. Sequence data has also been shared for phylogenetic analyses from Cambodia (via APQA, South Korea), Jordan (via Jordan University of Science and Technology), Nigeria (via NCFAD-CFIA, Canada and NVRI, Nigeria) and Palestine (via KVI, Israel and the Palestinian Veterinary Authorities). Further details of these laboratory results can be retrieved from our website (<http://www.wrlfmd.org/>).

During December 2021, there has been particular focus on FMD outbreaks occurring in the Eastern Mediterranean where FMD cases in Jordan and Palestine have been caused by viruses from the O/ME-SA/PanAsia-2^{ANT-10} sub-lineage. These viruses are most closely related to FMD viruses recovered from Pakistan (in 2019), which is perhaps unexpected and poses new questions about the East-to-West connectivity within Pool 3. A contemporary FMDV sequence from the Gaza Strip, Palestine also shows that FMD viruses from the O/EA-3 topotype most closely related to Egyptian FMD viruses (from 2017) are present. Elsewhere, new FMD outbreaks have been recently reported in the Orenburg Oblast in the Russian Federation (in one of the Southern FMD-free (with vaccination) zones) and China.

I take this opportunity to wish everyone “best wishes” for 2022.

Don King, Pirbright, January 2022

STOP PRESS: [1] an FMD outbreak has been reported (03/01/22) in Kazakhstan (Previously FMD-free zone without vaccination) and [2] an FMD outbreak in Tunisia was reported to the OIE (12/01/22), where sequence data shared by Institut de la Recherche Vétérinaire de Tunisie and ANSES France highlights a new incursion of the O/EA-3 topotype into the North African region.

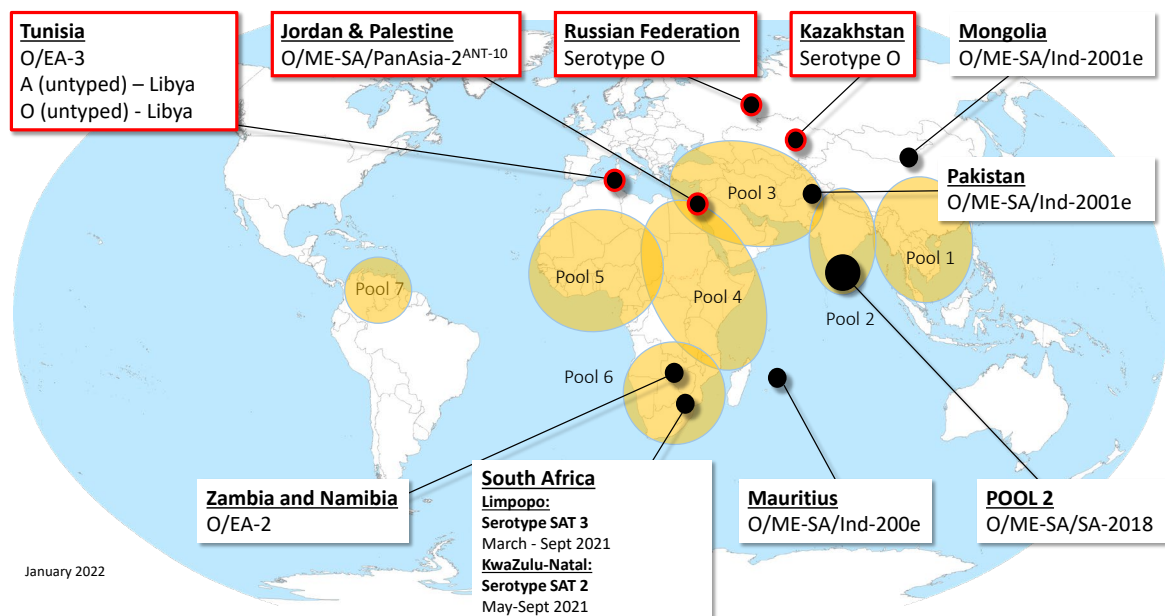


Figure 1: Recent FMD global outbreaks (new headline events reported **October to December 2021** are highlighted) with endemic pools highlighted in orange. Source: WRLFMD. Map conforms to the United Nations World Map, June 2020.

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
<u>SOUTHEAST ASIA/CENTRAL ASIA/EAST ASIA</u>		
1	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
<u>SOUTH ASIA</u>		
2	Bangladesh, Bhutan, India, Mauritius ¹ , Nepal, Sri Lanka	A, Asia 1 and O
<u>WEST EURASIA & MIDDLE EAST</u>		
3	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)
<u>NORTH AFRICA</u>²		
	Algeria, Libya, Morocco, Tunisia	A, O and SAT 2
<u>EASTERN AFRICA</u>		
4	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
<u>WEST/CENTRAL AFRICA</u>		
5	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
<u>SOUTHERN AFRICA</u>		
6	Angola, Botswana, Malawi, Mozambique, Namibia, South Africa, Zambia, Zimbabwe	SAT 1, SAT 2 and SAT 3 (O, A) ⁴
<u>SOUTH AMERICA</u>		
7	Venezuela (Bolivarian Republic of)	O and A

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

²Long-term maintenance of FMDV lineages has not been documented in 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

³Egypt represents a crossroads between African Pool 4 and the Middle East (Pool 3)

⁴Detection of O/EA-2 in southern/western Zambia (2018-2021) and Namibia 2021 represent 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.

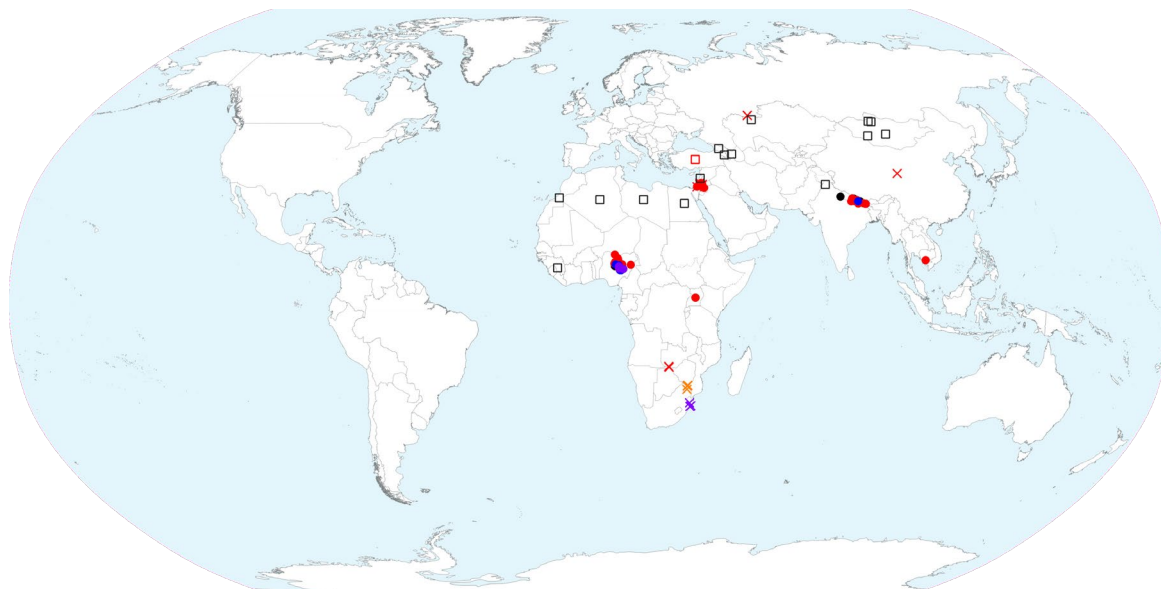
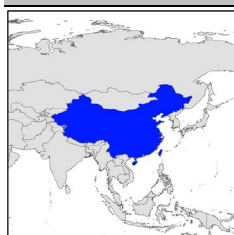


Figure 2: Samples tested by WRLFMD or reported in this quarter. ● indicates samples analysed; × indicates new outbreaks reported to the OIE, but where results to define the genotype have not been reported; □ indicates reports of FMD from other sources. Shape colours define the serotype detected ● O; ● 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 People's Republic of China



On 27th October 2021, an outbreak of **FMD type O** was reported in yaks (*Bos grunniens*) at Ningxiu Township, Zêkog county, Huangnan Tibetan Autonomous Prefecture, Qinghai Province. No genotyping has been reported.

OIE World Animal Health Information System (Event IDs: [evt 4046](#))

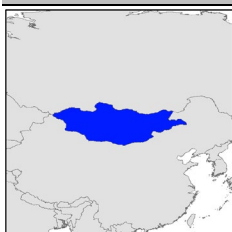
ProMED post: [20211116.8699693](#)

The Kingdom of Cambodia



Thirteen **FMD type O** VP1 sequences were downloaded from GenBank for sequencing performed by the Animal and Plant Quarantine Agency (APQA), South Korea. The samples had been collected from cattle in Kampong Speu in January 2019. Genotyping showed 10 belonged to the ME-SA/PanAsia lineage while three belonged to the ME-SA/Ind-2001e sublineage – the first detection of this lineage in Cambodia (see below).

Mongolia



In early October several thousand head of livestock (11 outbreaks from 85 holdings spread across 8 districts) were reported as being infected with FMD in the central province of Uvurkhangai according to local media. Vaccination of high-risk animals is taking place to halt the spread of the disease.

ProMED post: [20211006.8698879](https://www.promed.org/post/20211006.8698879)

The western province of Govi-Altai was quarantined in late October due to outbreaks of FMD in Sharga, Taishir, and Esunbulag soums.

ProMED post: [20211022.8699197](https://www.promed.org/post/20211022.8699197)

Outbreaks of FMD were registered in early December in Khövsgöl Province in the north of Mongolia (3 in Burentogtokh district and 4 in Tsagaan-Uul district). There are over 200,000 head of livestock in the affected areas, and almost 30,000 animals have so far been vaccinated in Burentogtokh district.

ProMED post: [20211209.8700166](https://www.promed.org/post/20211209.8700166)

3.3. Pool 2 (South Asia)

The Republic of India



FMD was reported in local media in mid November affecting sheep and goats in Himachal Pradesh.

ProMED post: [20211120.8699797](https://www.promed.org/post/20211120.8699797)

The Federal Democratic Republic of Nepal



A batch of 70 samples was received on 14th September 2021. Typing showed that 38 were **FMD type O**, one was **FMD type A**, 16 were FMDV-GD and 15 were NVD. VP1 genotyping showed that the type O viruses all belonged to the ME-SA/Ind-2001e sublineage, while the type A virus belonged to the ASIA/G-VII lineage (see below).

3.4. Pool 3 (West Eurasia and Middle East)

The Republic of Armenia



Passive and active surveillance is active in Armenia and a post-vaccination serological survey is on-going. 139,209 large and 46,486 small ruminants were vaccinated in this quarter.

[FAO Eu-FMD FAST report Oct-Dec 2021](#)

The Republic of Azerbaijan

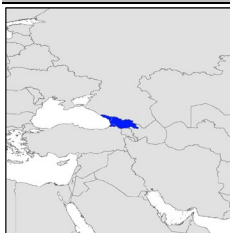


More than 5,750,000 cattle and small ruminants were vaccinated in the autumn vaccination campaign – achieving 88.7% coverage for cattle and 46.9% for small ruminants.

Passive and active surveillance is active in Azerbaijan and a post-vaccination serological survey has been completed.

[FAO Eu-FMD FAST report Oct-Dec 2021](#)

Georgia



The autumn prophylactic vaccination campaign has been completed, vaccinating 324,462 large and 411,045 small ruminants.

Non-Structural Protein serosurveillance has been conducted – samples have been collected and tested and the results are pending.

[FAO Eu-FMD FAST report Oct-Dec 2021](#)

The Hashemite Kingdom of Jordan



Between 4th and 21st November 2021, four outbreaks of **FMD type O** were reported in cattle, sheep and goats in three provinces, Amman, Mafrq and Irbid. VP1 sequencing was undertaken at the Jordan University of Science and Technology (JUST). Genotyping showed that the viruses belonged to the ME-SA/PanAsia-2^{ANT-10} sublineage (see below). A batch of 13 samples was received on 20th December 2021.

Typing and genotyping results are pending.

OIE World Animal Health Information System (Event IDs: [evt 4053](#))

ProMED post: [20211105.8699471](#) & [20211111.8699579](#)

Ring vaccination (10 km) for serotypes O and A has been implemented.

[FAO Eu-FMD FAST report Oct-Dec 2021](#)

The Lebanese Republic



FMD control measures actively in use in the country include vaccination and sero-surveillance.

[FAO Eu-FMD FAST report Oct-Dec 2021](#)

The State of Palestine



On the 12th December 2021 and 20th December 2021, two outbreaks of **FMD type O** were reported in sheep and in goats at Al-Hadidiya, Tubas, West Bank. VP1 sequencing was undertaken at the Kimron Veterinary Institute (KVI), Israel, and genotyping showed that the virus belonged to the ME-SA/PanAsia-2^{ANT-10} sublineage being closely related to the outbreaks in Jordan (see below).

On 13th December 2021, an outbreak of FMD type O was reported in cattle at East Jabalia, Gaza ash Shamaliyah, Gaza. VP1 sequencing was undertaken at the KVI and genotyping showed that the virus belonged to the EA-3 toponotype (see below).

OIE World Animal Health Information System (Event IDs: [evt 4176](#) & [evt 4193](#))

ProMED post: [20211216.8700299](#), [20211224.8700454](#) & [20211231.8700601](#)

[FAO Eu-FMD FAST report Oct-Dec 2021](#)

The Russian Federation



On 20th December 2021, an outbreak of **FMD type O** was reported in cattle close to the border with Kazakhstan in Karagach, Belyaevskiy raion, Orenburg oblast. Genotyping results are awaited from FGBI ARRIAH.

OIE World Animal Health Information System (Event IDs: [evt 4200](#))

ProMED post: [20211231.8700591](#)

The Republic of Kazakhstan



An outbreak of FMD in the village of Bestamak, Alga district, Aktobe region, and three other villages, was reported in local media in mid-November. An emergency vaccination program has been launched by local authorities – by 21st November 8000 head of animal had been vaccinated. NB: FMD outbreaks in Kazakhstan have now been reported to OIE

ProMED post: [20211121.8699810](#)

The Republic of Turkey



During this quarter there were 6 outbreaks of FMD in the Anatolia region. These were typed as O/ME-SA/PanAsia-2^{QOM-15} and O/ME-SA/PanAsia-2^{ANT-10}.

The autumn preventative and emergency vaccination program has been completed – achieving >94% coverage in large ruminants.

[FAO Eu-FMD FAST report Oct-Dec 2021](#)

3.5. Pool 4 (North and Eastern Africa)

The People's Democratic Republic of Algeria



Algeria has had no outbreak of FMD in over 2½ years. There is a vaccination campaign currently ongoing that has so far vaccinated 149,020 bovines.

[FAO Eu-FMD FAST report Oct-Dec 2021](#)

The Arab Republic of Egypt



There were two FMD outbreaks reported in Egypt in October 2021. Surveillance (passive and active) and vaccination are active in Egypt to help detect and control FMD.

[FAO Eu-FMD FAST report Oct-Dec 2021](#)

The State of Libya



The current FMD vaccination strategy is biannual vaccination for cattle and ring vaccination for sheep/goats.

Passive surveillance is in use in the country to help deter outbreaks.

[FAO Eu-FMD FAST report Oct-Dec 2021](#)

The Kingdom of Morocco



Morocco has a FMD control program endorsed by the OIE and there has been no outbreak of FMD in Morocco in over 2 years.

The current vaccination strategy is biannual vaccination in high-risk and border areas.

[FAO Eu-FMD FAST report Oct-Dec 2021](#)

The Republic of Uganda



A batch of 14 samples was received on 11th October 2021. Typing showed that four samples were **FMD type O**, four were FMDV-GD and six were NVD. Genotyping revealed that the type O viruses belonged to the EA-2 topotype (see below).

3.6. Pool 5 (West/Central Africa)

The Republic of Guinea



In late October local media reported several outbreaks of FMD in the Sangardo sub-prefecture of Kissidougou prefecture (information from the Head of Veterinary Services). Several localities in the adjacent Kankan Prefecture have also reported suspect cases of FMD.

ProMED post: [20201010.7849996](https://www.promed.org/post/20201010.7849996)

The Federal Republic of Nigeria



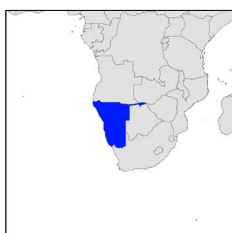
A batch of 107 samples was received on 8th October 2021. Typing showed that 43 samples were **FMD type O**, 22 were **FMD type A**, 14 were **FMD type SAT 2**, 22 were FMDV-GD and six were NVD. Genotyping revealed that the type O viruses belonged to the EA-3 topotype, the type A viruses belonged to the AFRICA/G-IV lineage and the SAT 2 viruses belonged to topotype VII.

Eighty-two near complete genome sequences were received on the 11th December 2021 from National Centre for Foreign Animal Disease (NCFAD), Canada in collaboration with the National Veterinary Research Institute (NVRI), Nigeria. VP1 sequences were extracted from 76 (six were not sufficiently complete) and genotyped. Fifty-five were **FMD type O** (EA-3 topotype), nine were **FMD type A** (AFRICA/G-IV lineage) and 12 were **FMD type SAT 2** (topotype VII) (see below).

A further batch of 13 samples was received on 21th December 2021. Typing and genotyping results are pending.

3.7. Pool 6 (Southern Africa)

The Republic of Namibia



On 4th November 2021, a fourth outbreak of **FMD type O** was reported in cattle at Lusesse, Kabe, Zambezi Region.

OIE World Animal Health Information System (event ID: [evt 3752](https://www.oie.int/eng/affairsofworld/diseases/diseases.htm?id=3752))

The Republic of South Africa



Between March and September 2021, 28 outbreaks of **FMD type SAT 3** were reported in cattle in the Limpopo region. Between May and September 2021, 29 outbreaks of **FMD type SAT 2** were reported in cattle in KwaZulu-Natal.

OIE World Animal Health Information System (Event IDs: [36933](#), [evt 3758](#) & [evt 3738](#))

3.8. Pool 7 (South America)

No new outbreaks of FMD were reported in South America.

3.9. Extent of global surveillance

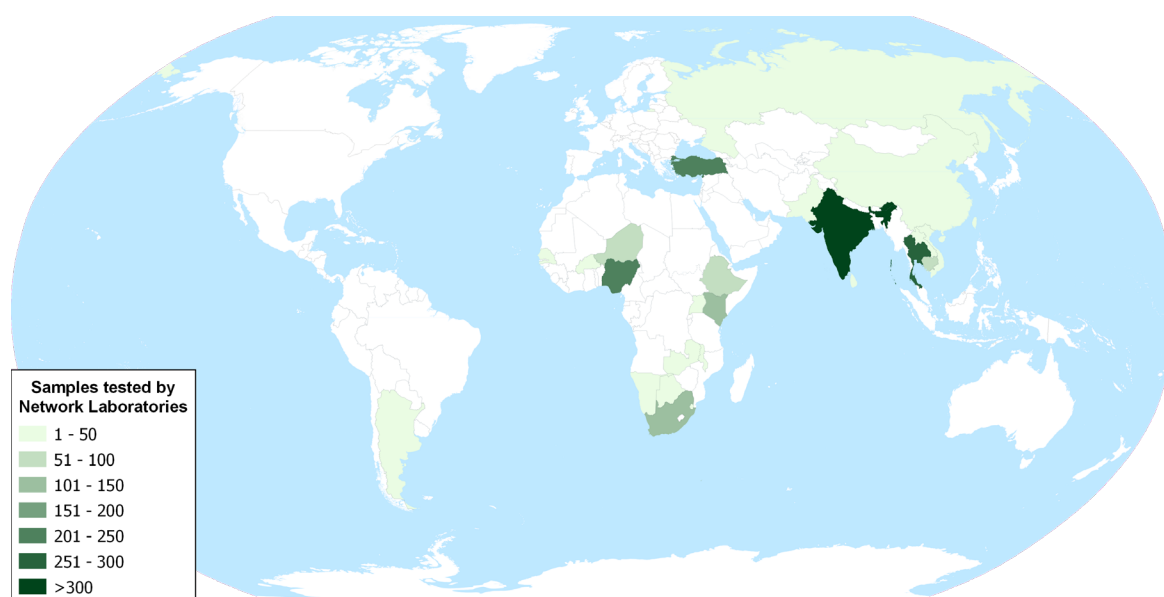


Figure 3: Samples received during 2020 from FMD outbreaks (routine surveillance that is undertaken in countries that are FMD-free without vaccination is not shown). Data from presentations given at the OIE/FAO Reference laboratory Network annual meeting (<https://www.foot-and-mouth.org/Ref-Lab-Network/Network-Annual-Meeting>) NB: corresponding data for 2021 is pending and will be reported shortly .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 (%) of total FMD cases that occur in domesticated hosts]. These scores (reviewed at the OIE/FAO FMD 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	60	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				38	22	17		
A EURO-SA								10
Asia-1	0	4	12.5					
SAT 1				0	8	5	16	
SAT 2			0.5	0	14	13	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 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-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 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 October to December 2021 (* indicates a batch carried over from the previous quarter).

WRLFMD Batch No.	Date received	Country	Total No. samples	Serotype	No. of samples	No. of sequences	Sequencing status
WRLFMD/2021/00013	14/09/2021	Nepal *	70	O	38	38	Finished
				A	1	1	Finished
				FMDV-GD	16	-	-

			NVD	15	-	-
			O	4	4	Finished
WRLFMD/2021/00014	11/10/2021	Uganda	14	FMDV-GD	4	-
				NVD	6	-
				O	43 †	43
				A	22	22
WRLFMD/2021/00016	08/10/2021	Nigeria	106	SAT 2	14 †	14
				FMDV-GD	22	-
				NVD	6	-
WRLFMD/2021/00017	20/12/2021	Jordan	[13 samples, testing pending]			
WRLFMD/2021/00018	21/12/2021	Nigeria	[13 samples, testing pending]			
Totals			190	191	122	

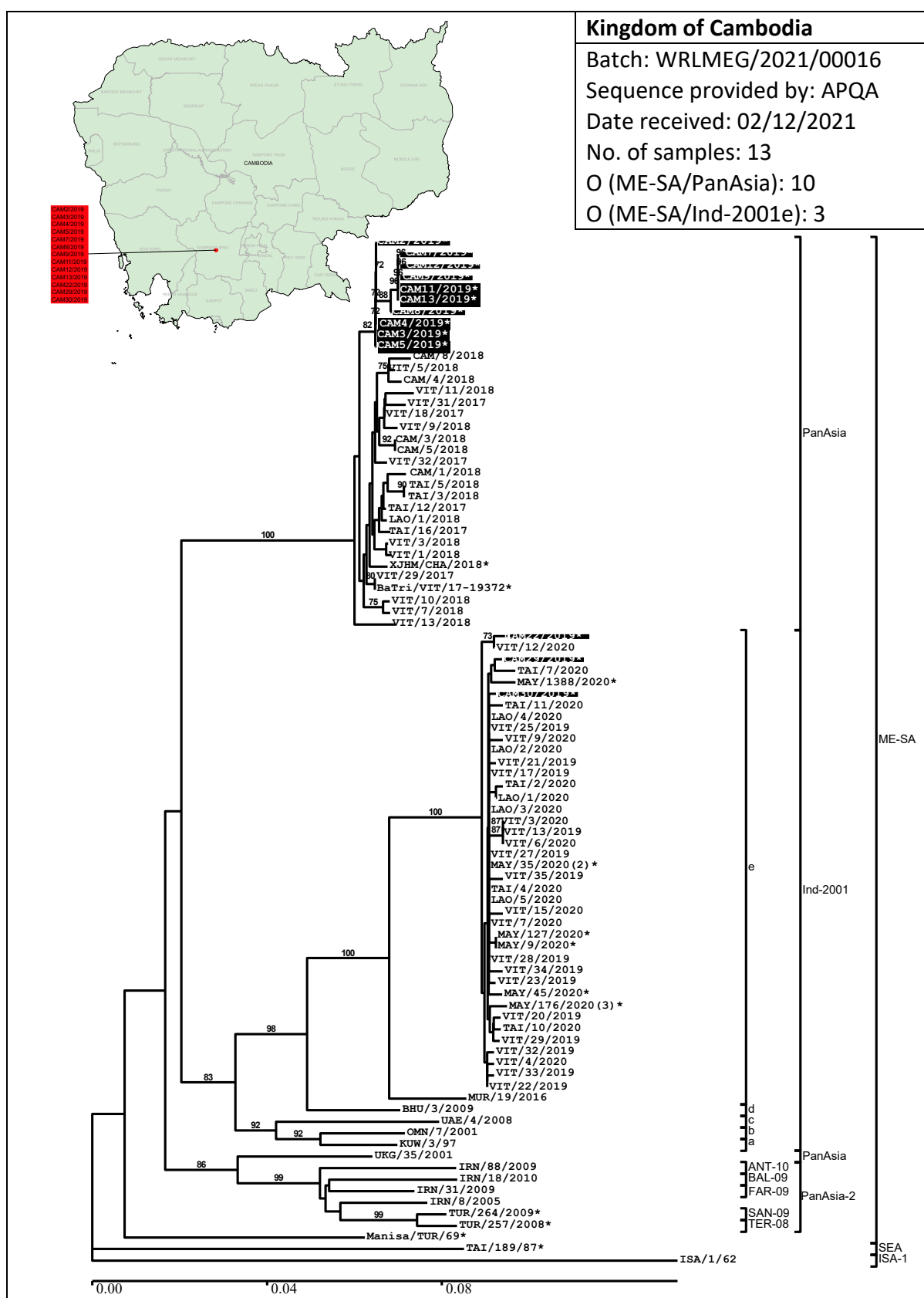
† One sample tested positive for O and SAT 2.

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

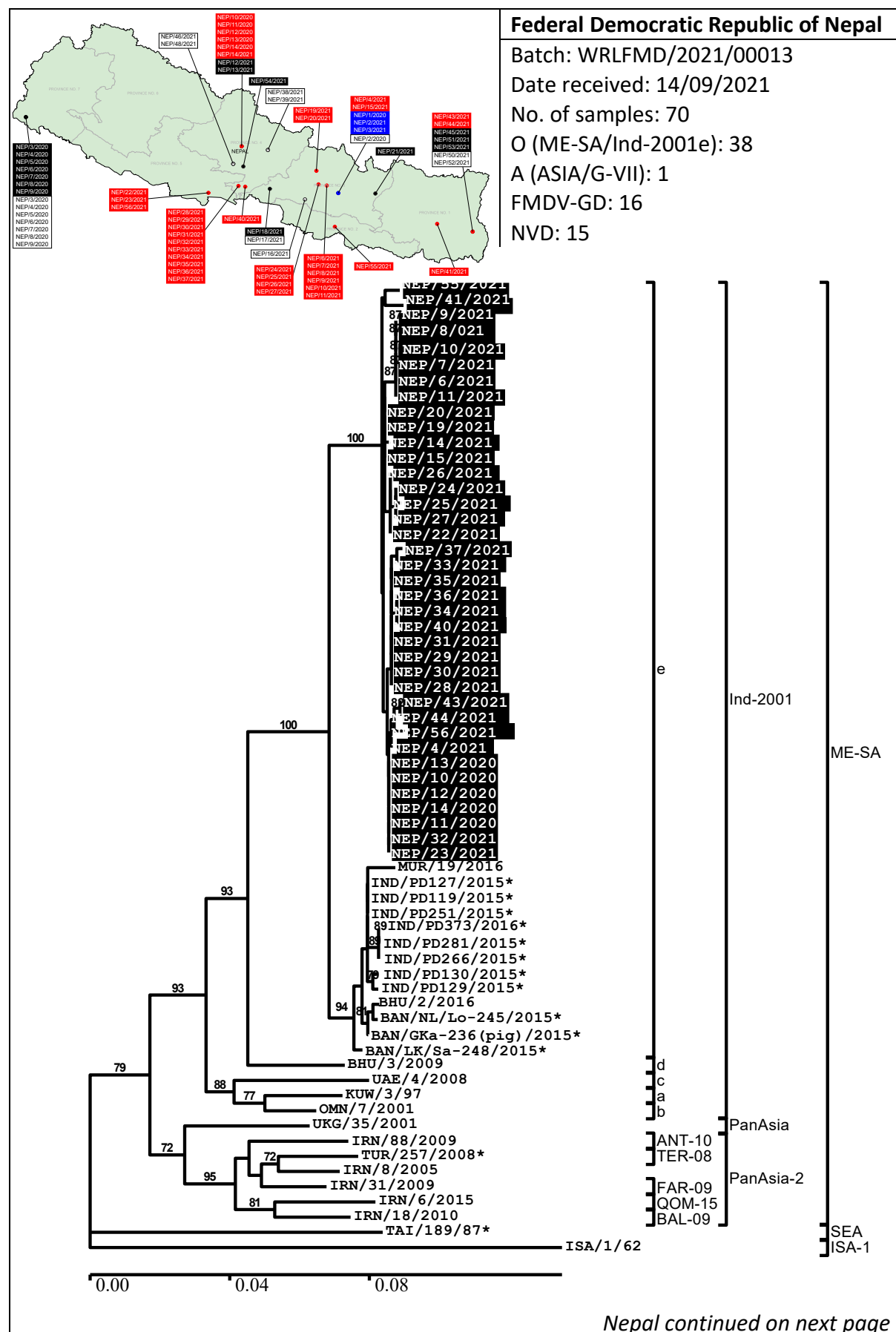
WRLFMD Batch No.	Date received	Country	Serotype	Date Collected	No. of sequences	Submitting laboratory
WRLMEG/2021/00015	30/11/2021	Jordan	O	2021	2	JUST
WRLMEG/2021/00016	02/12/2021	Cambodia	O	01/2021	13	APQA
WRLMEG/2021/00018	06/12/2021	Jordan	O	2021	2	JUST
WRLMEG/2021/00019	11/12/2021	Nigeria	O	09-10/2020	55	NCFAD/C FIA & NVRI
			A	09/2020	9	
			SAT 2	09/2020	12	
WRLMEG/2021/00020	17/12/2021	Palestinian A.T.	O	12/12/2021	1	KVI
WRLMEG/2021/00021	21/12/2021	Palestinian A.T.	O	12/2021	1	KVI
WRLMEG/2021/00022	24/12/2021	Jordan	O	12/2021	4	JUST
Total					99	

4. Detailed analysis

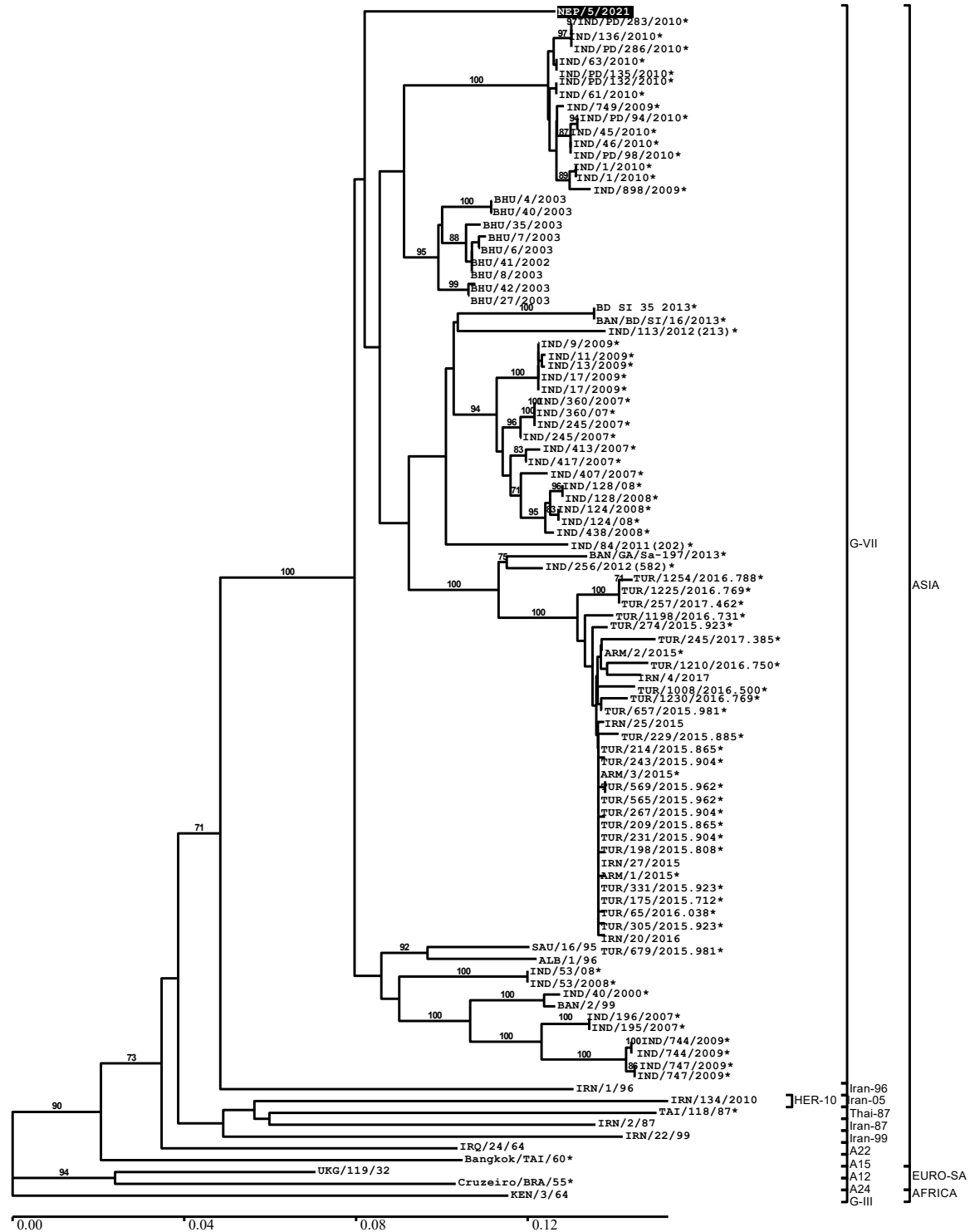
4.1. Pool 1 (Southeast Asia/Central Asia/East Asia)



4.2. Pool 3 (West Eurasia and Middle East)



Nepal continued



The Hashemite Kingdom of Jordan

Batch: WRLMEG/2021/00015

Sequence provided by: JUST

Date received: 30/11/2021

No. of samples: 2

O (ME-SA/PanAsia-2/ANT-10): 2

Batch: WRLMEG/2021/00018

Sequence provided by: JUST

Date received: 06/12/2021

No. of samples: 2

O (ME-SA/PanAsia-2/ANT-10): 2

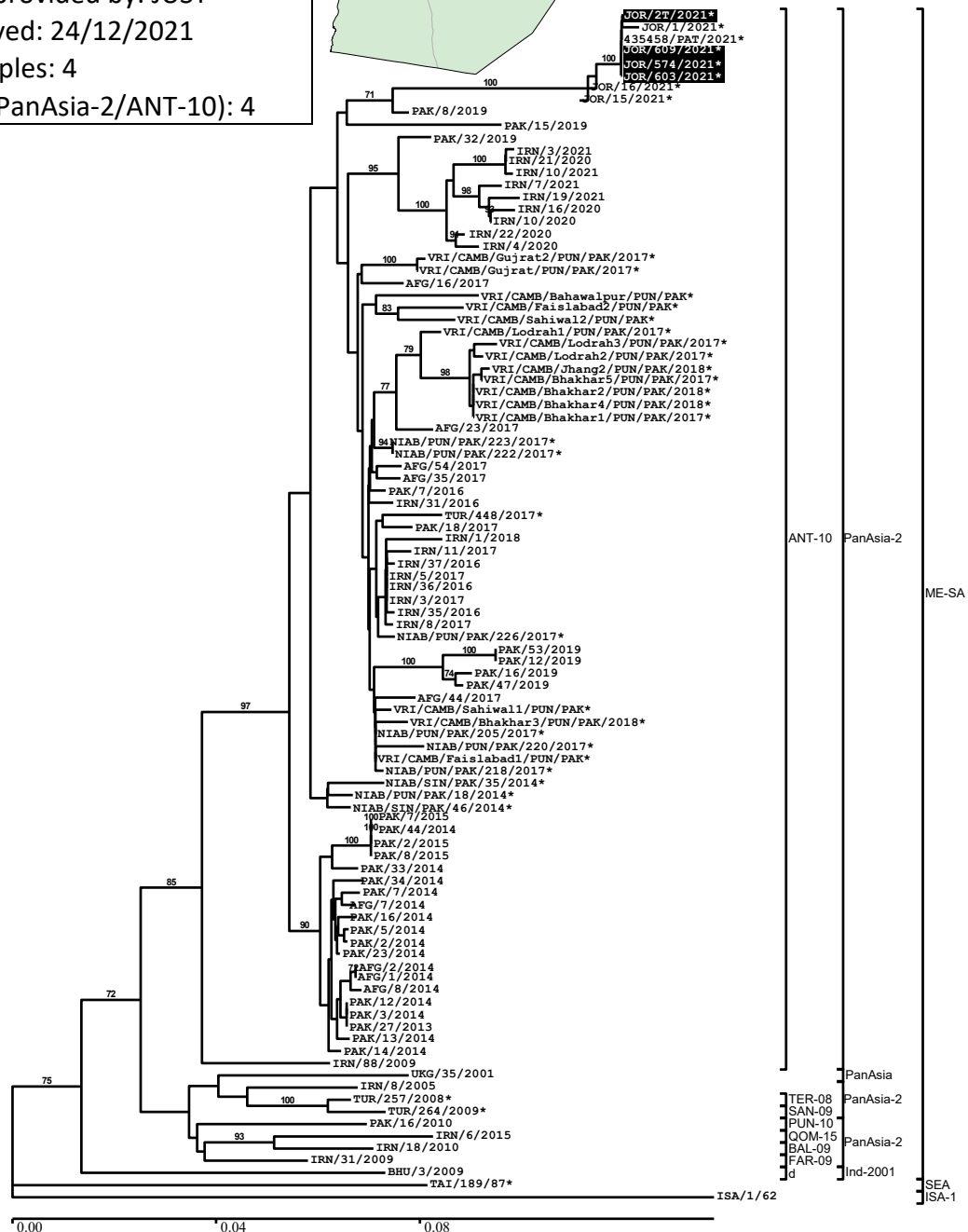
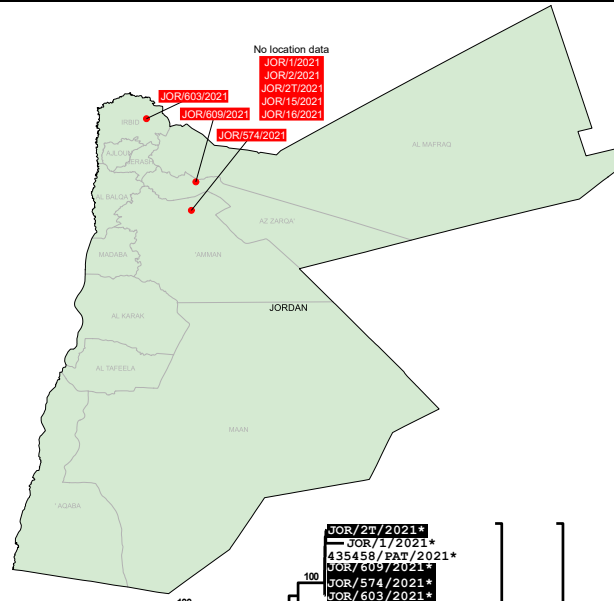
Batch: WRLMEG/2021/00022

Sequence provided by: JUST

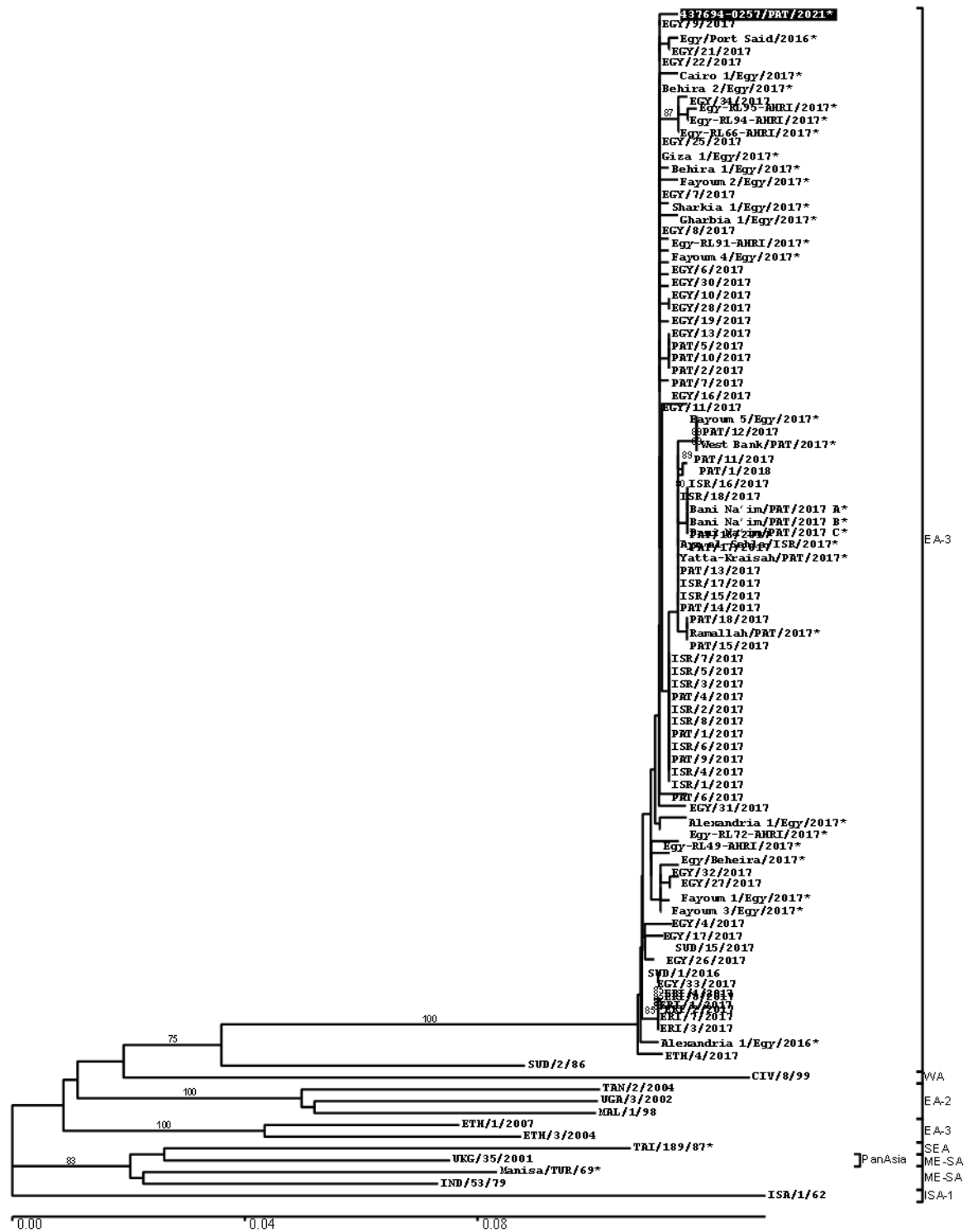
Date received: 24/12/2021

No. of samples: 4

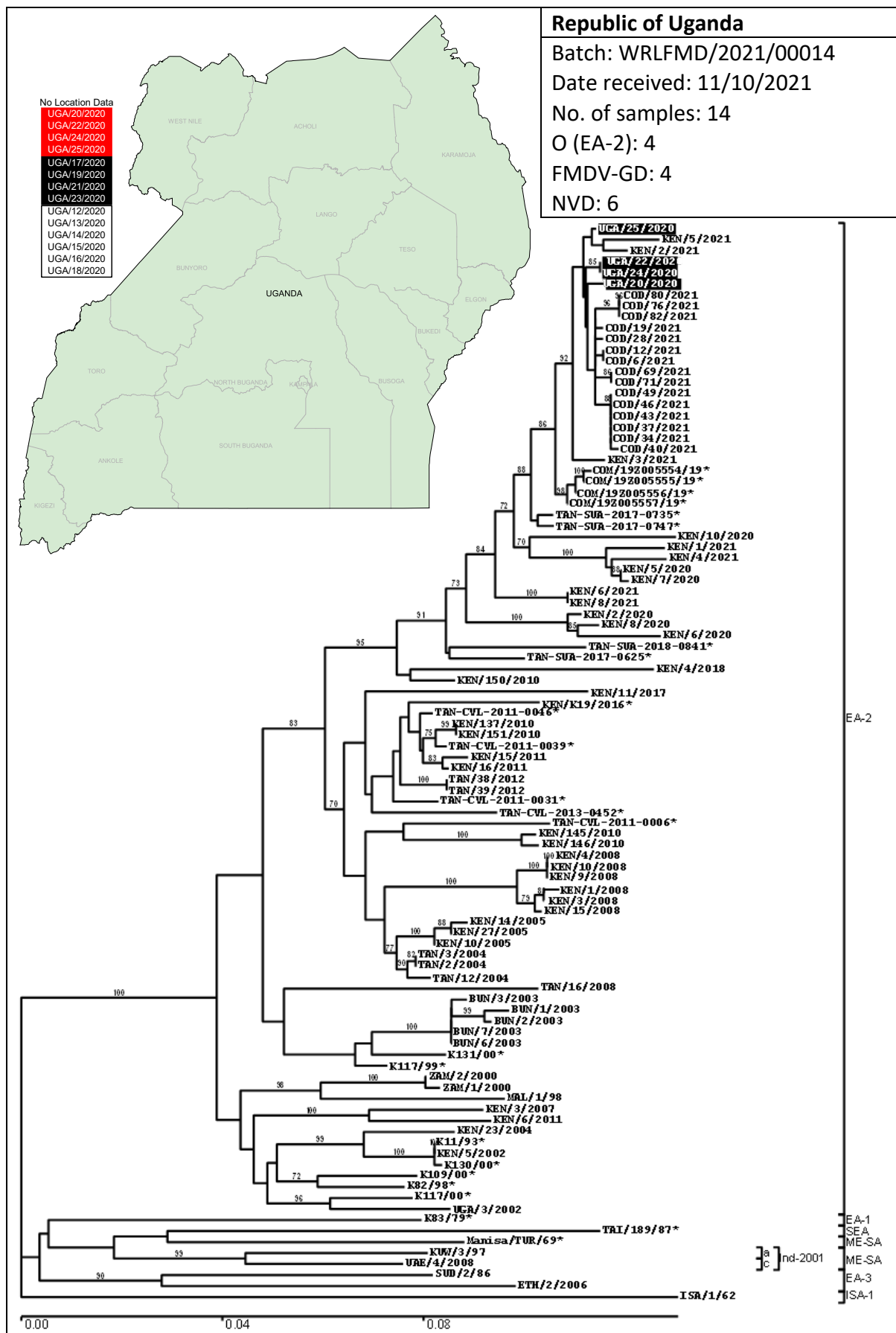
O (ME-SA/PanAsia-2/ANT-10): 4



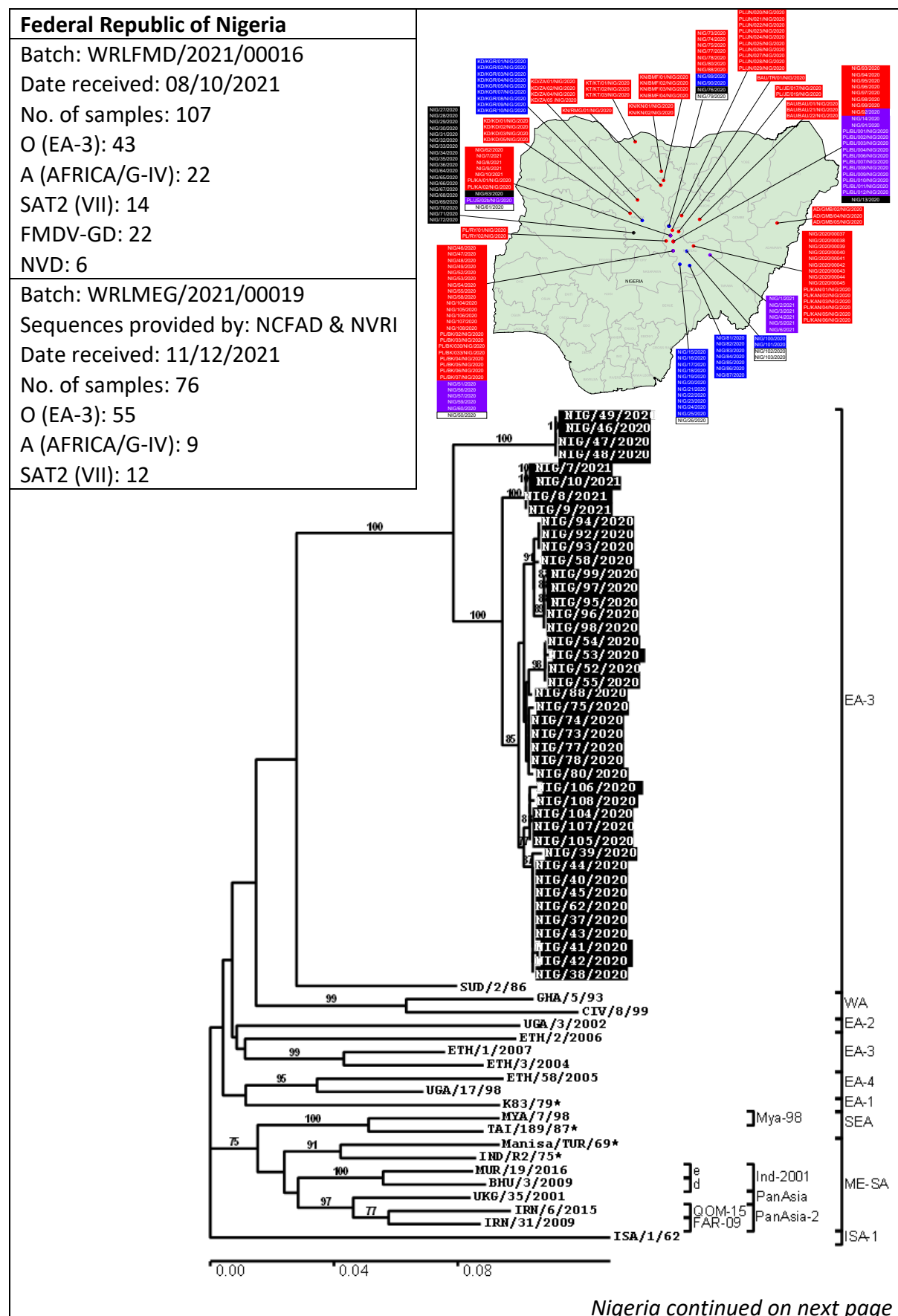
Palestine continued



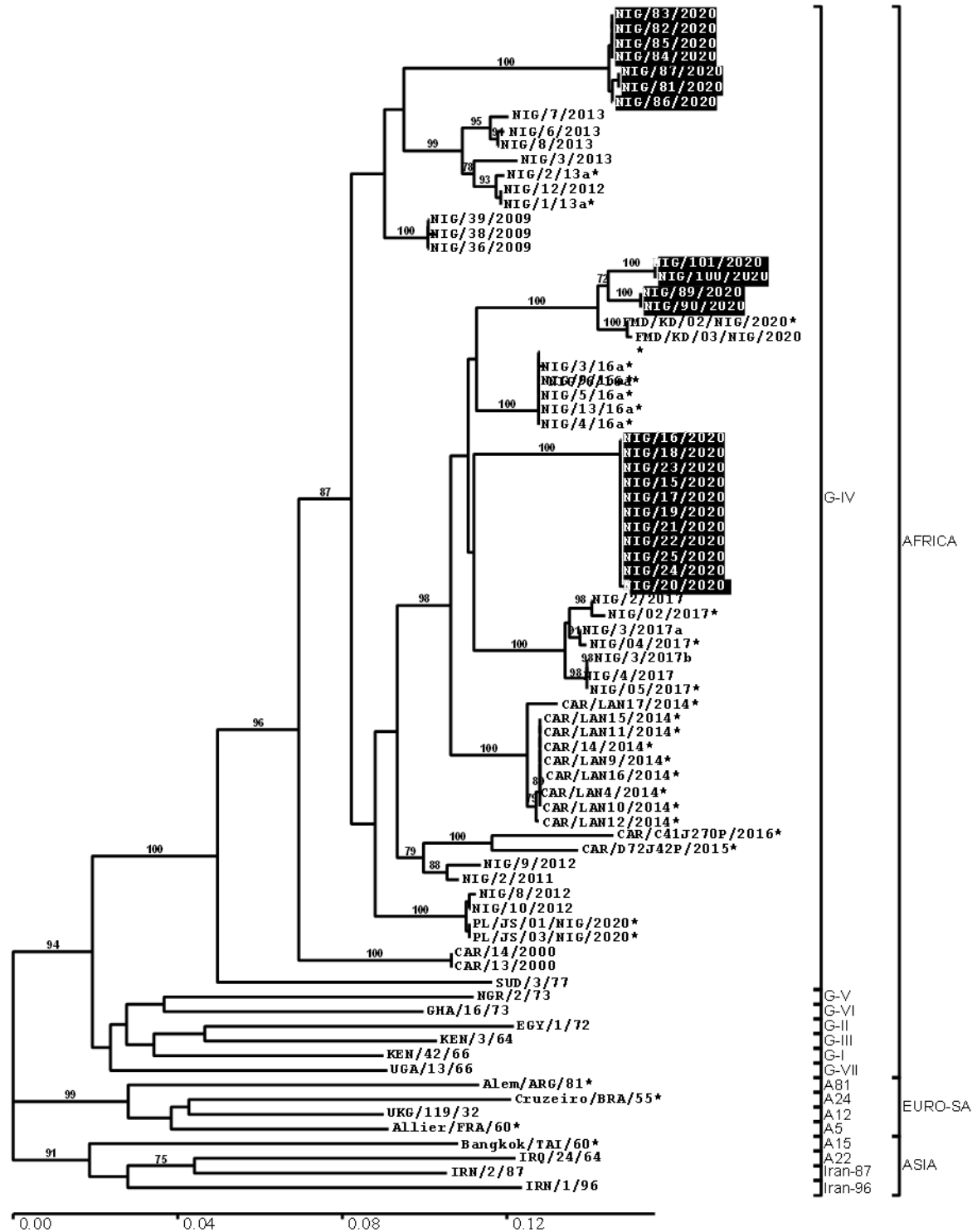
4.3. Pool 4 (North and East Africa)



4.4. Pool 5 (West Africa)

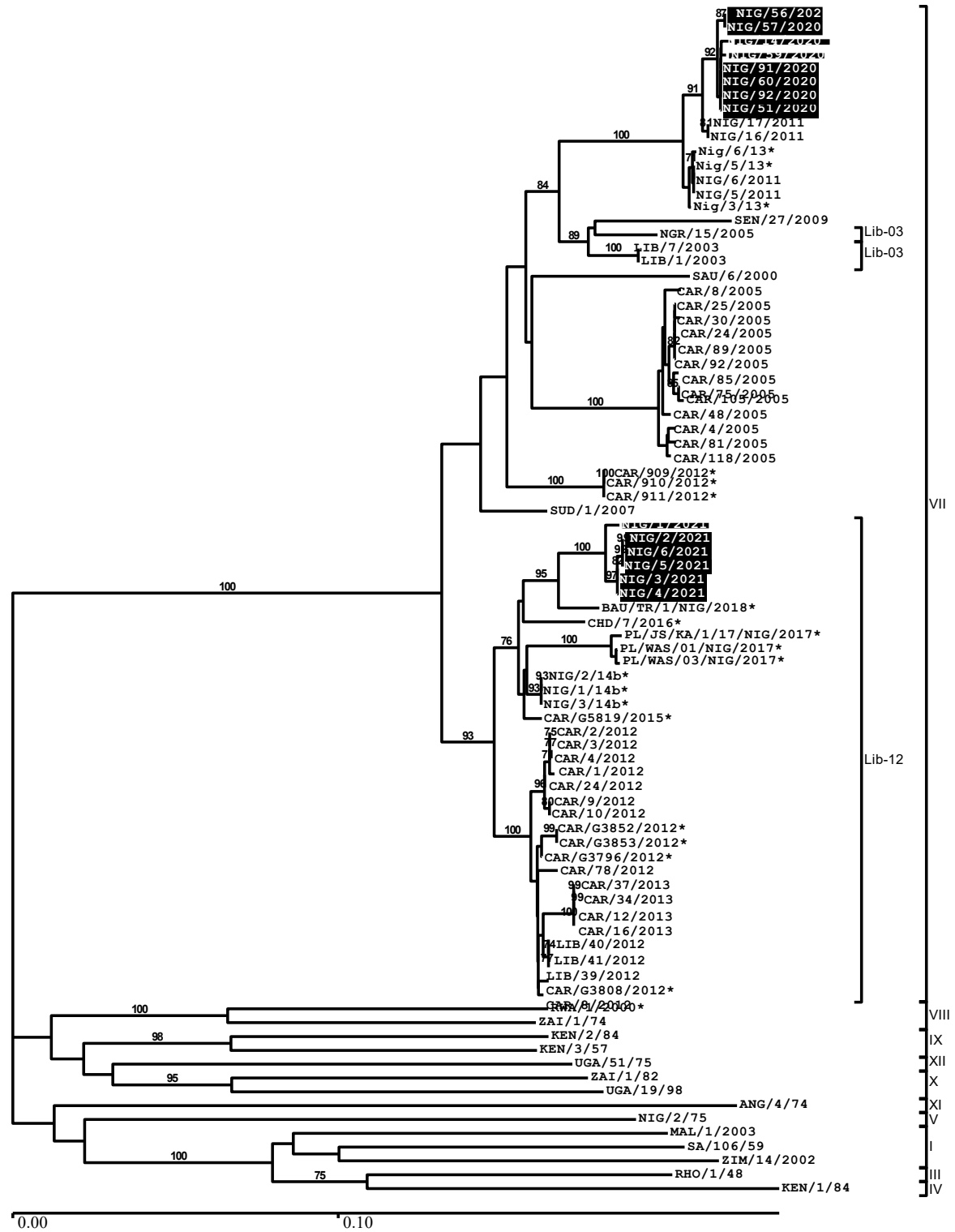


Nigeria continued



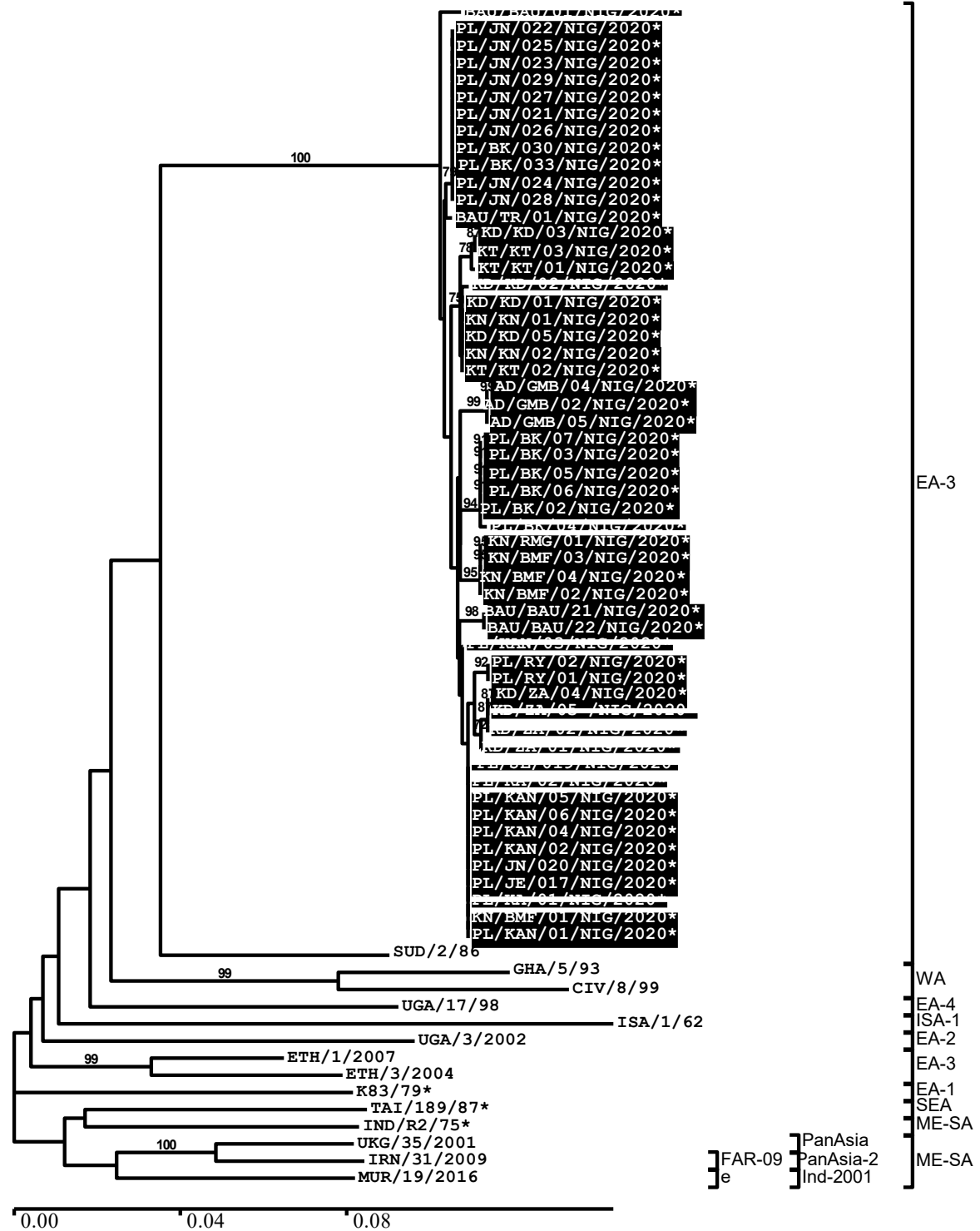
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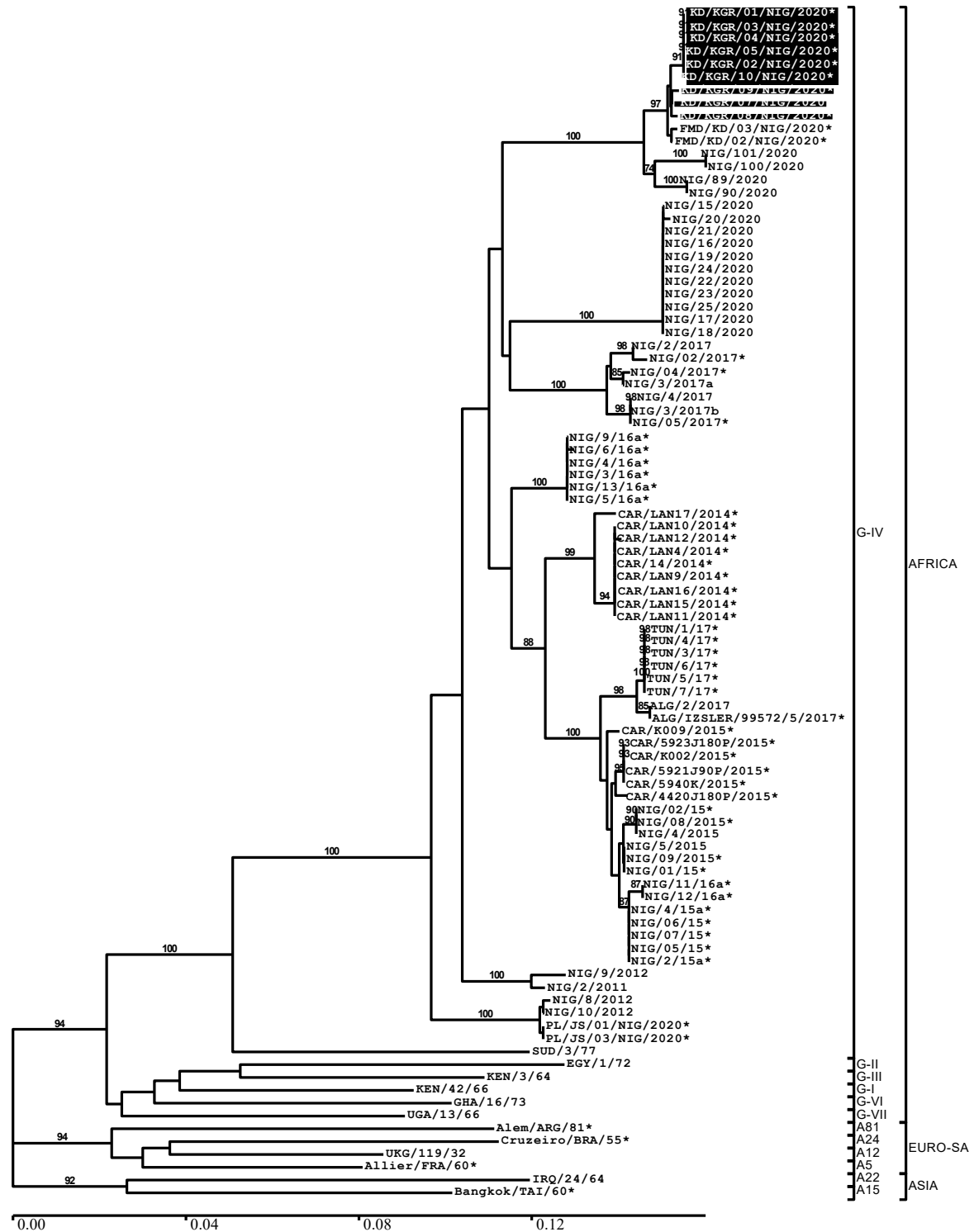
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4.5. Vaccine matching

Antigenic characterisation of FMD field isolates by matching with vaccine strains by 2dmVNT from October to December 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
Iran	2	2	-	1	-	-	-
Kenya	2	1	-	-	2	-	-
Mongolia	2	-	-	-	-	-	-
Total	6	3	0	1	2	0	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 $r_1 = \geq 0.3$ - 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 TCID₅₀.

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 Manisa Boehringer Ingelheim		O/TUR/5/09 MSD		O ₁ Campos Biogénesis Bagó		O Panasia 2 Boehringer Ingelheim		O Campos Boehringer Ingelheim	
	Topotype	Lineage	r ₁	Titre	r ₁	Titre	r ₁	Titre	r ₁	Titre	r ₁	Titre	r ₁	Titre
IRN/3/2021	ME-SA	PanAsia-2	0.58	1.84	0.22	1.95	0.63	2.12	0.59		0.26	2.02		
IRN/7/2021	ME-SA	PanAsia-2	0.50	1.78	0.31	1.94	0.13		0.48	2.46	0.22	1.95		
MOG/2/2021	ME-SA	Ind-2001	0.69	1.94	0.51	2.29	1	2.37	0.65	2.61			0.33	2.20
MOG/3/2021	ME-SA	Ind-2001	0.62	1.89	0.52	2.30	0.87	2.22	0.60	2.58			0.33	2.20
KEN/10/2020	EA-2	-	0.45	1.79	0.40	2.04	0.5	1.98	0.35	2.35	0.34	2.01		
KEN/6/2021	EA-2	-	0.74	2.01	0.74	2.31	0.85	2.21	0.51	2.51	0.43	2.11		

Table 6: Vaccine matching studies for A FMDV

Isolate	Serotype A		A Iran 05 Boehringer Ingelheim		A Eritrea 98 Boehringer Ingelheim		A/TUR/20/06 MSD		A22 Iraq Boehringer Ingelheim		A GVII 2015 Boehringer Ingelheim		A Saudi 95 Boehringer Ingelheim	
	Topotype	Lineage	r ₁	Titre	r ₁	Titre	r ₁	Titre	r ₁	Titre	r ₁	Titre	r ₁	Titre
KEN/10/2021	AFRICA	G-I	0.08	1.48	0.11	1.71	0.08		0.27	2.11	0	-	0.25	1.82
IRN/18/2021	ASIA	Iran-05	0.39	2.20			0.23	1.25	0.14	1.81	0	-		
IRN/22/2021	ASIA	Iran-05	0.28	2.05			0.36	1.44	0.32	2.17	0	-		

Table 7: Vaccine matching studies for Asia-1 FMDV

Isolate	Serotype Asia-1		Asia 1 Shamir Boehringer Ingelheim	
	Topotype	Lineage	r ₁	Titre
IRN/1/2020	ASIA	Sindh-08	0.24	1.95

Table 8: Vaccine matching studies for SAT 1 FMDV

Isolate	Serotype SAT 1		SAT1 Rho 78 Boehringer Ingelheim	
	<i>Topotype</i>	<i>Lineage</i>	<i>r₁</i>	<i>Titre</i>
KEN/3/2020	I (NWZ)	-	1	2.46
KEN/9/2020	I (NWZ)	-	0.43	1.88

Annex 1: Sample data

Summary of submissions

Table 9: Summary of samples collected and received to WRLFMD (October to December 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
NEPAL	70	32	1	0	0	0	0	0	37	55	15
NIGERIA	106	43	22	0	0	14	0	0	28	99	7
UGANDA	14	4	0	0	0	0	0	0	10	8	6
TOTAL	190	79	23	0	0	14	0	0	75	162	28

Clinical samples

Table 10: Clinical sample diagnostics made by the WRLFMD October to December 2021

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
NEPAL	14/09/2021	01/11/2021	NEP 1/2020	BOVINE	05-Aug-20	NEG	POS	FMDV GD
			NEP 2/2020	BOVINE	05-Aug-20	NEG	NEG	NVD
			NEP 3/2020	BUFFALO	27-Sep-20	NEG	NEG	NVD
			NEP 4/2020	BOVINE	27-Sep-20	NEG	NEG	NVD
			NEP 5/2020	BOVINE	27-Sep-20	NEG	NEG	NVD
			NEP 6/2020	BOVINE	27-Sep-20	NEG	NEG	NVD
			NEP 7/2020	OX	27-Sep-20	NEG	NEG	NVD
			NEP 8/2020	OX	27-Sep-20	NEG	NEG	NVD
			NEP 9/2020	BOVINE	27-Sep-20	NEG	NEG	NVD
			NEP 10/2020	BOVINE	20-Dec-20	O	POS	O
			NEP 11/2020	BOVINE	20-Dec-20	O	POS	O
			NEP 12/2020	BOVINE	20-Dec-20	O	POS	O
			NEP 13/2020	BOVINE	20-Dec-20	O	POS	O
			NEP 14/2020	BUFFALO	21-Dec-20	O	POS	O
			NEP 1/2021	BOVINE	01-Jan-21	NEG	POS	FMDV GD
			NEP 2/2021	BOVINE	01-Jan-21	NEG	POS	FMDV GD
			NEP 3/2021	BOVINE	01-Jan-21	NEG	POS	FMDV GD
			NEP 4/2021	BOVINE	01-Jan-21	NEG	POS	FMDV GD
			NEP 5/2021	BOVINE	01-Jan-21	A	POS	A
			NEP 6/2021	BOVINE	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
			NEP 7/2021	BOVINE	05-Jan-21	O	POS	O
			NEP 8/2021	BOVINE	05-Jan-21	NEG	POS	FMDV GD
			NEP 9/2021	BOVINE	05-Jan-21	O	POS	O
			NEP 10/2021	BOVINE	05-Jan-21	O	POS	O
			NEP 11/2021	BOVINE	05-Jan-21	O	POS	O
			NEP 12/2021	BOVINE	10-Jan-21	NEG	POS	FMDV GD
			NEP 13/2021	BOVINE	10-Jan-21	NEG	POS	FMDV GD
			NEP 14/2021	BOVINE	21-Jan-21	NEG	POS	FMDV GD
			NEP 15/2021	BOVINE	27-Jan-21	O	POS	O
			NEP 16/2021	BOVINE	28-Jan-21	NEG	NEG	NVD
			NEP 17/2021	BOVINE	28-Jan-21	NEG	NEG	NVD
			NEP 18/2021	BOVINE	28-Jan-21	NEG	POS	FMDV GD
			NEP 19/2021	BUFFALO	31-Jan-21	O	POS	O
			NEP 20/2021	BOVINE	31-Jan-21	O	POS	O
			NEP 21/2021	OX	08-Feb-21	NEG	POS	FMDV GD
			NEP 22/2021	BOVINE	16-Feb-21	O	POS	O
			NEP 23/2021	BOVINE	16-Feb-21	O	POS	O
			NEP 24/2021	BOVINE	17-Feb-21	O	POS	O
			NEP 25/2021	BOVINE	17-Feb-21	O	POS	O
			NEP 26/2021	BOVINE	17-Feb-21	O	POS	O
			NEP 27/2021	BOVINE	17-Feb-21	O	POS	O
			NEP 28/2021	BOVINE	23-Feb-21	O	POS	O
			NEP 29/2021	BOVINE	23-Feb-21	O	POS	O
			NEP 30/2021	BOVINE	23-Feb-21	O	POS	O
			NEP 31/2021	BOVINE	23-Feb-21	NEG	POS	FMDV GD
			NEP 32/2021	BOVINE	23-Feb-21	O	POS	O
			NEP 33/2021	BOVINE	23-Feb-21	O	POS	O
			NEP 34/2021	BOVINE	23-Feb-21	O	POS	O
			NEP 35/2021	BOVINE	23-Feb-21	O	POS	O
			NEP 36/2021	BOVINE	23-Feb-21	O	POS	O
			NEP 37/2021	BOVINE	23-Feb-21	O	POS	O
			NEP 38/2021	BULL	28-Feb-21	NEG	POS	FMDV GD
			NEP 39/2021	BULL	28-Feb-21	NEG	POS	FMDV GD
			NEP 40/2021	BOVINE	02-Mar-21	NEG	POS	FMDV GD
			NEP 41/2021	BOVINE	14-Mar-21	O	POS	O
			NEP 42/2021	BUFFALO	24-Mar-21	NEG	NEG	NVD
			NEP 43/2021	BOVINE	25-Mar-21	O	POS	O
			NEP 44/2021	BOVINE	25-Mar-21	NEG	POS	FMDV GD
			NEP 45/2021	BOVINE	25-Mar-21	NEG	POS	FMDV GD
			NEP 46/2021	BOVINE	29-Mar-21	NEG	NEG	NVD

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
			NEP 47/2021	BOVINE	29-Mar-21	NEG	POS	FMDV GD
			NEP 48/2021	BOVINE	29-Mar-21	NEG	NEG	NVD
			NEP 49/2021	BOVINE	29-Mar-21	NEG	POS	FMDV GD
			NEP 50/2021	BOVINE	02-Apr-21	NEG	NEG	NVD
			NEP 51/2021	BOVINE	02-Apr-21	NEG	POS	FMDV GD
			NEP 52/2021	BOVINE	02-Apr-21	NEG	NEG	NVD
			NEP 53/2021	BOVINE	02-Apr-21	NEG	POS	FMDV GD
			NEP 54/2021	BOVINE	02-Apr-21	NEG	POS	FMDV GD
			NEP 55/2021	BOVINE	05-May-21	O	POS	O
			NEP 56/2021	BOVINE	10-Aug-21	O	POS	O
NIGERIA	08/10/2021	08/12/2021	NIG 13/2020	CATTLE	30-Sep-20	NEG	POS	FMDV GD
			NIG 14/2020	CATTLE	30-Sep-20	SAT 2	POS	SAT 2
			NIG 15/2020	CATTLE	01-Oct-20	A	POS	A
			NIG 16/2020	CATTLE	01-Oct-20	A	POS	A
			NIG 17/2020	CATTLE	01-Oct-20	A	POS	A
			NIG 18/2020	CATTLE	01-Oct-20	A	POS	A
			NIG 19/2020	CATTLE	01-Oct-20	A	POS	A
			NIG 20/2020	CATTLE	01-Oct-20	A	POS	A
			NIG 21/2020	CATTLE	01-Oct-20	A	POS	A
			NIG 22/2020	CATTLE	01-Oct-20	A	POS	A
			NIG 23/2020	CATTLE	01-Oct-20	A	NEG	A
			NIG 24/2020	GOAT	01-Oct-20	A	POS	A
			NIG 25/2020	GOAT	01-Oct-20	A	POS	A
			NIG 26/2020	GOAT	01-Oct-20	NEG	NEG	NVD
			NIG 27/2020	CATTLE	02-Oct-20	NEG	POS	FMDV GD
			NIG 28/2020	CATTLE	02-Oct-20	NEG	POS	FMDV GD
			NIG 29/2020	CATTLE	02-Oct-20	NEG	POS	FMDV GD
			NIG 30/2020	CATTLE	02-Oct-20	NEG	POS	FMDV GD
			NIG 31/2020	CATTLE	02-Oct-20	NEG	POS	FMDV GD
			NIG 32/2020	CATTLE	02-Oct-20	NEG	POS	FMDV GD
			NIG 33/2020	CATTLE	02-Oct-20	NEG	POS	FMDV GD
			NIG 34/2020	CATTLE	02-Oct-20	NEG	POS	FMDV GD
			NIG 35/2020	CATTLE	02-Oct-20	NEG	POS	FMDV GD
			NIG 36/2020	CATTLE	02-Oct-20	NEG	POS	FMDV GD
			NIG 37/2020	CATTLE	06-Oct-20	O	POS	O
			NIG 38/2020	CATTLE	06-Oct-20	O	POS	O
			NIG 39/2020	CATTLE	06-Oct-20	O	POS	O
			NIG 40/2020	CATTLE	06-Oct-20	O	POS	O
			NIG 41/2020	CATTLE	06-Oct-20	O	POS	O
			NIG 42/2020	CATTLE	06-Oct-20	O	POS	O
			NIG 43/2020	CATTLE	06-Oct-20	O	POS	O

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
			NIG 44/2020	CATTLE	06-Oct-20	O	POS	O
			NIG 45/2020	SHEEP	06-Oct-20	O	POS	O
			NIG 46/2020	CATTLE	07-Oct-20	O	POS	O
			NIG 47/2020	CATTLE	07-Oct-20	O	POS	O
			NIG 48/2020	CATTLE	07-Oct-20	O	POS	O
			NIG 49/2020	CATTLE	07-Oct-20	O	POS	O
			NIG 50/2020	CATTLE	07-Oct-20	NEG	NEG	NVD
			NIG 51/2020	CATTLE	08-Oct-20	SAT 2	POS	SAT 2
			NIG 52/2020	CATTLE	08-Oct-20	O	POS	O
			NIG 53/2020	CATTLE	08-Oct-20	O	POS	O
			NIG 54/2020	CATTLE	08-Oct-20	O	POS	O
			NIG 55/2020	CATTLE	08-Oct-20	O	POS	O
			NIG 56/2020	CATTLE	08-Oct-20	SAT 2	POS	SAT 2
			NIG 57/2020	CATTLE	08-Oct-20	SAT 2	POS	SAT 2
			NIG 58/2020	CATTLE	08-Oct-20	O	POS	O
			NIG 59/2020	CATTLE	08-Oct-20	SAT 2	POS	SAT 2
			NIG 60/2020	CATTLE	08-Oct-20	SAT 2	POS	SAT 2
			NIG 61/2020	CATTLE	10-Oct-20	NEG	NEG	NVD
			NIG 62/2020	CATTLE	10-Oct-20	O	POS	O
			NIG 63/2020	CATTLE	10-Oct-20	NEG	POS	FMDV GD
			NIG 64/2020	CATTLE	12-Oct-20	NEG	POS	FMDV GD
			NIG 65/2020	CATTLE	12-Oct-20	NEG	POS	FMDV GD
			NIG 66/2020	CATTLE	12-Oct-20	NEG	POS	FMDV GD
			NIG 67/2020	CATTLE	12-Oct-20	NEG	POS	FMDV GD
			NIG 68/2020	CATTLE	12-Oct-20	NEG	POS	FMDV GD
			NIG 69/2020	CATTLE	12-Oct-20	NEG	POS	FMDV GD
			NIG 70/2020	CATTLE	12-Oct-20	NEG	POS	FMDV GD
			NIG 71/2020	CATTLE	12-Oct-20	NEG	POS	FMDV GD
			NIG 72/2020	CATTLE	12-Oct-20	NEG	POS	FMDV GD
			NIG 73/2020	CATTLE	13-Oct-20	O	POS	O
			NIG 74/2020	CATTLE	13-Oct-20	O	POS	O
			NIG 75/2020	CATTLE	13-Oct-20	O	POS	O
			NIG 76/2020	CATTLE	13-Oct-20	NEG	POS	FMDV GD
			NIG 77/2020	CATTLE	13-Oct-20	O	POS	O
			NIG 78/2020	SHEEP	13-Oct-20	O	POS	O
			NIG 79/2020	SHEEP	13-Oct-20	NEG	NEG	NVD
			NIG 80/2020	SHEEP	13-Oct-20	O	POS	O
			NIG 81/2020	CATTLE	15-Oct-20	A	POS	A
			NIG 82/2020	CATTLE	15-Oct-20	A	POS	A
			NIG 83/2020	CATTLE	15-Oct-20	A	POS	A
			NIG 84/2020	CATTLE	15-Oct-20	A	POS	A

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
			NIG 85/2020	CATTLE	15-Oct-20	A	POS	A
			NIG 86/2020	CATTLE	15-Oct-20	A	POS	A
			NIG 87/2020	CATTLE	15-Oct-20	A	POS	A
			NIG 88/2020	CATTLE	16-Oct-20	O	POS	O
			NIG 89/2020	CATTLE	16-Oct-20	A	POS	A
			NIG 90/2020	CATTLE	16-Oct-20	A	POS	A
			NIG 91/2020	CATTLE	03-Nov-20	SAT 2	POS	SAT 2
			NIG 92/2020	CATTLE	03-Nov-20	SAT2,O	POS	SAT 2, O
			NIG 93/2020	CATTLE	03-Nov-20	O	POS	O
			NIG 94/2020	CATTLE	03-Nov-20	O	POS	O
			NIG 95/2020	CATTLE	03-Nov-20	O	POS	O
			NIG 96/2020	CATTLE	03-Nov-20	O	POS	O
			NIG 97/2020	CATTLE	03-Nov-20	O	POS	O
			NIG 98/2020	CATTLE	03-Nov-20	O	POS	O
			NIG 99/2020	CATTLE	03-Nov-20	O	POS	O
			NIG 100/2020	CATTLE	04-Nov-20	A	POS	A
			NIG 101/2020	CATTLE	04-Nov-20	A	POS	A
			NIG 102/2020	SHEEP	04-Nov-20	NEG	NEG	NVD
			NIG 103/2020	SHEEP	04-Nov-20	NEG	NEG	NVD
			NIG 104/2020	CATTLE	04-Dec-20	O	POS	O
			NIG 105/2020	CATTLE	04-Dec-20	O	POS	O
			NIG 106/2020	CATTLE	04-Dec-20	O	POS	O
			NIG 107/2020	CATTLE	04-Dec-20	O	POS	O
			NIG 108/2020	CATTLE	04-Dec-20	O	POS	O
			NIG 1/2021	CATTLE	08-Sep-21	SAT 2	POS	SAT 2
			NIG 2/2021	CATTLE	08-Sep-21	SAT 2	POS	SAT 2
			NIG 3/2021	CATTLE	08-Sep-21	SAT 2	POS	SAT 2
			NIG 4/2021	CATTLE	08-Sep-21	SAT 2	POS	SAT 2
			NIG 5/2021	CATTLE	08-Sep-21	SAT 2	POS	SAT 2
			NIG 6/2021	CATTLE	08-Sep-21	SAT 2	POS	SAT 2
			NIG 7/2021	CATTLE	30-Sep-21	O	POS	O
			NIG 8/2021	CATTLE	30-Sep-21	O	POS	O
			NIG 9/2021	CATTLE	30-Sep-21	O	POS	O
			NIG 10/2021	CATTLE	30-Sep-21	O	POS	O
UGANDA	11/10/2021	05/11/2021	UGA 12/2020	CATTLE	09-Aug-20	NEG	NEG	NVD
			UGA 13/2020	CATTLE	09-Aug-20	NEG	NEG	NVD
			UGA 14/2020	CATTLE	09-Aug-20	NEG	NEG	NVD
			UGA 15/2020	CATTLE	09-Aug-20	NEG	NEG	NVD
			UGA 16/2020	CATTLE	09-Aug-20	NEG	NEG	NVD
			UGA 17/2020	CATTLE	09-Aug-20	NEG	POS	FMDV GD
			UGA 18/2020	CATTLE	12-Sep-20	NEG	NEG	NVD

Country	Date		WRL for FMD Sample Identification	Animal	Date of Collection	Results		
	Received	Reported				VI/ELISA	RT-PCR	Final report
			UGA 19/2020	CATTLE	12-Sep-20	NEG	POS	FMDV GD
			UGA 20/2020	CATTLE	12-Sep-20	O	POS	O
			UGA 21/2020	CATTLE	12-Sep-20	NEG	POS	FMDV GD
			UGA 22/2020	CATTLE	12-Sep-20	O	POS	O
			UGA 23/2020	CATTLE	12-Sep-20	NEG	POS	FMDV GD
			UGA 24/2020	CATTLE	12-Sep-20	O	POS	O
			UGA 25/2020	CATTLE	12-Sep-20	O	POS	O
TOTAL					247			

Annex 2: FMD publications

Recent FMD Publications (October to December 2021) cited by Web of Science.

1. Adamchick, J., K.M. Rich, and A.M. Perez (2021). Self-reporting of risk pathways and parameter values for foot-and-mouth disease in slaughter cattle from alternative production systems by Kenyan and Ugandan veterinarians. *Viruses-Basel*, **13**(11): 21. DOI: 10.3390/v13112112.
2. Ahn, Y.H., W.A.G. Chaturanga, Y.J. Shim, D.K. Haluwana, E.H. Kim, I.J. Yoon, Y.T. Lim, S.H. Shin, H. Jo, S.Y. Hwang, H.M. Kim, M.J. Lee, J.H. Park, S.S. Yoo, and J.S. Lee (2021). The potential adjuvanticity of CAvant®SOE for foot-and-mouth disease vaccine. *Vaccines*, **9**(10): 11. DOI: 10.3390/vaccines9101091.
3. Akram, Q., S.H. Farooqi, H.M. Rizwan, B. Zahid, M.A. Naeem, Q. Ali, A. Idrees, M.S.A. Taseer, M.U. Farid, and Z. Iqbal (2021). Antibody response of buffalo calves to different levels of *Foot-and-mouth disease virus* immunogen. *Journal of Pharmaceutical Research International*, **33**(44A): 466-471. DOI: 10.9734/JPRI/2021/v33i44A32639.
4. Arjkumpa, O., C. Picasso-Risso, A. Perez, and V. Punyapornwithaya (2021). Subdistrict-level reproductive number for foot-and-mouth disease in cattle in northern Thailand. *Frontiers in Veterinary Science*, **8**: 7. DOI: 10.3389/fvets.2021.757132.
5. Banda, F., Y. Sinkala, L. Mataa, P. Lebea, T. Sikombe, H.L. Kangwa, E.M. Fana, M. Mokopasetso, J. Wadsworth, N.J. Knowles, D.P. King, and M.L.Y. Quan (2021). Characterization of foot-and-mouth disease viruses in Zambia-implications for the epidemiology of the disease in southern Africa. *Viruses-Basel*, **13**(11): 14. DOI: 10.3390/v13112195.
6. Chanchaidechachai, T., M.C.M. de Jong, and E.A.J. Fischer (2021). Spatial model of foot-and-mouth disease outbreak in an endemic area of Thailand. *Preventive Veterinary Medicine*, **195**: 10. DOI: 10.1016/j.prevetmed.2021.105468.
7. Coffman, M.S., M. Sanderson, C.C. Dodd, J. Arzt, and D.G. Renter (2021). Estimation of foot-and-mouth disease windborne transmission risk from USA beef feedlots. *Preventive Veterinary Medicine*, **195**: 11. DOI: 10.1016/j.prevetmed.2021.105453.
8. Condoleo, R., R.A. Taylor, R.R.L. Simons, P. Gale, Z. Mezher, and H. Roberts (2021). A semi-quantitative model for ranking the risk of incursion of exotic animal pathogens into a European Union Member State. *Microbial Risk Analysis*, **18**: 12. DOI: 10.1016/j.mran.2021.100175.
9. Di Nardo, A., L. Ferretti, J. Wadsworth, V. Mioulet, B. Gelman, S. Karniely, A. Scherbakov, G. Ziay, F. Ozyoruk, U. Parlak, P. Tuncer-Goktuna, R. Hassanzadeh, M. Khalaj, S.M. Dastoor, D. Abdollahi, E.U.H. Khan, M. Afzal, M. Hussain, N.J. Knowles, and D.P. King (2021). Evolutionary and ecological drivers shape the emergence and extinction of Foot-and-mouth disease virus lineages. *Molecular Biology and Evolution*, **38**(10): 4346-4361. DOI: 10.1093/molbev/msab172.
10. Dong, H., Y.L. Lu, Y. Zhang, S.Y. Mu, N. Wang, P. Du, X.Y. Zhi, X.B. Wen, X.X. Wang, S.Q. Sun, Y.M. Zhang, and H.C. Guo (2021). A heat-induced mutation on VP1 of *Foot-and-mouth disease virus* serotype O enhanced capsid stability and immunogenicity. *Journal of Virology*, **95**(16): 13. DOI: 10.1128/jvi.00177-21.

11. Ekanayaka, P., S.H. Shin, P. Weeratunga, H. Lee, T.H. Kim, K. Chathuranga, A. Subasinghe, J.H. Park, and J.S. Lee (2021). *Foot-and-mouth disease virus* 3C protease antagonizes interferon signaling and C142T substitution attenuates the FMD virus. *Frontiers in Microbiology*, **12**: 16. DOI: 10.3389/fmicb.2021.737031.
12. Garcia-Pintos, C., F. Riet-Correa, and A. Menchaca (2021). Effect of foot-and-mouth disease vaccine on pregnancy failure in beef cows. *Frontiers in Veterinary Science*, **8**: 8. DOI: 10.3389/fvets.2021.761304.
13. Hammond, J.M., B. Maulidi, and N. Henning (2021). Targeted FMD vaccines for Eastern Africa: The AgResults footand m-outh disease challenge project. *Viruses-Basel*, **13**(9): 13. DOI: 10.3390/v13091830.
14. Han, L.L., Y.C. Yuan, J.J. Hu, J.D. Li, S.M. Zhu, P. Yang, A.D. Cheng, X.M. Li, and C. Shen (2021). Next-generation sequencing sheds light on the interaction between virus and cell during *Foot-and-mouth disease virus* persistent infection. *Veterinary Microbiology*, **263**: 10. DOI: 10.1016/j.vetmic.2021.109247.
15. Hanthorn, C.J., M.W. Sanderson, and A.L. Dixon (2021). Survey of emergency response plans for managing the movement of cattle during a foot-and-mouth disease outbreak in North America. *Journal of the American Veterinary Medical Association*, **259**(9): 1047-1056.
16. Hasler, B., G. Limon, K. Queenan, J. Rushton, M. Madege, J. Mlangwa, and J. Mghwira (2021). Cost-benefit and feasibility analysis for establishing a foot-and-mouth disease free zone in Rukwa region in Tanzania. *Preventive Veterinary Medicine*, **196**: 19. DOI: 10.1016/j.prevetmed.2021.105494.
17. Kim, A.Y., S.Y. Park, S.H. Park, J.S. Jin, E.S. Kim, J.Y. Kim, J.H. Park, and Y.J. Ko (2021). Validation of pretreatment methods for the in-process quantification of foot-and-mouth disease vaccine antigens. *Vaccines*, **9**(11): 15. DOI: 10.3390/vaccines9111361.
18. Kim, D., J. Ha, J. Moon, D. Kim, W. Lee, C. Lee, D. Kim, and J. Yi (2021). Increased ruminoreticular temperature and body activity after foot-and-mouth vaccination in pregnant Hanwoo (*Bos taurus coreanae*) cows. *Vaccines*, **9**(11): 9. DOI: 10.3390/vaccines9111227.
19. Li, K., Y. He, L. Wang, P.H. Li, S. Wang, P. Sun, H.F. Bao, Y.M. Cao, X.R. Liu, G.Q. Zhu, Y.L. Song, X.W. Bai, X.Q. Ma, Y.F. Fu, H. Yuan, J. Zhang, J. Wang, Y.L. Chen, D. Li, Z.Y. Lou, Z.X. Liu, and Z.J. Lu (2021). Two cross-protective antigen sites on *Foot-and-mouth disease virus* serotype O structurally revealed by broadly neutralizing antibodies from cattle. *Journal of Virology*, **95**(21): 16. DOI: 10.1128/jvi.00881-21.
20. Li, Q.X., X.L. Ba, H. Cao, X. Weng, Y. Yang, B. Wang, and A.L. Zhang (2021). Crude polysaccharides from *Cistanche deserticola* YC Ma as an immunoregulator and an adjuvant for foot-and-mouth disease vaccine. *Journal of Functional Foods*, **87**: 13. DOI: 10.1016/j.jff.2021.104800.
21. Ludi, A.B., V. Mioulet, L.B. Kassimi, D.J. Lefebvre, K. De Clercq, E. Chitsungu, N. Nwankpa, W. Vosloo, D.J. Paton, and D.P. King (2021). Selection and use of reference panels: a case study highlighting current gaps in the materials available for foot-and-mouth disease. *Revue Scientifique Et Technique-Office International Des Epizooties*, **40**(1): 239-251. DOI: 10.20506/rst.40.1.3221.
22. Marschik, T., I. Kopacka, S. Stockreiter, F. Schmoll, J. Hiesel, A. Hoflechner-Poltl, A. Kasbohrer, and B. Conrady (2021). What are the human resources required to control a foot-and-mouth disease outbreak in Austria? *Frontiers in Veterinary Science*, **8**: 8. DOI: 10.3389/fvets.2021.727209.

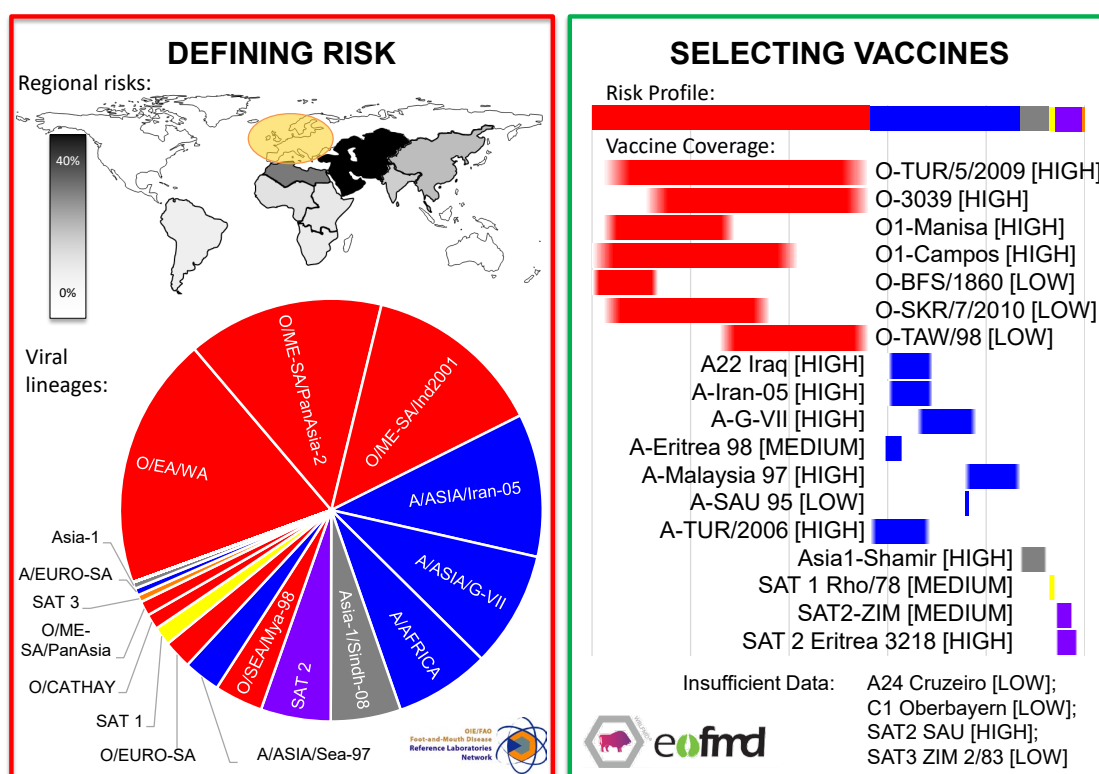
23. Paton, D.J., A. Di Nardo, N.J. Knowles, J. Wadsworth, E.M. Pituco, O. Cosivi, A.M. Rivera, L.B. Kassimi, E. Brocchi, K. de Clercq, C. Carrillo, F.F. Maree, R.K. Singh, W. Vosloo, M.K. Park, K.J. Sumption, A.B. Ludi, and D.P. King (2021). The history of *Foot-and-mouth disease virus* serotype C: the first known extinct serotype? *Virus Evolution*, **7**(1): 12. DOI: 10.1093/ve/veab009.
24. Rathogwa, N.M., K.A. Scott, P. Opperman, J. Theron, and F.F. Maree (2021). Efficacy of SAT 2 Foot-and-mouth disease vaccines formulated with montanide ISA 206b and Quil-A saponin adjuvants. *Vaccines*, **9**(9): 15. DOI: 10.3390/vaccines9090996.
25. Riaz, R., M.S. Khan, F.A. Joyia, and M.A. Zia (2021). Designing of multiepitope-based subunit vaccine (MESV) against prevalent serotype of *Foot-and-mouth disease virus* (FMDV) using immunoinformatics approach. *Pakistan Veterinary Journal*, **41**(3): 400-408. DOI: 10.29261/pakvetj/2021.033.
26. Russell, J. (2021). Marking 20 years since FMD 2001. *Veterinary Record*, **188**(5): 197-197.
27. Ryoo, S., H. Lee, D.R. Lim, J.W. Lee, S. Bunnary, S. Tum, D.S. Lee, H. Hwang, S. Jeong, J. Nah, B.K. Ku, J.M. Kim, and S.H. Cha (2021). Identification of the O/ME-SA/Ind-2001e sublineage of *Foot-and-mouth disease virus* in Cambodia. *Frontiers in Veterinary Science*, **8**: 6. DOI: 10.3389/fvets.2021.749966.
28. Sarkar, S., V.V.S. Suryanarayana, S.C. Sekar, S.R.M. Shankar, G.R. Reddy, and H.J. Dechamma (2021). A strategy to develop disabled infectious single-cycle (DISC) *Foot-and-mouth disease virus* by 3B3 gene deletion using the infective cDNA copy of the genome. *Indian Journal of Biotechnology*, **20**(1): 35-42.
29. Sarkar, S., V.V.S. Suryanarayana, G.R. Reddy, H.J. Dechamma, and S.R.M. Shankar (2021). Creation of leaderless FMDV replicon for development of replication defective virus (leaderless FMDV): A strategy towards the development of attenuated vaccine with marker facility. *Indian Journal of Biotechnology*, **20**(1): 26-34.
30. Siengsan-Lamont, J. and S.D. Blacksell. Surveillance for One Health and high consequence veterinary pathogens (Brucellosis, Coxiellosis and Foot and Mouth Disease) in Southeast Asia: Lao PDR and Cambodia in focus and the importance of international partnerships. *Microbiology Australia*: 5. DOI: 10.1071/ma21045.
31. Singanallur, N.B., A. Dekker, P.L. Eble, F. van Hemert-Kluitenber, K. Weerdmeester, J.J. Horsington, and W. Vosloo (2021). Emergency Fmd serotype O vaccines protect cattle against heterologous challenge with a variant *Foot-and-mouth disease virus* from the O/ME-SA/ind2001 lineage. *Vaccines*, **9**(10): 11. DOI: 10.3390/vaccines9101110.
32. Sui, C., D.D. Jiang, X.J. Wu, S.D. Liu, F. Li, L. Pan, X.Y. Cong, J.T. Li, D.W. Yoo, D.L. Rock, L.C. Miller, C. Lee, Y.J. Du, and J. Qi (2021). Inhibition of antiviral innate immunity by *Foot-and-mouth disease virus* L-pro through interaction with the N-terminal domain of swine RNase L. *Journal of Virology*, **95**(15): 15. DOI: 10.1128/jvi.00361-21.
33. Upadhyaya, S., M. Mahapatra, V. Mioulet, and S. Parida (2021). Molecular basis of antigenic drift in serotype O foot-and-mouth disease viruses (2013-2018) from Southeast Asia. *Viruses-Basel*, **13**(9): 13. DOI: 10.3390/v13091886.
34. Wang, H.R., J.H. Xiao, M.L. Ouyang, H.Y. Gao, J. Bie, L. Gao, X. Gao, and H.B. Wang (2021). Assessment of foot-and-mouth disease risk areas in mainland China based spatial multi-criteria decision analysis. *BMC Veterinary Research*, **17**(1): 12. DOI: 10.1186/s12917-021-03084-5.

35. Wang, X.Y., H.Q. Sun, and J.N. Yang (2021). Temporal-spatial analysis of an age-space structured foot-and-mouth disease model with Dirichlet boundary condition. *Chaos*, **31**(5): 18. DOI: 10.1063/5.0048282.
36. Zhang, J., D. Li, W.P. Yang, Y. Wang, L.L. Li, and H.X. Zheng (2021). *Foot-and-mouth disease virus* VP3 protein acts as a critical proinflammatory factor by promoting Toll-like receptor 4-mediated signaling. *Journal of Virology*, **95**(23): 11. DOI: 10.1128/jvi.01120-21.
37. Zhu, Z.X., G.Q. Wang, F. Yang, W.J. Cao, R.Q. Mao, X.L. Du, X.L. Zhang, C.T. Li, D. Li, K.S. Zhang, H.B. Shu, X.T. Liu, and H.X. Zheng (2021). *Foot-and-mouth disease virus* viroporin 2B antagonizes RIG-I-mediated antiviral effects by inhibition of its protein expression (vol 90, pg 11106, 2016). *Journal of Virology*, **95**(13): 1. DOI: 10.1128/jvi.00545-21.

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 prioritisation (for Europe): October 2021: NB: Data in Table 1 (draft format) was discussed at the OIE/FAO FMD Reference Laboratory meeting and these analyses will be updated once the meeting minutes are agreed.



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:
 - **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.
 - **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.
 - **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).
- **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 next [WRLFMD residential training course on FMD diagnostic methods](#) is scheduled for May 2022.

Other resources

Podcasts (<http://www.fao.org/eufmd/resources/podcasts/en/>)

We have a constantly updated series of short podcasts relating to the FAST world:

- A series of videos on foot-and-mouth disease in English, Bulgarian, Greek and Turkish
- Leaflets on FMD in English, Turkish, Bulgarian and Greek, for the Thrace region
- Join our Telegram channel to receive EuFMD updates <https://t.me/eufmd>
- Find out who TOM is and why you need him

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

- [Public-private partnerships for Progressive Control of foot-and-mouth disease in endemic settings](#) - Joint GFRA // EuFMD Regional workshop for Africa will be held on 16-17 February 2022.
- Open Session 2022 - Digitalization and innovation applied to the prevention and control of foot-and-mouth and similar transboundary animal diseases (FAST) – it will be held on 26, 27, 28 October 2022. <https://www.eufmd.info/os22>

Proficiency test scheme organised by WRLFMD

Phase XXXIII of the WRLFMD proficiency testing scheme (PTS) is underway. Two panels have been prepared and are being dispatched to participating laboratories. Panel 1 (available as either "live" FMDV or inactivated FMDV) will test virological methods, while Panel 2 will evaluate serological assays. Particular tests and assays are not specified: however, laboratories must select appropriate tests, and use them to interpret the status of the samples. We expect that labs will employ test systems in their laboratories to address the scenarios that accompany these samples. Further updates on the progress of this PTS will be described in future quarterly reports.



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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, Whatsapp, Quarterly Global Reports, Real Time Training.

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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