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



THE
Pirbright
INSTITUTE
www.pirbright.ac.uk

FMD vaccine update

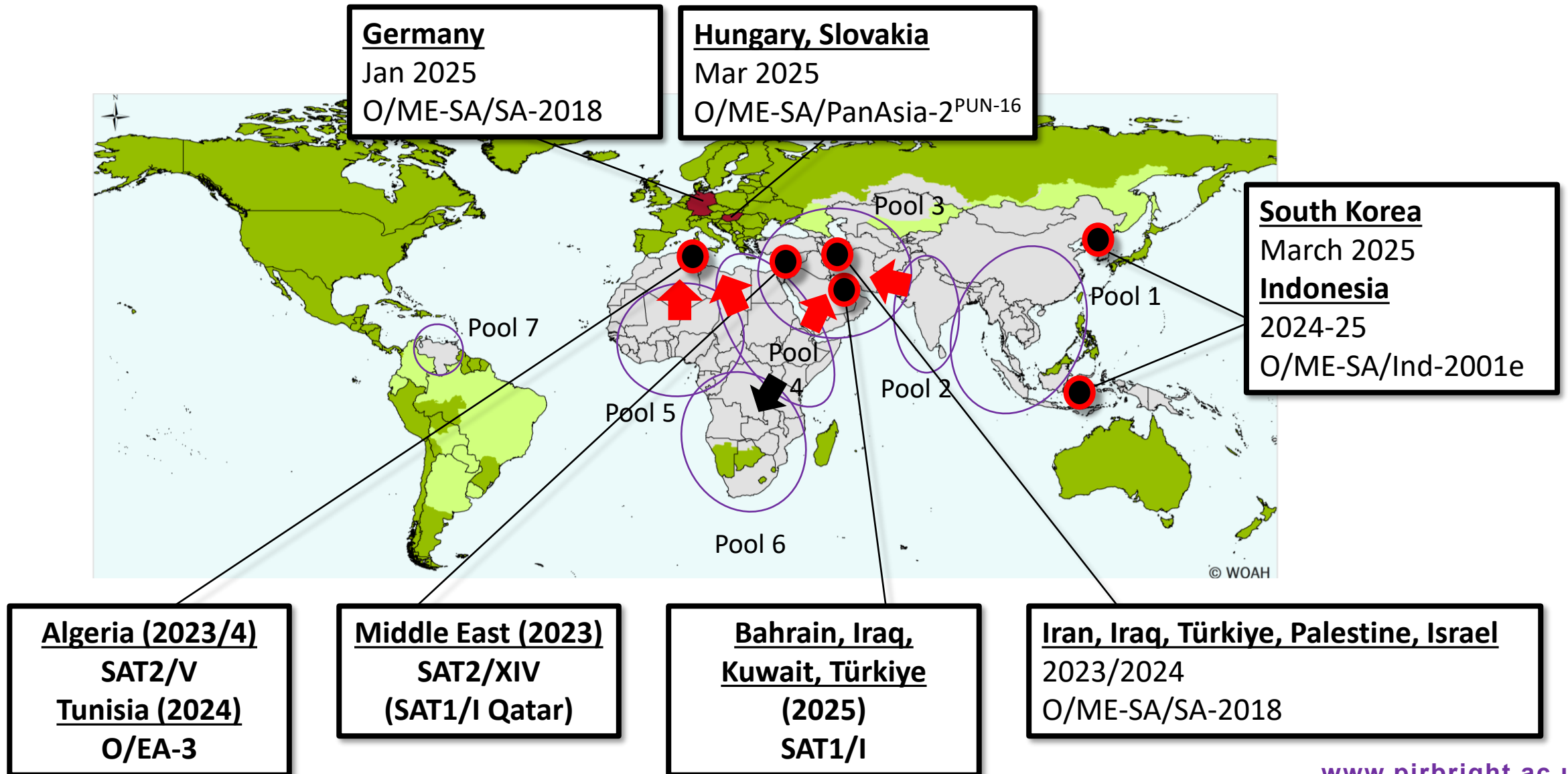
Anna Ludi

FAO World Reference Laboratory for FMD

WOAH Reference Laboratories for FMD and SVD

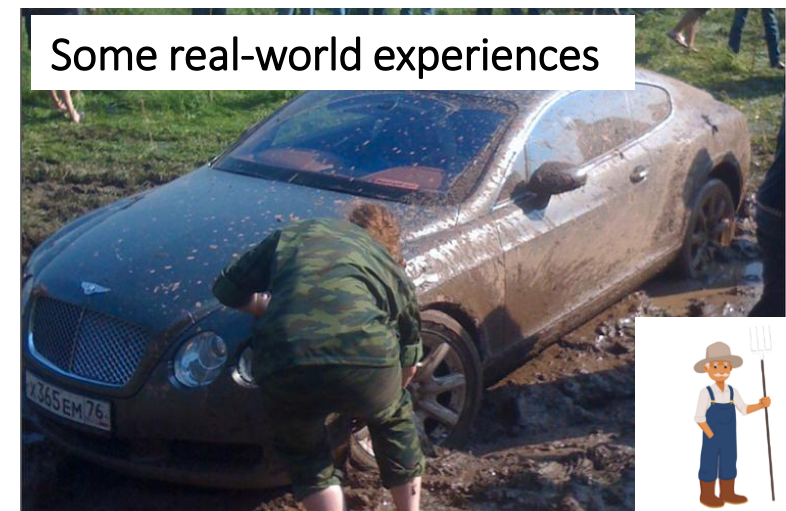
anna.ludi@pirbright.ac.uk

Headline global status for FMD



FMD Vaccines

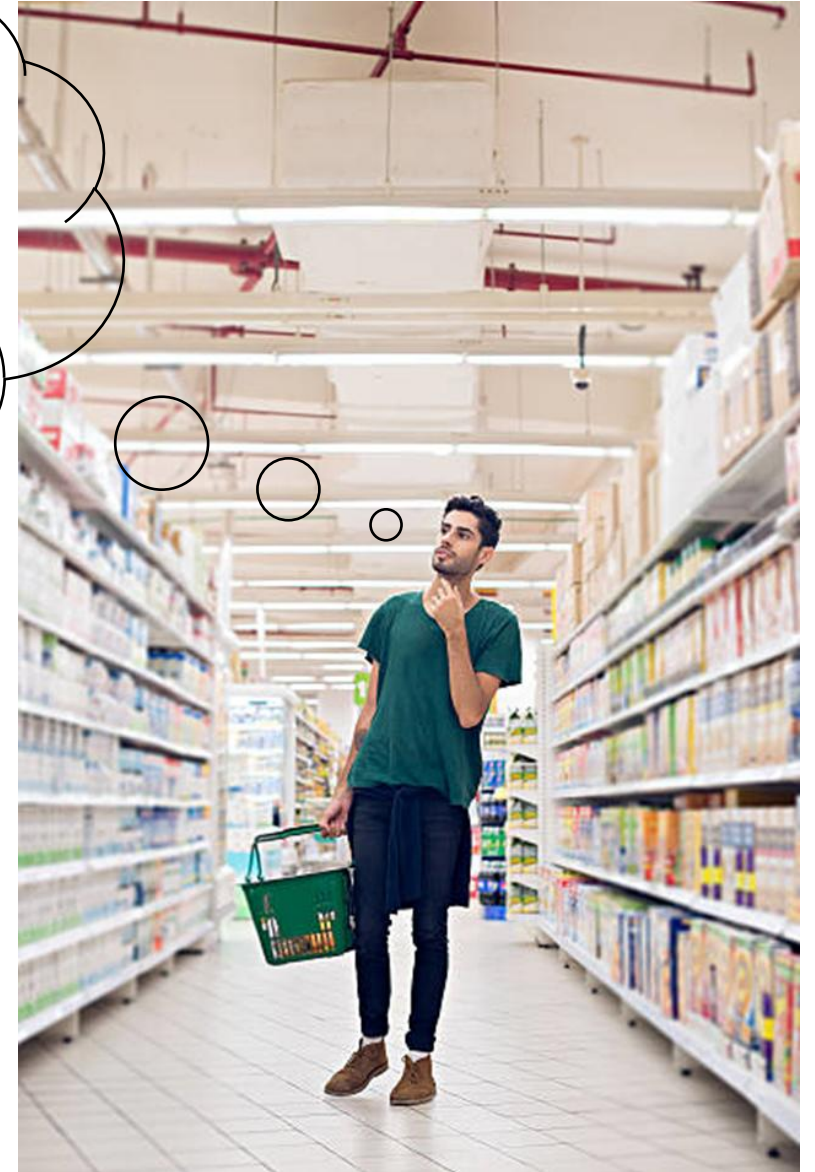
- > 2 billion doses administered annually!
- Success in Europe and South America show that vaccination is an important tool to control and eradicate FMD
- ...but we know there are bad vaccines out there...



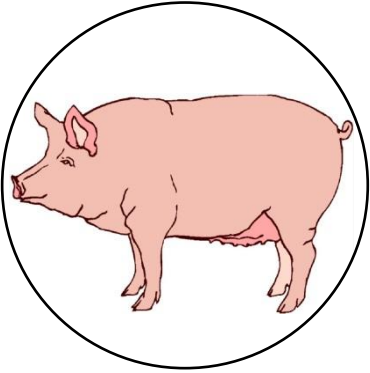
Which FMD vaccine should I purchase?



- How can I ensure that a FMD vaccine is fit for purpose? (i.e. will it be efficacious for the specific viruses that threaten livestock)

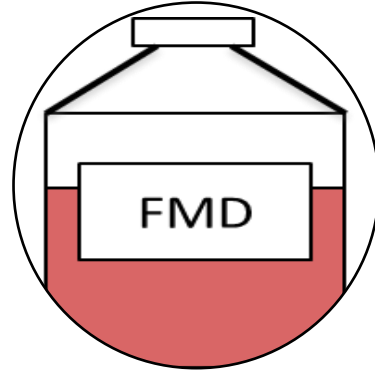


Reasons for vaccination “failure”



Host-related

- Immunodeficiency
- Suboptimal immune response
- Immature immune system
- Poor health
- Waning immunity
- Immunological interference
- Incubating infection



Vaccine-related

- Low potency or efficacy
- Incorrect serotype
- Poor match to field strain of same serotype
- Interference from other vaccines
- Manufacturer problems (e.g. poor quality batch)



Incorrect usage

- Incorrect dose or route of administration
- No booster vaccination
- Poor storage (e.g. cold chain issues)
- Beyond expiry date of product



Programme problems

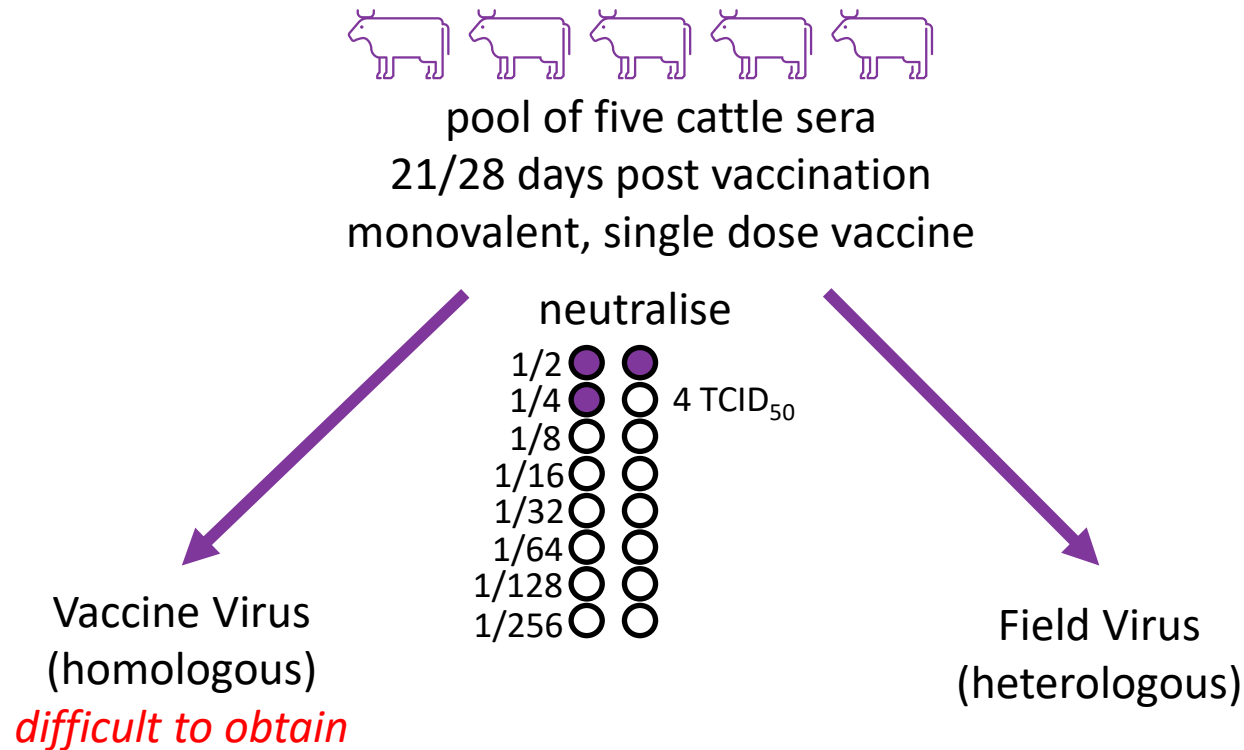
- Vaccine availability
- Incorrect timing (e.g. relative to high risk period)
- Suboptimal schedules (number and timing of doses) and coverage

VACCINE FAILURE

FAILURE TO VACCINATE

Vaccine Matching

- Compares the ability of defined bovine vaccinal sera (BVS) to neutralise field strains vs a **single** homologous vaccine strain



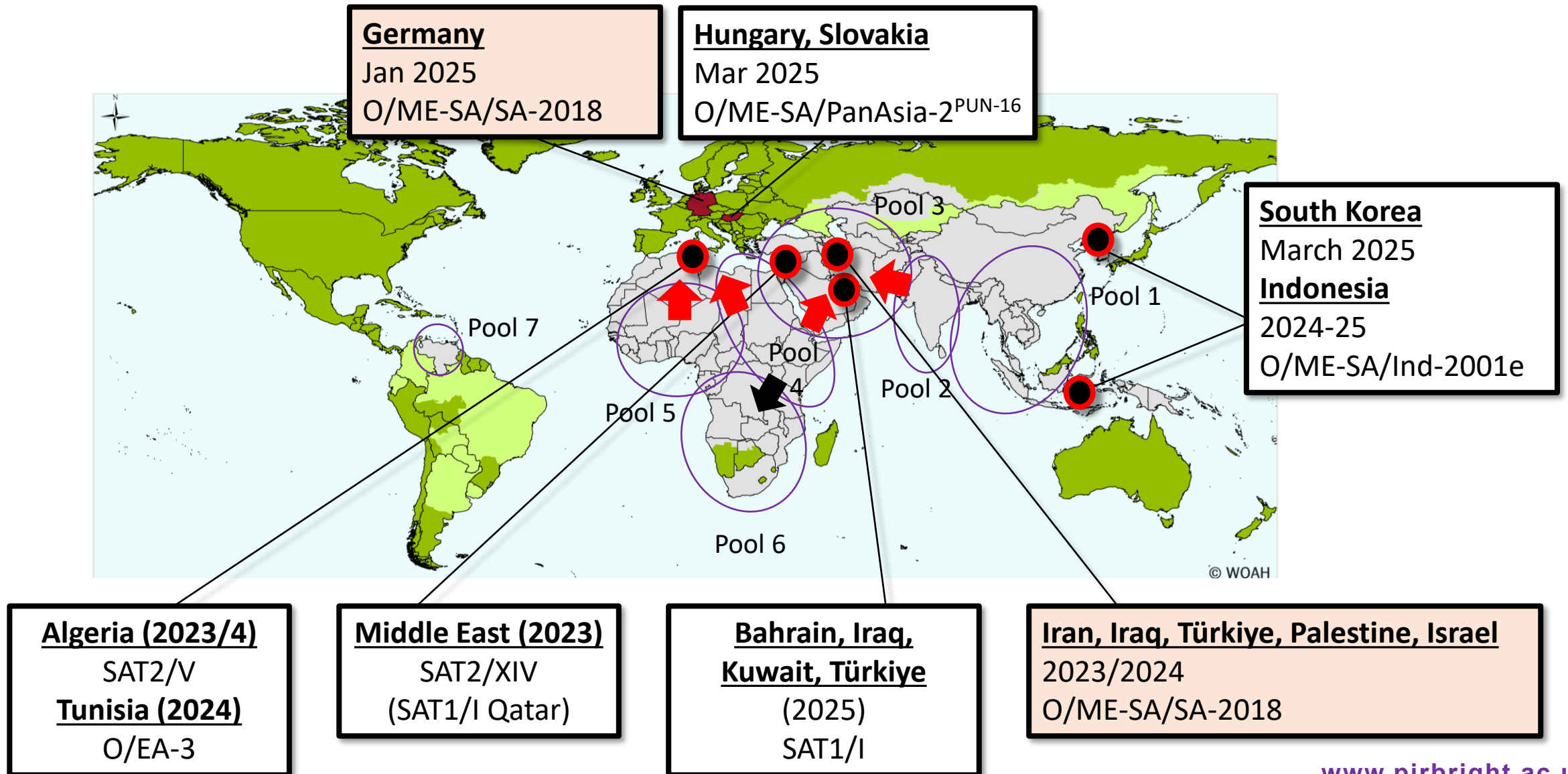
Vaccine Matching

Relationship coefficient (r_1 -value)

$$\frac{\text{antibody titre of ref. serum against field isolates (heterologous)}}{\text{antibody titre of ref. serum against vaccine strain (homologous)}}$$

- r_1 -value ≥ 0.3 - suggest that there is a close relationship between the field isolate and vaccine strain. A potent vaccine containing this vaccine strain is likely to confer protection
- r_1 -value < 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
- Used by vaccine banks where high potency monovalent vaccine would be used

Headline global status for FMD



Vaccine Matching - O/ME-SA/SA-2018

- History tells us that pandemic serotype O lineages emerge from Pool 2
- O/ME-SA/SA-2018 lineage originates in Pool 2 (India, Nepal, Bangladesh and Sri Lanka)
 - Lineage estimated to represent ~ 40% of serotype O cases in India
- 2021: introduction into Pool 3 - UAE and Oman in small ruminants
- 2023-2024: further evidence for infection in Iran, Palestinian AT and Türkiye
- 2025: detected in Iraq and Israel
 - Sequences from Palestine/Israel are distinct to those from Türkiye, Iraq and Iran (~4% nt dif.)
- Data support multiple recent introductions of this lineage from Pool 2**

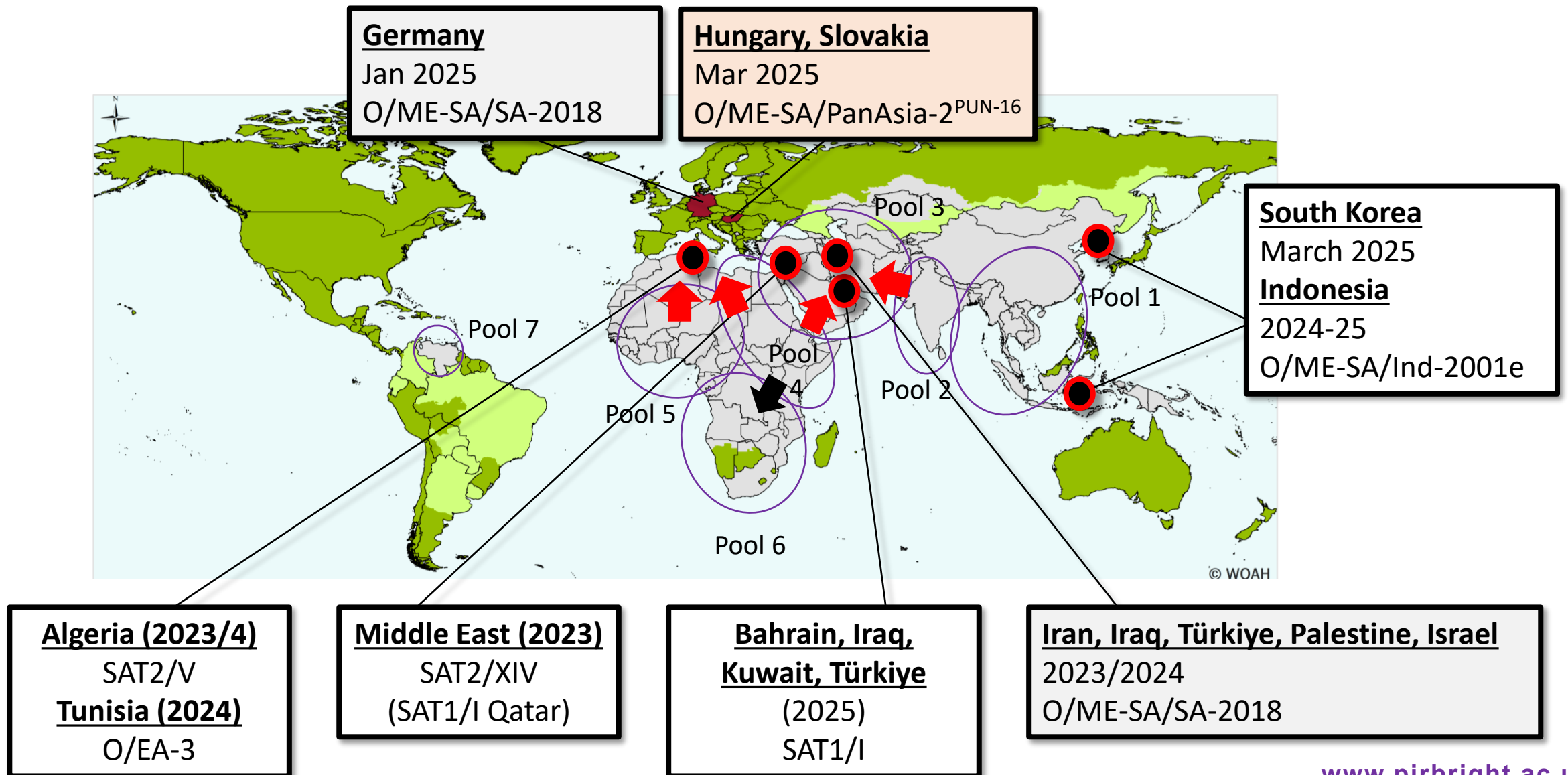


Vaccine Matching data is available for 9 field isolates from the O/ME-SA/SA-2018 lineage



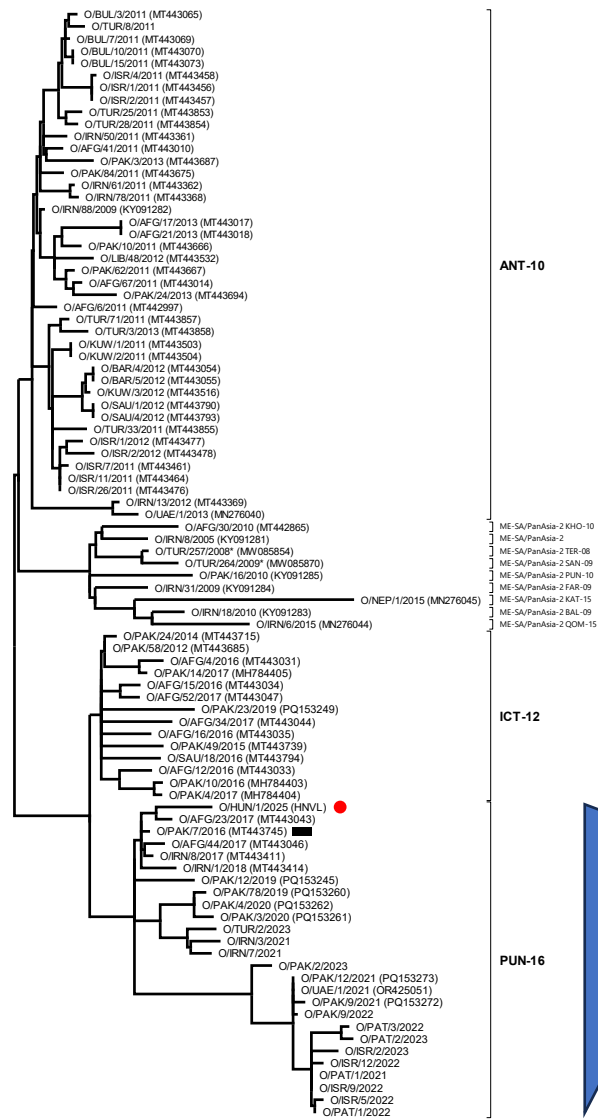
Isolate	O1-Manisa ^{BI}		O-TUR/5/09 ^{MSD}		O-3039 ^{BI}		O-Campos ^{BI}		O-PanAsia-2 ^{BI}		O-Campos ^{BB}	
	r1value	heterologous titre (log ₁₀)	r1value	heterologous titre (log ₁₀)	r1value	heterologous titre (log ₁₀)	r1value	heterologous titre (log ₁₀)	r1value	heterologous titre (log ₁₀)	r1value	heterologous titre (log ₁₀)
UAE/15/2021	0.56	2.15	0.69	2.32	0.75	1.94	0.28	2.19	0.47	2.30	0.51	2.63
UAE/9/2021	0.44	2.04	0.68	2.32	0.59	1.83	0.23	2.10	0.32	2.13	0.60	2.70
NEP/13/2022	0.63	2.33	1.00	2.32	1.00	2.02	0.40	2.28	0.57	2.35	0.51	2.65
NEP/26/2022	0.32	2.04	0.68	2.15	0.66	1.82	0.23	2.03	0.32	2.10	0.20	2.29
NEP/38/2022	0.98	2.45	0.89	2.29	0.84	2.00	0.45	2.17	0.50	2.31	0.66	2.71
NEP/13/2024	0.88	2.40	0.78	2.23	0.82	1.99	0.74	2.27	0.99	2.49	0.68	2.72
IRQ/10/2025	0.73	2.23	0.62	2.23	0.46	1.87	0.38	2.22	0.50	2.21	0.59	2.64
IRQ/21/2025	0.70	2.22	0.71	2.29	0.64	2.01	0.39	2.23	0.54	2.24	0.50	2.56
GER/1/2025	1.00	2.41	0.97	2.37	0.84	1.96	0.48	2.06	0.56	2.15	0.58	2.44

Headline global status for FMD



Vaccine Matching – O/ME-SA/PanAsia-2^{PUN-16}

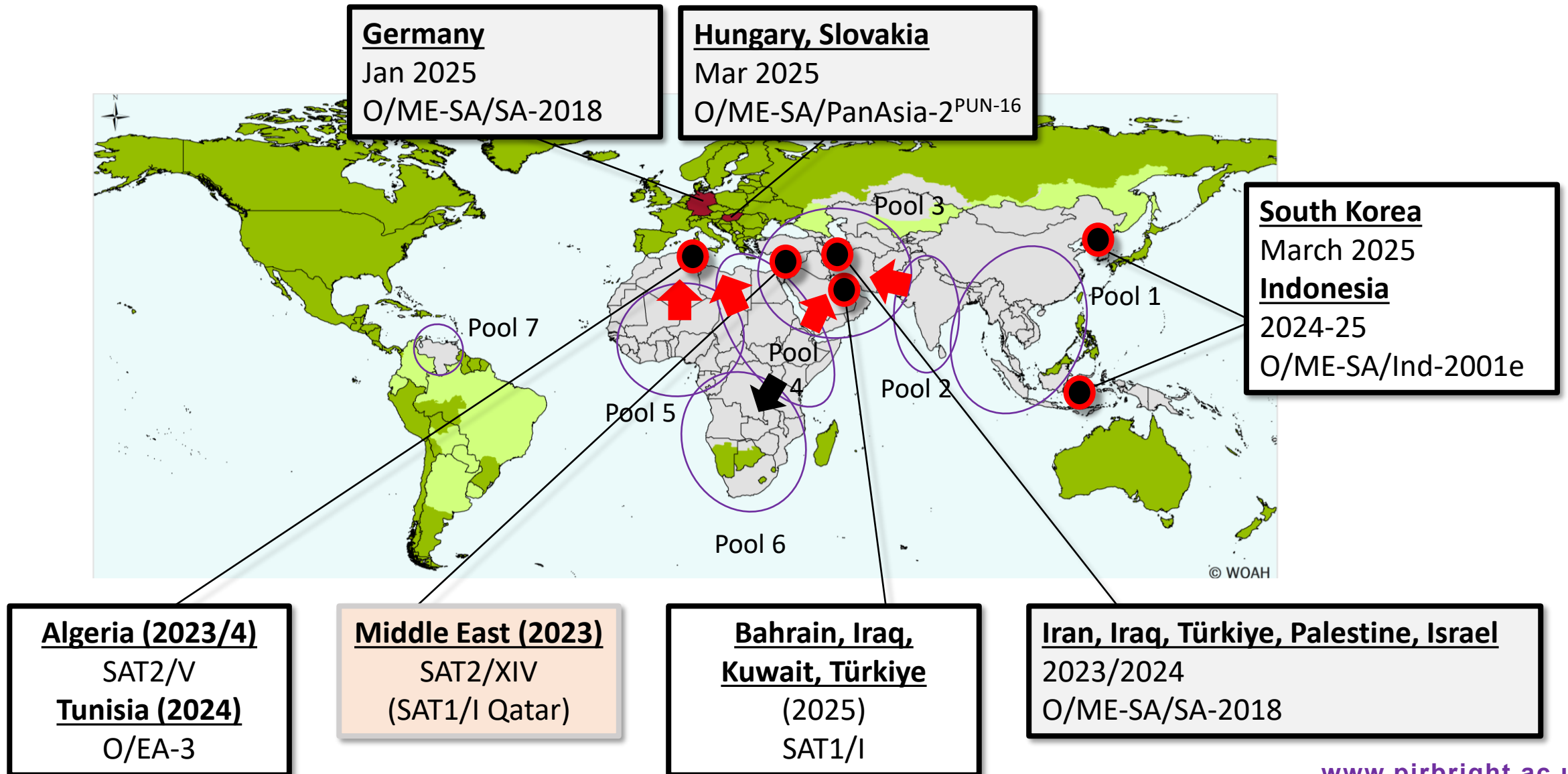
Vaccine Matching data is available for 78 isolates from the ANT-10 lineage
Data in table is for clade most closely related to **HUN/1/2025** (O/ME-SA/PanAsia-2^{PUN-16})



Isolate	O-Manisa ^{BI}		O-TUR/5/09 ^{MSD}		O-3039 ^{BI}		O-Campos ^{BI}		O-PanAsia-2 ^{BI}		O-Campos ^{BB}	
	r ₁ value	titre	r ₁ value	titre	r ₁ value	titre	r ₁ value	titre	r ₁ value	titre	r ₁ value	titre
AFG/23/2017	0.72		0.74		0.46							
AFG/44/2017	0.36		0.65		0.44							
IRN/8/2017	0.29	1.87	0.52	1.71	0.43	1.57						
IRN/1/2018	0.37	1.95	0.34	1.83	0.58	1.66						
PAK/12/2019	0.50	2.20	0.76	2.11	0.66	1.79			0.32	2.00		
PAK/78/2019	0.32	2.03	0.49	1.99	0.33	1.56	0.36	1.97	0.41	2.14	0.40	2.42
PAK/3/2020	0.40	1.94	0.98	2.1	0.55	1.71			0.36	2.05	0.56	2.19
PAK/4/2020	0.07	1.41	0.59	2.07	0.11	1.10	0.26	1.83	0.34	2.03	0.39	2.41
TUR/2/2023	0.34	1.86	0.67	2.05	0.33	1.60	0.25	1.88	0.34	2.06	0.56	2.56
IRN/3/2021	0.22	1.95	0.63	2.12	0.58	1.84			0.26	2.02	0.59	
IRN/7/2021	0.31	1.94			0.50	1.78			0.22	1.95	0.48	2.46
PAK/2/2023	0.35	1.98	0.90	2.22	0.41	1.80	0.36	2.00	0.36	2.01	0.35	2.48
PAK/12/2021	0.25	2.06	0.78	2.34	0.81	1.87	0.25	1.95	0.32	2.19	0.42	2.53
UAE/1/2021	0.48	2.08	0.44	2.13	0.38	1.64	0.19	2.02	0.32	2.14	0.43	2.56
PAK/9/2021	0.19	1.94	0.30	1.92	0.45	1.61	0.15	1.72	0.32	2.19	0.47	2.58
PAK/9/2022	0.28	1.91	0.26	1.88	0.41	1.79	0.16	1.66	0.27	1.88	0.13	2.04
PAT/3/2022	0.52	1.90	0.59	2.02	0.65	1.82	0.29	1.79	0.27	1.93	0.51	2.43
PAT/2/2023	0.37	1.76	0.58	2.01	0.52	1.62	0.30	1.76	0.15	1.68	0.34	2.26
ISR/2/2023	0.32	1.85	0.47	1.84	0.38	1.74	0.26	1.75	0.28	1.80	0.45	2.40
ISR/12/2022	0.38	1.89	0.43	1.81	0.32	1.66	0.24	1.72	0.34	1.90	0.59	2.52
PAT/1/2021	0.40	2.01	0.72	2.31	0.53	1.78	0.29	2.01	0.53	2.15	0.36	2.46
ISR/9/2022	0.33	1.97	0.54	2.16	0.57	1.76	0.25	1.92	0.39	2.18	0.58	2.51
ISR/5/2022	0.33	1.97	0.57	2.18	0.48	1.69	0.18	1.78	0.32	2.09	0.42	2.37
PAT/1/2022	0.50	2.10	0.60	2.23	0.56	1.79	0.26	1.95	0.64	2.23	0.51	2.61

Note: New O/ME-SA/PanAsia-2 designations are shown proposed by Jamal et al., (2025) Emergence of new sublineages of serotype O foot-and-mouth disease viruses circulating in Pakistan during 2012-2021. *Virology* **605**: 110455

Headline global status for FMD

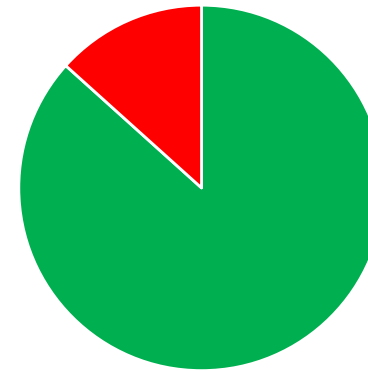


Vaccine Matching – SAT2/XIV

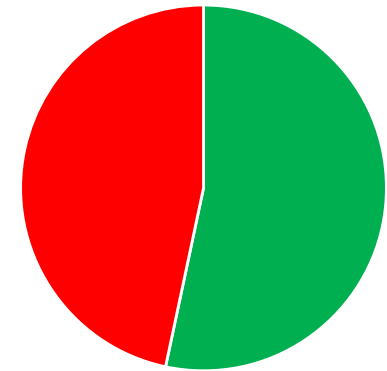
- Prior to 2023, SAT2 vaccines were not widely used in the region
- Vaccine matching results from Pirbright (n=15):

	SAT2 Eritrea 98 - BI		SAT2 Zim 83 - BI	
	r1-value	titre	r1-value	titre
ETH/2/2022	0.81	1.62	0.54	2.17
ETH/3/2022	0.49	1.66	0.15	1.7
IRQ/2/2022	0.73	1.75	0.38	2.04
IRQ/5/2023	0.53	1.61	0.74	2.33
IRQ/9/2023	0.42	1.51	0.31	1.95
JOR/11/2023	0.58	1.69	0.2	1.74
JOR/20/2023	0.83	1.85	0.24	1.81
JOR/26/2023	0.86	1.86	0.32	1.94
BAR/2/2022	0.4	1.5	0.39	1.85
BAR/7/2022	0.53	1.62	0.53	1.99
TUR/4/2023	1	1.68	0.31	1.95
TUR/17/2023	0.72	1.52	0.25	1.86
ETH/11/2022	0.33	1.58	0.18	1.88
ETH/105/2022	0.26	1.49	0.17	1.87
ETH/1/2023	0.27	1.49	0.1	1.64

SAT2-Eritrea-98 (BI)



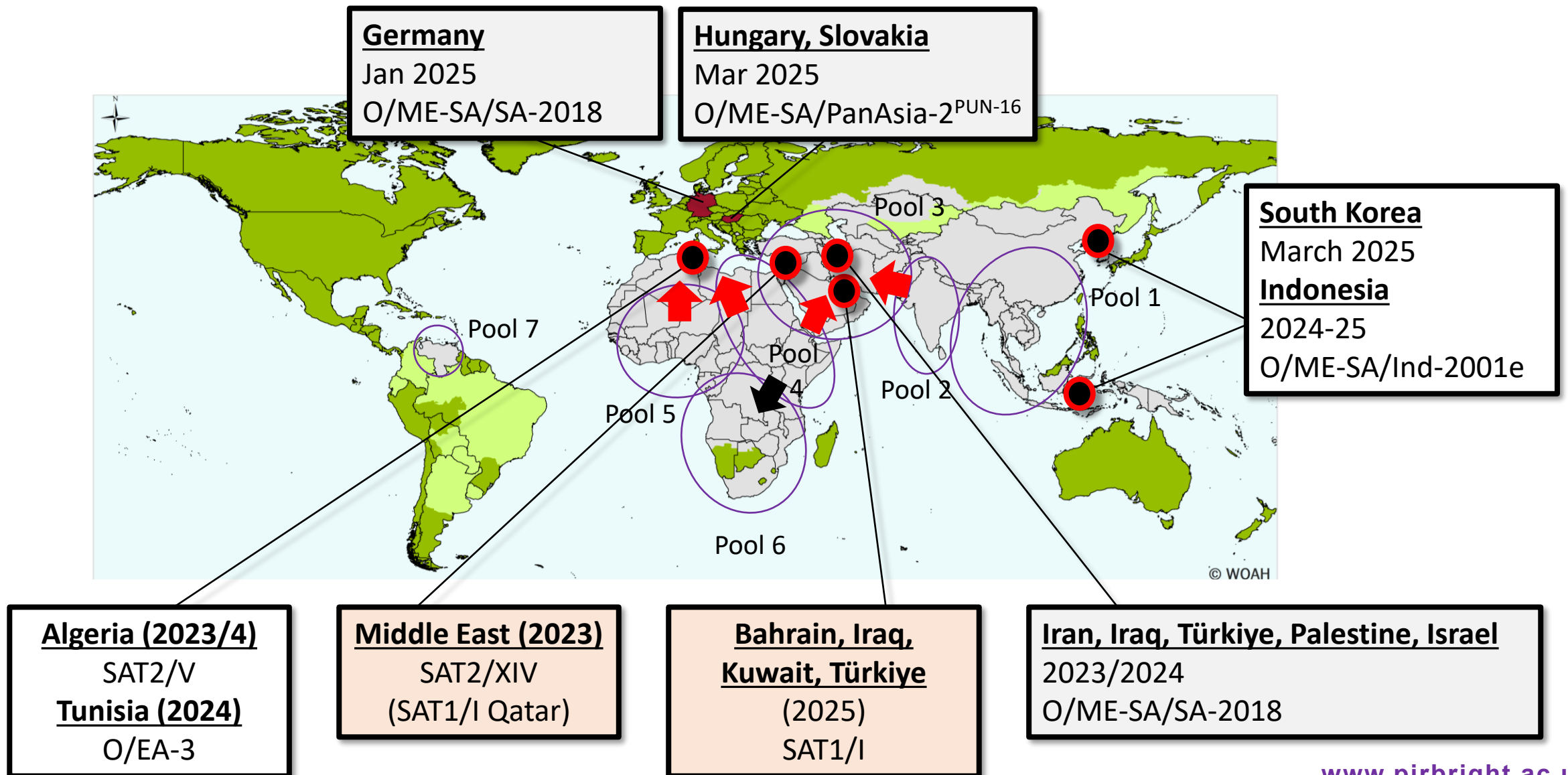
SAT2-Zim 7/83 (BI)



■ Matched
■ Not matched

New SAT 2 vaccine from Biogenesis Bago (SAT2 Oman/2015) also tested for six isolates with encouraging results

Headline global status for FMD



Vaccine Matching - SAT1/I

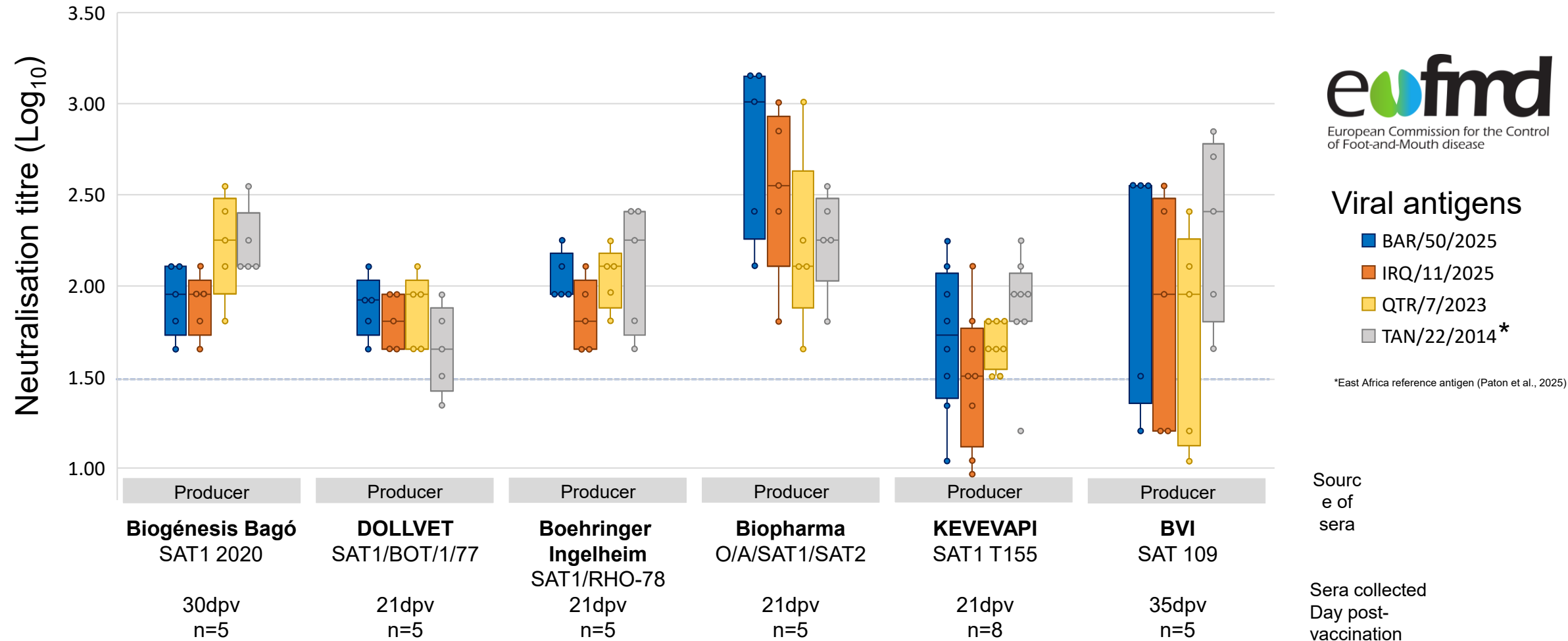
- Limited vaccines are available for this serotype (SAT1/Rho78^{BI})

Isolate	SAT1/Rho78 ^{BI}	
	r1value	heterologous titre (log ₁₀)
BAR/37/2025	0.31	2.20
BAR/50/2025	0.39	2.30
IRQ/1/2025	0.26	2.13
IRQ/11/2025	0.19	2.00
QTR/6/2023	0.42	2.34
QTR/7/2023	0.61	2.50

Further evidence via heterologous testing for other vaccines by VNT (not vaccine matching)

- Additional sera raised against SAT 1 vaccine viruses tested by VNT
- Sera included: BVI, Boehringer Ingelheim, Biogenesis Bago, KEVEVAPI and Dollvet
- Viruses: Iraq, Bahrain, Qatar and East African ancestor (n=4)

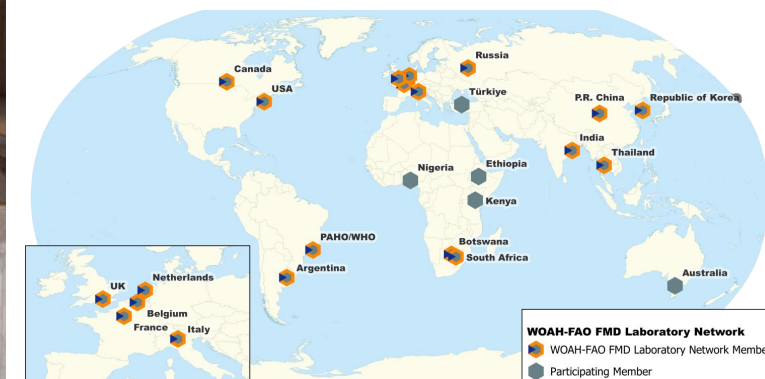
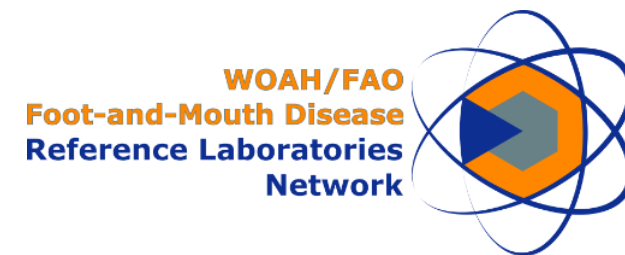
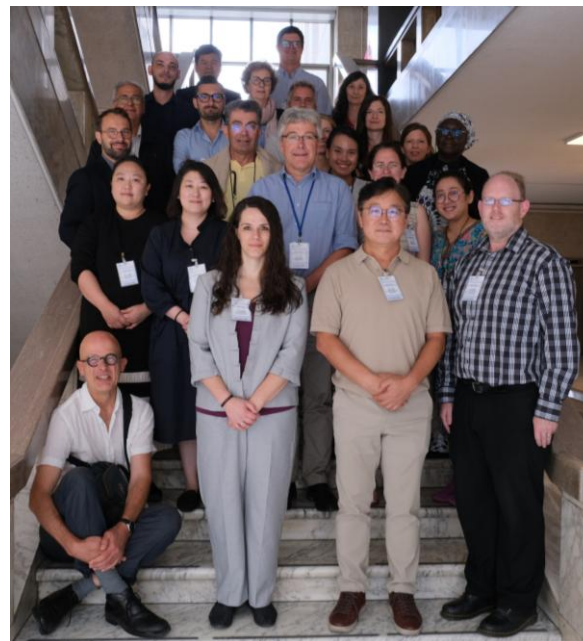
Heterologous responses of SAT1 vaccines against SAT1/I field isolates



NB: Some of the sera used for this testing was generated from trial-blends of vaccines and therefore customers are advised to carry out in-country testing with the final formulated product to confirm that responses in vaccinated animals achieve these levels of FMDV-specific antibody.

WOAH/FAO FMD Laboratory Network for FMD

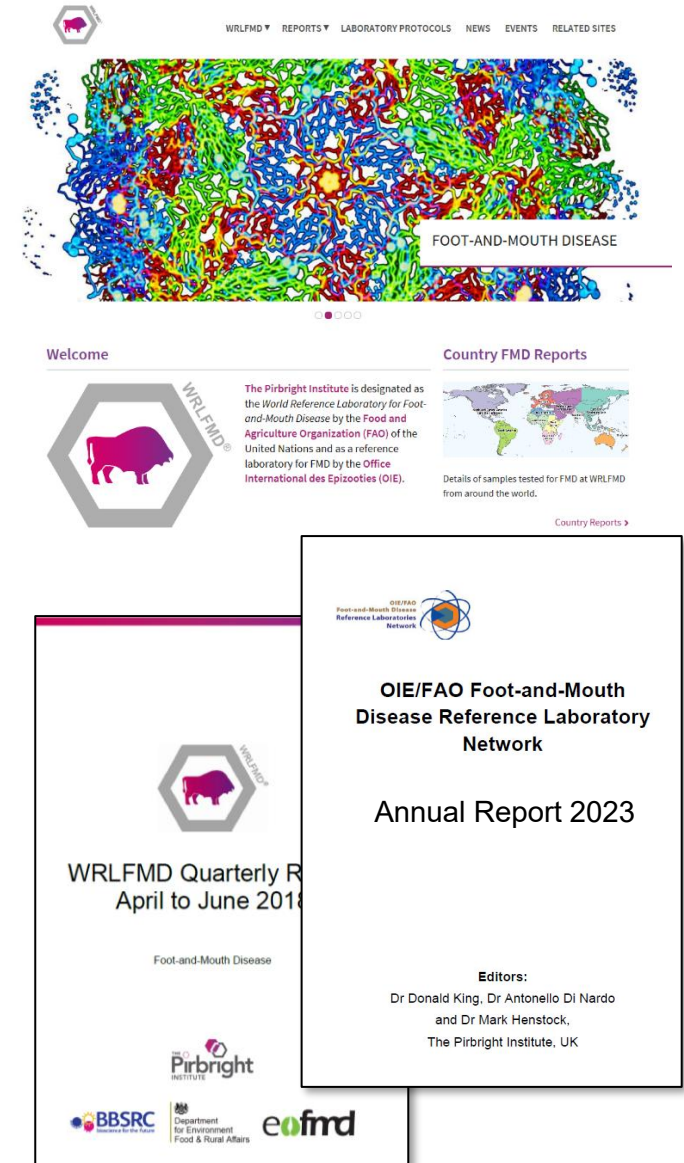
- WRLFMD/Pirbright are the Secretariates
- 5 WOA and FAO laboratories + “affiliates”
- Core activities of the Network:
 - **Using data shared between partners... to understand global epidemiology of FMDV and use these data to inform vaccine recommendations**
 - To harmonise and improve the quality of laboratory testing
 - Support to regional roadmaps of GF-TAFDS



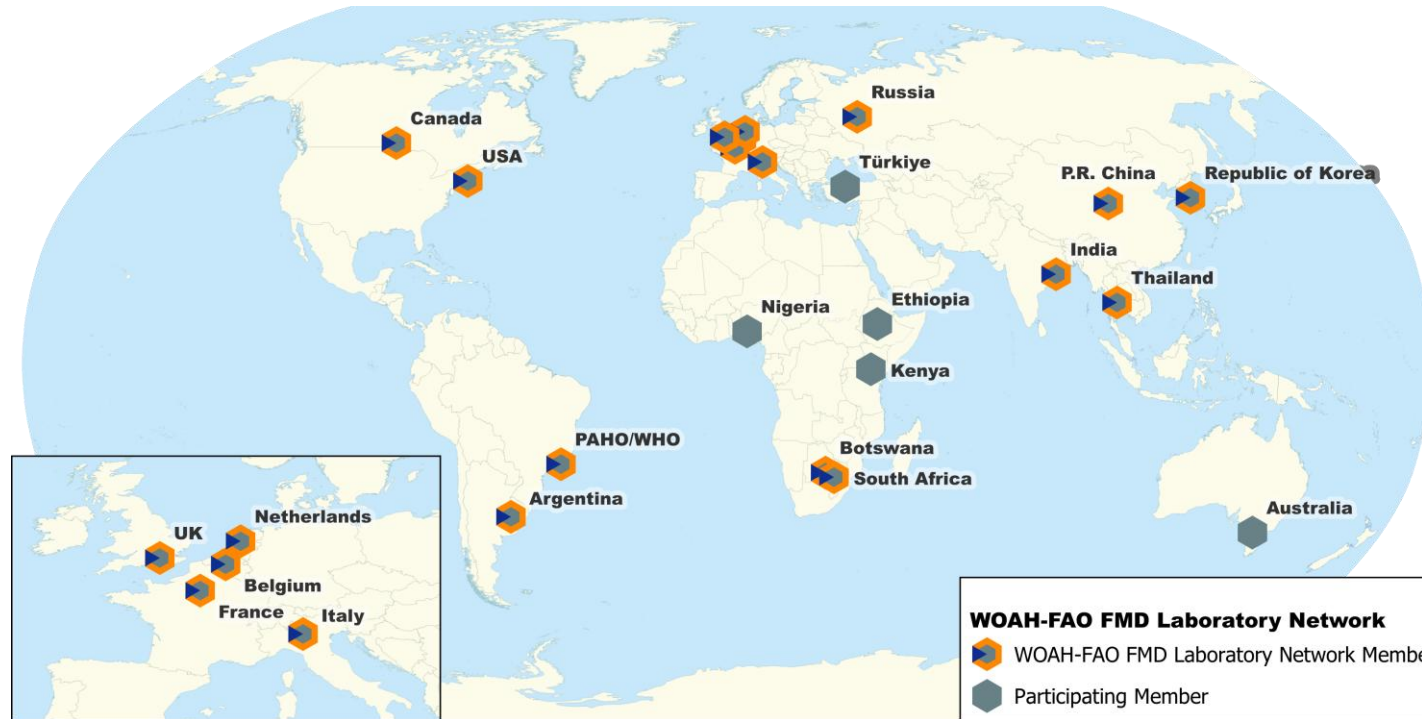
Network Meeting, Rome, September 04

Further Information...

- FMD reports and lab testing (<https://www.wrlfmd.org/ref-lab-reports>)
 - Genotyping reports, Vaccine matching and Serotyping reports
- Other data sources:
 - Quarterly WRLFMD/EuFMD report (<https://www.wrlfmd.org/ref-lab-reports>)
 - Annual report of the WOA/FAO FMD Laboratory Network (<http://foot-and-mouth.org/>)
 - OpenFMD (www.openfmd.org) – sequences, genotyping, vaccine selection and surveillance



THANK YOU!



& all the organisations (including vaccine companies, governments, private farms and individuals) that send valuable serological and virological samples for evaluation and provide valuable insight.