ANNUAL REPORT 2021

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ICAR

ICAR-Directorate of Foot and Mouth Disease
ICFMD, Arugul, Bhubaneswar-752050

DFMD
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ICAR-Directorate of Foot and mouth Disease

ANNUAL REPORT 2021

International Centre for Foot and Mouth Disease
Arugul, Bhubaneswar-752050

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PREFACE

FMD is a well-known and economically destructive infectious disease that affects cloven-hoofed animals. In India, the disease is endemic, with three FMDV serotypes (O, A, and Asia1) and multiple genetic groups in circulation. Despite ongoing surveillance, no new cases of FMDV serotype C have been reported since 1995. Serotypes SAT 1, 2, and 3 of FMDV were never found in the country. ICAR-DFMD is recognised as 'FAO Reference Centre for FMD' and serves as the National Referral Laboratory for the disease. FMD surveillance in India is carried out by a countrywide network of 30 FMD regional and collaborating centres, which are supported by the DAHD, GoI and run under the auspices of the ICAR-DFMD, Bhubaneswar. The state FMD centre also carry out numerous programmes of ICAR under the NEH, SCSP, and TSP schemes.

The Network laboratories use sandwich ELISA to serotype the clinical materials gathered from suspected outbreaks/cases, and the clinical samples are then sent to ICAR-DFMD for comprehensive characterisation of virus isolates. Regularly, Molecular epidemiological study based on the P1/1D gene sequence and vaccine matching studies of the virus from field outbreaks with vaccination strains are carried out to monitor antigenic changes, if any, occurring in the field. The institute and state FMD laboratories analysed a considerable number of serum samples under the NADCP for DIVA-serosurveillance and post vaccination seromonitoring (PVM), and the results were sent to the DAHD, GoI. ICAR-DFMD also took part in vaccine quality control (QC) testing. Since 2003-04, the institute has provided all technical/laboratory and diagnostic support to the DAHD, GoI's FMD Control Program. Several new initiatives were undertaken in 2021, including the systematic monitoring of the NSP DIVA reactor and the alteration of the SPCE cut-off. The institute's staff also assisted in the development of an online module for DAHD's FMD seromonitoring and serosurveillance.

I express deep sense of gratitude to Dr T. Mohapatra, Hon'ble Secretary, DARE & DG, ICAR; Shri Sanjay Garg, Addl. Secretary, DARE & Secretary ICAR; Shri B. Pradhan, AS&FA, DARE; Dr B N Tripathi, DDG (AS), ICAR and Dr Ashok Kumar, ADG (AH), ICAR for providing all the necessary support & guidance in steering the Institute. Also, the help and support extended by Dr Jyoti Misri, Principal Scientist (AH), Dr Vineet Bhasin, Principal Scientist (AGB) and Dr Rajan Gupta, Principal Scientist (ANP) is duly acknowledged. The generous funding support from Shri Atul Chaturvedi, Secretary, DAHD under NADCP is gratefully acknowledged along with entire team including Dr Praveen Malik, Animal Husbandry Commissioner, Shri Upamanyu Basu, Joint Secretary (LH), Dr. Sujit Nayak, Joint Commissioner (NADCP) and Dr Anirban Guha, Assistant Commissioner (NADCP). The technical support from ICAR-NIVEDI for formulation of FMD seromonitoring and serosurveillance plan and administrative support from ICAR-IVRI, Mukteswar and Bengaluru are duly acknowledged. Untiring effort of a small group of young scientists in achieving new milestones at this institute and state FMD Laboratories is praiseworthy. I place on record my appreciation for Administration, Audit & Accounts, Technical, and Skilled support staff of the ICAR-DFMD for their excellent assistance in achieving the targets.

R. P. Singh
Director, ICAR-DFMD

ABOUT ICAR-DFMD

Genesis

ICAR-Directorate of Foot and Mouth Disease (FMD), the premier institute for FMD in the country, was established as an All India Coordinated Research Project (AICRP) for FMD in 1968. During about five decades of its existence the scope of the project has been expanded progressively and several milestones were achieved. The AICRP for epidemiological studies on FMD was upgraded to the Project Directorate on FMD in July -2001 and then renamed as Directorate of FMD since 2015-16 with 27 Regional and Collaborating centres covering all the major regions of the country. With the announcement of NADCP in 2019, the AICRP on FMD was concluded with effect from 31st March 2020. Since then, the state FMD laboratories are being operated through funding from DAHD, GoI under NADCP. The centres are also supported by funding under TSP, SCSP and NEH from ICAR, and knowledge and technical input from ICAR-DFMD. The Directorate has developed scientific expertise in conventional as well as in cutting edge areas, in the field of FMD diagnosis, epidemiology and research. The mandate of the institute is to carry out research on the epidemiology of FMD in the country and develop technologies to control the disease with ultimate goal of eradication. It is also entrusted with the duty of providing technical support and scientific input/information to the planners and strategy making agencies in planning control of FMD in the country and the SAARC region.

Important milestones

1929 Research on FMD was initiated in India.

1943 Vaccination of Indian cattle against FMD funded by ICAR.

1968 All India Co-ordinated Research Project (AICRP) for FMD virus typing.

1971 AICRP for Epidemiological studies on Foot-and-Mouth Disease.

1995 Virus serotyping ELISA was developed.

2001 Upgraded to Project Directorate on FMD

2003 Liquid Phase Blocking ELISA (LPBE) to estimate level of serotype specific antibodies was developed

2004 Nucleic acid-based virus detection method multiplex PCR (mPCR) was developed

2007 Constituent Laboratory of OIE/FAO FMD Reference Laboratories Network.

2008 PD-FMD became "FAO Reference Centre for FMD for South Asia".

2009

i. Member Laboratory of Global FMD Research Alliance (GFRA).
ii. Recombinant nonstructural protein (3AB3) based ELISA test was developed for differentiation of FMD infected from vaccinated animals (DIVA).
iii. Foundation stone laid for ICFMD, Bhubaneswar.

2010 SAARC Regional Leading Diagnostic laboratory of FAO.

2015 Institute upgraded to ICAR-Directorate of FMD (ICAR-DFMD).

2016 Solid Phase Competitive ELISA (SPCE) to estimate level of serotype specific antibodies was developed.

2017 Inauguration of International Centre for FMD (ICFMD), Bhubaneswar.

2021 ICAR-DFMD became "FAO Reference Centre for FMD".

Vision, Mission, Objectives and Technical Programme

Vision:

India free from Foot and Mouth Disease.

Mission:

Active epidemiological surveillance through regularly monitoring antigenic and genomic make up of Foot and Mouth Disease virus strains responsible for disease incidences, to provide training in diagnosis and epidemiology, and to develop technologies for making country free from FMD.

Mandate:

- Surveillance, epidemiology through systematic monitoring of antigenicity and genomic make of FMD virus strains
- Repository and capacity development

Objectives:

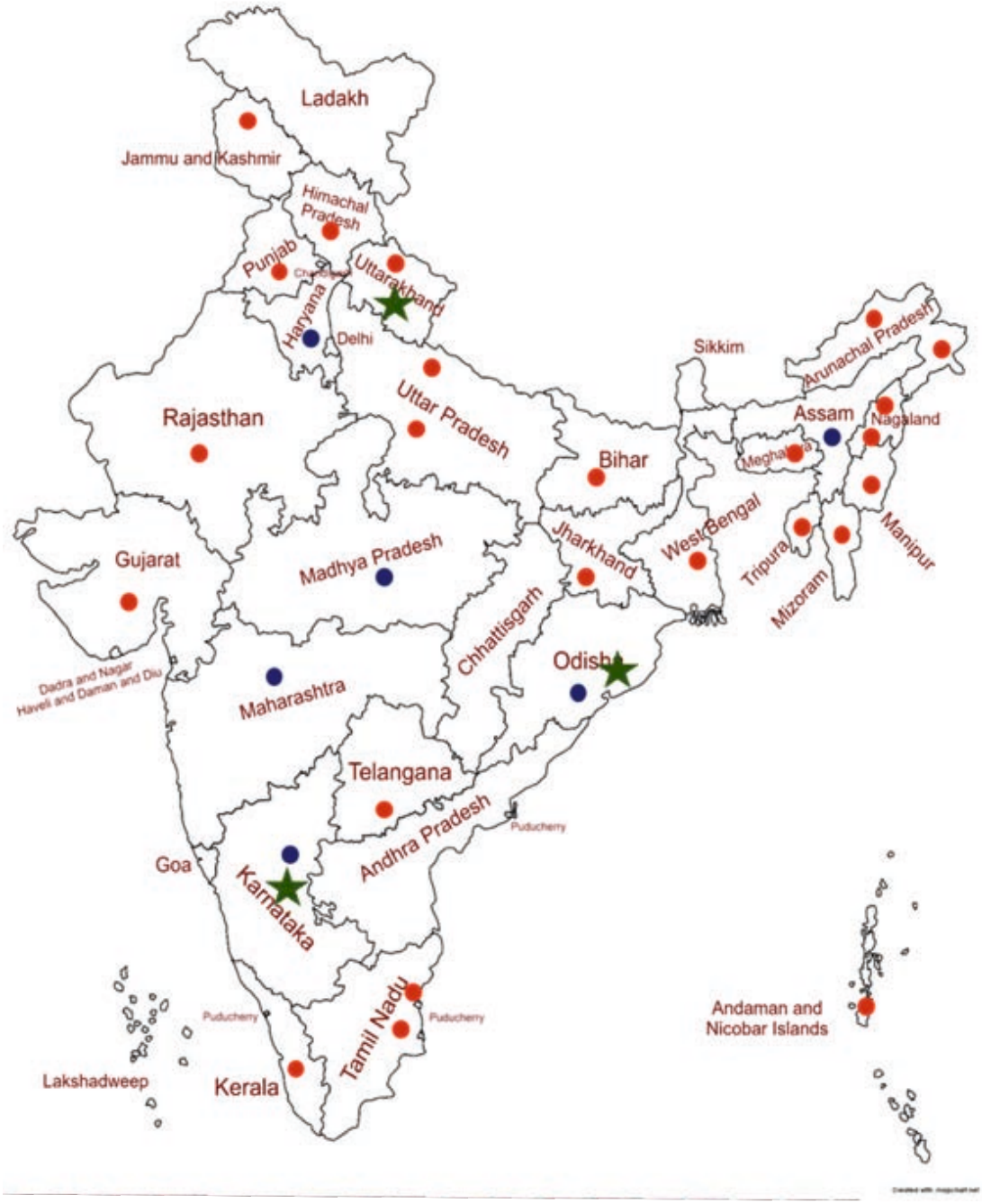
1. To conduct systematic epidemiological and molecular epidemiological studies on Foot-and- Mouth Disease (FMD), and also to study carrier status of the infection and latency of the virus.
2. Antigenic and molecular characterization and cataloguing of FMD virus strains isolated from incidences, and monitoring suitability of the vaccine strains in use along with maintenance of National Repository of FMD Virus.
3. Production, standardization and supply of diagnostic reagents for FMD virus serotyping and post-vaccinal seroconversion.
4. Maintenance and supply of most appropriate vaccine strain to the FMD vaccine manufacturers.
5. Development of newer diagnostic techniques using cutting-edge technologies in molecular biology.
6. To act as FAO Reference Centre for FMD.

Technical Programme:

1. Active and passive surveillance of FMD in the country in network mode
2. To carryout antigenic and molecular characterization of field isolates.
3. To study molecular epidemiology of FMD in India.
4. Confirmatory diagnosis and expert advice.
5. To carryout vaccine matching exercise for monitoring of appropriateness of in-use vaccine strains.
6. Maintenance of National Repository of FMD virus isolates.
7. Production, standardization and supply of diagnostic kits for FMD virus diagnosis, sero-monitoring and serosurveillance.
8. To develop and standardize advanced laboratory techniques in compliance with the International standards and pass them on to the concerned Centres/ Users/ Stakeholders with proforma details to facilitate and ensure their uniform application.
9. To organize skill orientation programme for the scientific staff of the project for keeping them abreast with the latest knowledge and expertise from time to time through short-term training courses
10. Participation in FMD Control Programme with vital contribution in monitoring pre and post vaccinal antibody response for assessment at individual and herd immunity level.
11. National FMD Serosurveillance
12. International collaborations in the areas of interest.

Location of FMD laboratories

Red dot (●) represent collaborating centres (n=24), blue (●) represent regional centres (n=6) and Green (★) denotes DFMD Laboratories



Designation and geographical indicators of regional centres

Regional Centres	State/Geographies
Hisar	Haryana, Punjab, Himachal Pradesh, Uttarakhand, Jammu & Kashmir (UT), Ladakh (UT), Chandigarh (UT)and Delhi(UT)
Bhopal	Madhya Pradesh, Uttar Pradesh and Chhattisgarh
Pune	Maharashtra, Gujarat, Rajasthan, Goa and Dadra and Nagar Haveli and Daman and Diu(UT)
Cuttack	Odisha, Bihar, West Bengal and Jharkhand
Guwahati	Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Tripura, Nagaland and Sikkim
Bengaluru	Karnataka, Tamilnadu, Kerala, Telangana, Andhra Pradesh, Lakshadweep (UT), Puducherry (UT)and A& and N Islands (UT)

Scientific Staff Positions and Vacancy

Name of Discipline	Scientist		Senior Scientist		Principal Scientist	
	Sanctioned	In position	Sanctioned	In position	Sanctioned	In position
Agricultural Bioinformatics	1	-	-	-	-	-
Animal Biochemistry	1	1	1	-	-	-
Animal Biotechnology	2	2	-	-	-	-
Animal Physiology	1	1	-	-	-	-
Animal Genetics & Breeding	1	1	-	-	-	-
Veterinary Microbiology	8	2	2	1	2	-
Veterinary Pathology	2	3	1	1	-	-

1.0 EXECUTIVE SUMMARY

- Using sandwich ELISA and multiplex PCR, 2824 clinical samples were analyzed for serotype identification in 378 from FMD outbreaks. During 2021, all three FMD virus serotypes were documented, with serotype O leading the outbreak scenario followed by serotype A. Overall, the disease incidences have increased compared to previous year
- A total of 113 FMD virus isolates (102 serotype O, 10 serotype A and 1 serotype Asia 1) revived in BHK-21 cell system were added to the ever growing National Repository of FMD Virus maintained at International Centre for FMD, Bhubaneswar and Mukteswar Laboratory
- The capsid coding region (P1/VP1) sequences of 68 FMD viral strains were inferred and added to the sequencing database of Indian FMD viruses (54 serotype O, 13 serotype A and 1 serotype Asia1). In serotype O, dominance of the O/ME-SA/Ind2001e and O/ME-SA/2018 lineages was discovered, as was the advent of G-18/non-deletion/2019 lineage in serotype A and Group IX in Asia1.
- Vaccine matching analysis of 67 FMD isolates (53 serotype O, 10 serotype A and 4 serotype Asia1) were carried. The vaccine strains of serotypes O and Asia1 showed very good antigenic match. In case of serotype A, only 40% of the field isolates had an antigenic match with the currently used vaccine strain A/IND/40/2000. The new candidate vaccine stain A/IND/27/2011, on the other hand, demonstrated great antigenic match (100%) with the recent serotype A field isolates.
- Under FMD serosurveillance, 98,185 bovine serum samples from around the country were analyzed using the r3AB3 NSP-ELISA (DIVA) to determine the prevalence of NSP-antibody (NSP-Ab) positive animals. Overall seropositivity was found in 16.0% of the samples tested, which is higher than the previous year's average of 13.8%. In addition, 14,061 serum samples from small ruminants and pigs were also screened.
- During 2021, a total of 30,137 serum samples were examined using Solid Phase Competitive ELISA (SPCE) under NADCP to assess the efficiency of immunization, of which 13108 and 17029 samples were from NADCP-1 and NADCP-2, respectively. In addition, 8183 serum samples received from various Breeding Bull stations and surrounding villages were also tested to assess the protection level.
- For seromonitoring, initially protective titre cut-off was fixed at $\geq 1.8 \log_{10}$(@ 50 PI) based on literature evidence and correlation with LPBE. In 2021, SPCE was correlated with the gold standard method VNT. Based on the results, the antibody titre of $\geq 1.65 \log_{10}$ (@ 35 PI) was found deemed to be protective at herd level. This cut off has been adopted since then and used for estimation of protective titre for NADCP round 2.
- The effectiveness of disinfectants and cleansers against FMDV was thoroughly investigated. The mixture of Citric Acid (2%) and Sodium Chloride (10%) solution showed higher reduction of virus titre in 5 min contact time against FMDV serotype O on plastic and stainless steel surface *in vitro*.
- Procedure for rapid decontamination of used RNA columns has been developed for complete removal of the residual FMD viral RNA from the used RNA-binding silica column. Used silica columns regenerated have the viral RNA

purification capability that is similar to the fresh silica-based RNA purification columns

- The institute provided the state FMD centers with three main test kits (3AB3 indirect DIVA ELISA for 1,75,583 samples, Solid Phase Competitive ELISA (SPCE) for 1,56,778 samples, and Sandwich ELISA for 3893 samples).
- Several training programs and workshops were organized as part of capacity building program under HRD notably workshops on 'Systematic follow-up investigation of the NSP reactors' was conducted for FMD centers Telangana and Haryana
- Several extension and training program were organized under SCSP/TSP scheme for FMD stakeholders
- Two new FMD collaborating centers at Shillong, Meghalaya and Ranchi, Jharkhand were established to cater the need for the respective states
- For the quality control (QC) testing of FMD vaccines to be utilized for the vaccination under NADCP, ICAR-DFMD carried out QC testing of eight batches of vaccines.

1.0 कार्यकारी सारांश

- 2021 के दौरान, 378 एफएमडी प्रकोपों में 2824 नैदानिक नमूनों का जाँच सैंडविच एलिसा और मल्टीप्लेक्स पीसीआर के द्वारा एफएमडी विषाणु सीरोटाइप की पहचान का विश्लेषण किया गया। इस वर्ष, एफएमडी वायरस के सभी तीन सीरोटाइप को प्रलेखित किया गया, जिसमें एफएमडी वायरस सीरोटाइप ओ के द्वारा सबसे अधिक प्रकोप पाया गया इसके तत्पश्चात सीरोटाइप ए से। इस प्रकार देखा गया है कि पिछले वर्ष की तुलना में इस वर्ष एफएमडी बीमारी की घटनाओं में वृद्धि हुई है।
- बीएचके-21 सेल सिस्टम (कोशिका प्रणाली) में पुनर्जीवित कुल 113 एफएमडी वायरस आइसोलेट्स (102 ओ, 10 ए और 1 एशिया 1) को एफएमडी राष्ट्रीय भंडार, अंतर्राष्ट्रीय केंद्र खुरपका एवं मुंहपका रोग, भुवनेश्वर और मुक्तेश्वर प्रयोगशाला में रखा गया।
- 68 एफएमडी वायरल स्ट्रेन के कैप्सिड कोडिंग क्षेत्र (पी1/वीपी1) अनुक्रमों का अनुमान लगाया गया और भारतीय एफएमडी वायरस (54 सीरोटाइप ओ, 13 सीरोटाइप ए और 1 सीरोटाइप एशिया1) के अनुक्रमण डेटाबेस में जोड़ा गया। सीरोटाइप ओ में, ओ/एम ई-एस ई / इंड2001ई (O/ME-SA/Ind2001e) और ओ/एम ई-एस ई / 2018 (O/ME-SA/2018) वंशावली के प्रभुत्व की खोज की गई, जैसा कि एशिया1 में G-18/नॉन-डिलीशन/2019 वंशावली सीरोटाइप A और समूह IX का पाया गया।
- 67 एफएमडी आइसोलेट्स (53 सीरोटाइप ओ, 10 सीरोटाइप ए और 4 सीरोटाइप एशिया1) का वैक्सीन मिलान विश्लेषण किया गया। सीरोटाइप ओ और एशिया 1 के टीके के सीरोटाइप (उपभेदों) ने बहुत अच्छा एंटीजेनिक मैच दिखाया। सीरोटाइप ए के मामले में, केवल 40% फील्ड आइसोलेट्स का एंटीजेनिक मैच वर्तमान में इस्तेमाल किए गए वैक्सीन स्ट्रेन ए/इंड/40/2000 के साथ पाया गया। दूसरी ओर, न्यू वैक्सीन कैंडीडेट स्ट्रेन ए/इंड/27/2011 (A/IND/27/2011) ने हाल के सीरोटाइप ए फील्ड आइसोलेट्स के साथ बहुत अच्छा एंटीजेनिक मैच (100%) का प्रदर्शन किया।
- एफएमडी सीरोसर्विलांस के तहत, एनएसपी-एंटीबॉडी (एनएसपी-एबी) पॉजिटिव जानवरों की व्यापकता को निर्धारित करने के लिए आर3एबी3 एनएसपी-एलिसा (डीआईवीए, दीवा) का उपयोग करके देश भर से 98,185 गोजातीय/बोवाइन सीरम नमूनों का विश्लेषण किया गया। परीक्षण किए गए नमूनों में से 16.0% सेरोपोसिटिविटी पाई गई, जो पिछले वर्ष के औसत 13.8% से अधिक है। इसके अलावा, स्माल रूमीनेंट्स (छोटे जुगाली करने वालें) और सूअरों के 14,061 सीरम नमूनों की भी जांच की गई।
- 2021 के दौरान, टीकाकरण की दक्षता का आकलन करने के लिए NADCP के तहत सॉलिड फेज कॉम्पिटिटिव एलिसा (एसपीसीइ, SPCE) का उपयोग करके कुल 30,137 सीरम नमूनों की जांच की गई, जिनमें से 13108 और 17029 नमूनें क्रमशः एनएडीसीपी -1 और एनएडीसीपी -2 के थे। इसके अलावा, विभिन्न प्रजनन बुल (ब्रीडिंग बुल) स्टेशनों और आसपास के गांवों से प्राप्त 8183 सीरम नमूनों का भी परीक्षण किया गया ताकि इस बीमारी के प्रति सुरक्षा स्तर का आकलन किया जा सके।
- सेरोमोनिटोरिंग के लिए, शुरू में सुरक्षात्मक अनुमापांक (प्रोटेक्टिव टाइटर) कट-ऑफ 1.8 log10 (@ 50 PI) पर तय किया गया था, जो साहित्य साक्ष्य और एलपीबी के साथ सहसंबंध पर आधारित था। 2021 में, एसपीसी को स्वर्ण मानक विधि विएन्टी (VNT) के साथ सहसंबद्ध किया गया। परिणामों के आधार पर, 1.65 log10 (@ 35 PI) के एंटीबॉडी अनुमापांक को झुंड स्तर पर सुरक्षात्मक माना गया। इस कट ऑफ को तब से अपनाया गया है और एनएडीसीपी राउंड 2 के लिए सुरक्षात्मक अनुमापांक के आकलन के लिए उपयोग किया जा रहा है।
- एफएमडीवी के खिलाफ कीटाणुनाशक और सफाई करने वालों की प्रभावशीलता की पूरी तरह से जांच की गई। साइट्रिक एसिड (2%) और सोडियम क्लोराइड (10%) घोल के मिश्रण ने प्लास्टिक और स्टेनलेस स्टील की सतह पर इन विट्रो में एफएमडी विषाणु सीरोटाइप ओ के खिलाफ 5 मिनट के संपर्क समय में वायरस अनुमापांक की उच्च कमी को दिखाया।
- प्रयुक्त आरएनए-बाइंडिंग सिलिका कॉलम से अवशिष्ट एफएमडी वायरल आरएनए को पूरी तरह से हटाने के लिए प्रयुक्त आरएनए कॉलम के तेजी से परिशोधन के लिए प्रक्रिया विकसित की गई है। पुनर्जीवित प्रयुक्त सिलिका कॉलम में वायरल आरएनए शुद्धि क्षमता होती है जो ताजा सिलिका-आधारित आरएनए शुद्धि कॉलम के समान होती है।
- संस्थान ने राज्य के एफएमडी केंद्रों को तीन मुख्य परीक्षण किट (1,75,583 नमूनों के लिए 3एबी3 अप्रत्यक्ष दीवा एलिसा, 1,56,778 नमूनों के लिए सॉलिड फेज कॉम्पिटिटिव एलिसा (एसपीसीइ, SPCE) और 3893 नमूनों के लिए सैंडविच एलिसा) प्रदान किए।
- एचआरडी विभाग के द्वारा, क्षमता निर्माण (कैपेसिटी बिल्डिंग) कार्यक्रम के लिए कई प्रशिक्षण कार्यक्रम और कार्यशालाएं आयोजित की गईं। जिसमें विशेष रूप से एफएमडी केंद्र तेलंगाना और हरियाणा राज्य के लिए 'एनएसपी रिएक्टरों की व्यापक अनुवर्ती जांच' पर कार्यशालाएं आयोजित की गईं।
- एफएमडी हितधारकों के लिए एससीएसपी/ टीएसपी योजना के तहत कई विस्तार और प्रशिक्षण कार्यक्रम आयोजित किए गए।
- संबंधित राज्यों की जरूरतों को पूरा करने के लिए शिलांग, मेघालय और रांची, झारखंड में दो नए एफएमडी कोलेबोरटिंग केंद्र स्थापित किए गए।
- एनएडीसीपी के तहत टीकाकरण के लिए उपयोग किए जाने वाले एफएमडी टीकों के गुणवत्ता नियंत्रण (क्यूसी) परीक्षण के लिए, आईसीएआर-डीएफएमडी ने टीकों के आठ बैचों का क्यूसी परीक्षण किया।

2.0 RESEARCH ACHIEVEMENTS

2.1 Disease Monitoring and Surveillance

2.1.1 Epidemiological scenario during 2021

During the year 2021, a total of 378 FMD outbreaks were confirmed in India, which is almost eight fold higher than outbreaks recorded in the year 2020 (Table 1). The diseases were recorded in all the region and in several states and UTs (Fig 1). During 2020, FMD was recorded only in nine states and northern and central region was completely free from FMD. Though movement restrictions due to country wide lockdown might be one of the reasons for fewer number of outbreaks in 2020, delay in vaccination probably triggered more FMD outbreaks in 2021.A sharp increase in serotype A outbreaks compared to previous years is major concern in a present scenario where in-use vaccine strain IND40/2000 failed to offer optimal antigenic coverage. It is high time that the in-use vaccine strain to be replaced by new candidate vaccine strain IND27/2011 already identified by ICAR-DFMD. A total of 2824 clinical materials collected were tested using antigen differentiating sandwich ELISA and multiplex PCR. The test revealed serotype 'O' in 1122 samples, 'A' in 87 samples, 'Asia1' in 22 samples (Table 2). Out of 378 confirmed FMD outbreaks, serotype O was accountable for 349, and serotype A and Asia1 caused 25 and 4 outbreaks, respectively. In all the regions, increase in numbers of FMD outbreaks were observed compared to last year (Fig 2). The serotype O continued to be most predominant one and was responsible for 92.1% of the total outbreaks recorded during 2021 followed by serotype A in 6.8% and serotype Asia1 in 1.1% (Fig 3). All the three serotypes were recorded in the states of Tamilnadu and Jammu & Kashmir (UT). More numbers of outbreaks were recorded during August to December (Fig 4). Generally, in India, higher disease incidences observed during January-March and October–December though the FMD occurs throughout the year. Large numbers of FMD outbreaks were recorded in cattle as almost 77% of the outbreaks occurred in cattle. Buffalo was the second most affected species with 16% incidences followed by Pigs, Goat, Mithun, Sheep and Yak (Fig 5). In addition, almost 74% of the outbreaks exclusively recorded in cattle, and very few incidences (3%) occurred exclusively in goat, pigs and mithun. Rest 33% of the outbreaks were recorded in more than one species.

Table 1. FMD outbreaks recorded and diagnosed during 2021 and virus serotype(s) involved

State/UT	Number of FMD outbreaks	FMD Serotypes		
		O	A	Asia1
Southern Region				
Karnataka	96	86	10	-
Kerala	52	52	-	-
Tamilnadu	21	17	03	01
Telangana	07	07	-	-
Pudhucherry	02	02	-	-
Total	**178**	**164**	**13**	**01**
Central Region				
Madhya Pradesh	03	03	-	-
Chhattisgarh	03	03	-	-
Total	**06**	**06**	-	-
Western Region				
Maharashtra	36	35	01	-
Gujarat	04	04	-	-
Rajasthan	09	09	-	-
Goa	02	02	-	-
Total	**51**	**50**	**01**	-
Northern Region				
Uttar Pradesh	20	17	03	-
Uttarakhand	14	14	-	-
Haryana	01	01	-	-
Punjab	09	08	01	-
Himachal Pradesh	05	05	-	-
Jammu & Kashmir	15	10	02	03
Ladakh	02	02	-	-
Delhi	02	02	-	-
Total	**68**	**59**	**06**	**03**
Eastern Region				
Odisha	06	04	02	-
West Bengal	27	27	-	-
Bihar	12	12	-	-
Jharkhand	01	01	-	-
Total	**46**	**44**	**02**	-
North Eastern Region				
Assam	07	07	-	-
Arunachal Pradesh	04	04	-	-
Meghalaya	02	02	-	-
Mizoram	02	02	-	-
Manipur	04	04	-	-
Nagaland	07	04	03	-
Sikkim	01	01	-	-
Tripura	02	02	-	-
Total	**29**	**26**	**03**	-
Grand Total	**378**	**349**	**25**	**04**

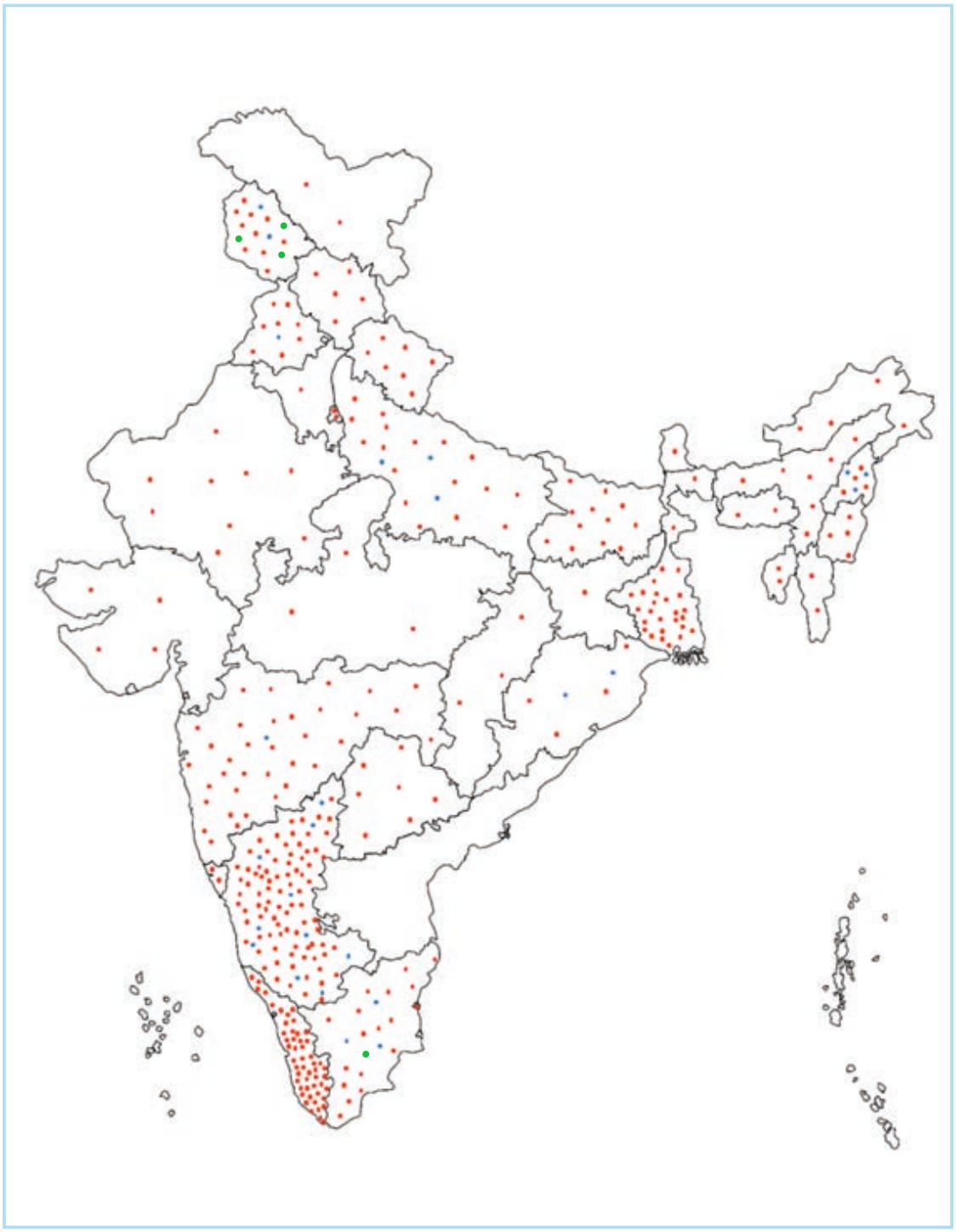


Fig 1. FMDV serotype distribution in different states during 2021. Red dot (●) denotes serotype O, blue (●) represent serotype A and Green (●) indicate serotype Asia1. One dot denotes one outbreak

Table 2. Number of clinical samples tested during 2021 and virus serotype(s) involved

State/UT	Number of Clinical material tested	FMD Serotypes		
		O	A	Asia1
Karnataka	716	321	40	-
Kerala	337	105	-	-
Tamilnadu	121	36	07	01
Telangana	73	35		
Pudhucherry	14	04	-	-
Maharashtra	260	82	02	-
Gujarat	19	06	-	-
Rajasthan	40	14	-	-
Goa	32	14	-	-
Uttar Pradesh	192	20	05	-
Uttarakhand	133	92	-	-
Haryana	01	01	-	-
Punjab	46	19	04	-
Himachal Pradesh	96	14	-	-
Jammu & Kashmir	252	94	07	21
Ladakh	57	36	-	-
Delhi	05	04	-	-
Madhya Pradesh	13	07	-	-
Chhattisgarh	48	06	-	-
Odisha	59	30	09	-
West Bengal	114	56	-	-
Bihar	74	31	-	-
Jharkhand	05	02	-	-
Assam	30	22	-	-
Arunachal Pradesh	22	22	-	-
Meghalaya	02	02	-	-
Mizoram	06	06	-	-
Manipur	20	18	-	-
Nagaland	50	16	13	-
Sikkim	05	05	-	-
Tripura	02	02	-	-
Total	**2824**	**1122**	**87**	**22**

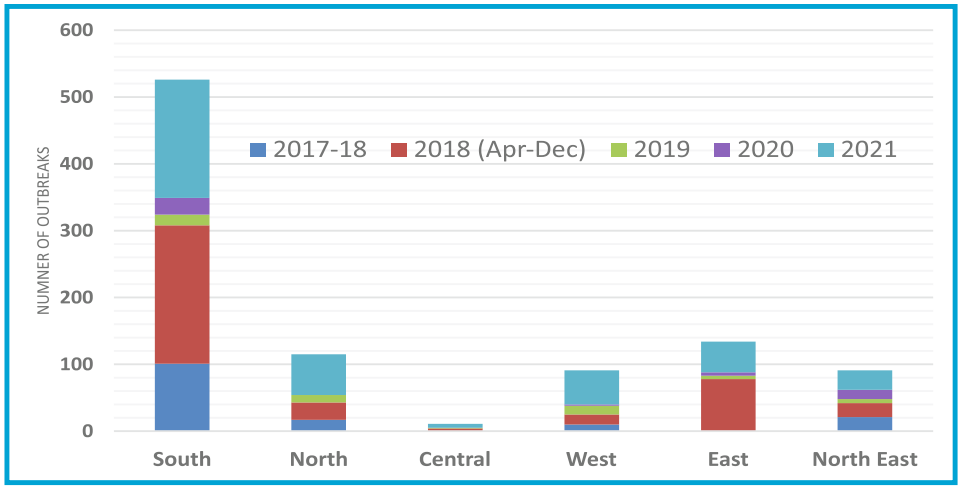


Fig 2. Number of confirmed FMD incidences in different geographical regions during the last five years.

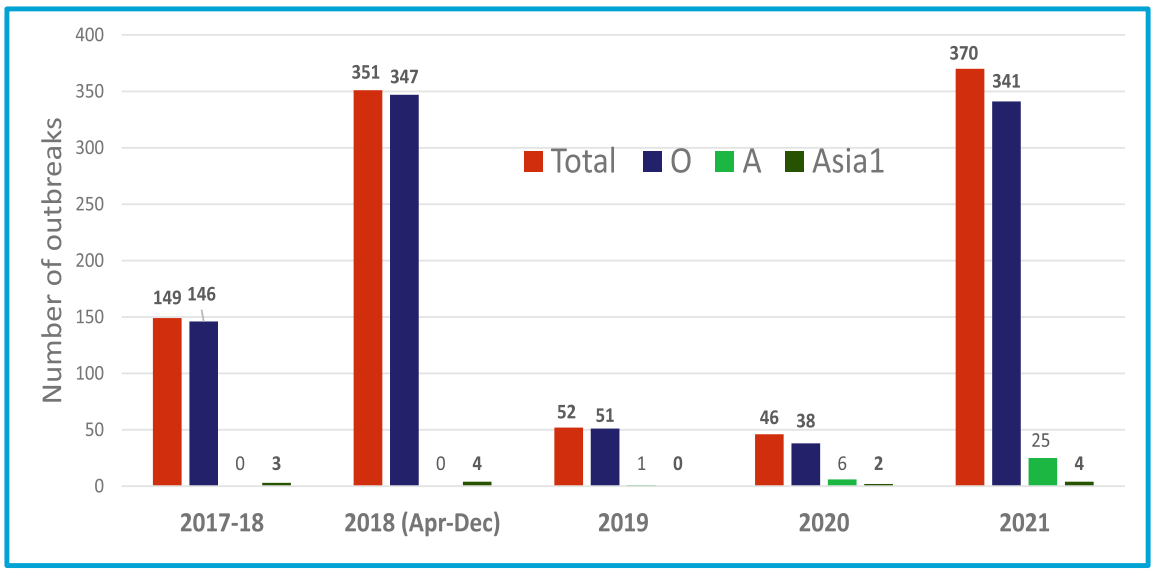


Fig 3. Year wise outbreaks/incidences of FMD and virus serotypes involved during last five years.

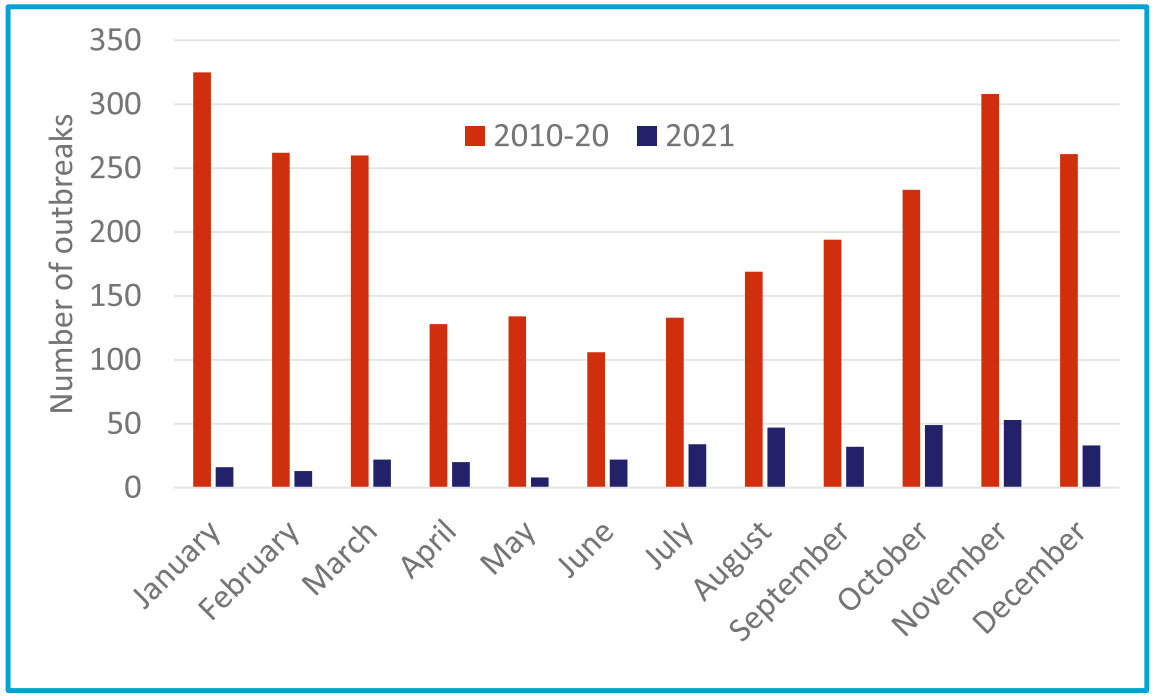


Fig 4. Month-wise FMD incidence during the year 2021 compared to last decade (2010-20)

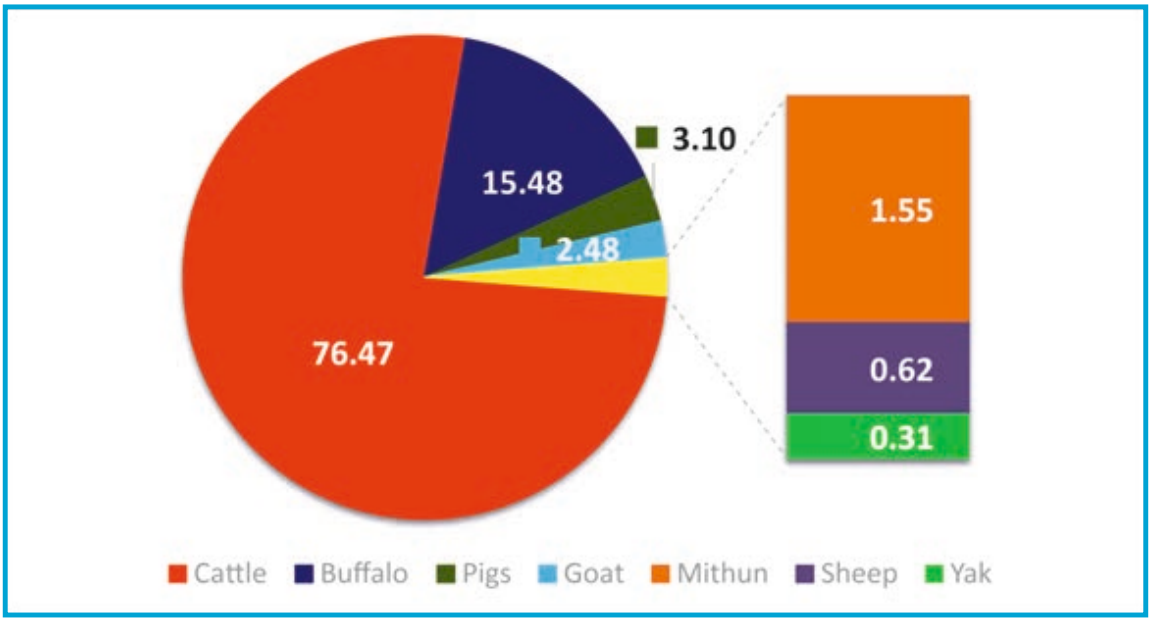


Fig 5. Species involved in FMD outbreaks during 2021

Southern Region

The southern region, which includes five states (Tamilnadu, Karnataka, Telangana, Andhra Pradesh and Kerala) and two UTs (Puducherry and the Andaman and Nicobar Islands), has roughly 21% of the country's FMD susceptible livestock. The region has no international borders, and the state of Karnataka has been identified as an FMD hyper-endemic area. In the year 2021, all the states/UTs reported FMD outbreaks except Andaman and Nicobar Islands. FMDCP has been operating in the southern peninsular region since 2010-11.

Karnataka: The state recorded highest number of FMD outbreaks during 2021 as 86 outbreaks were caused by serotype O and 10 outbreaks by serotype A. The outbreaks were recorded all through the year in the months of January (n=1), February (n=4), March (n=2), April (n=7), May (n=2), June (n=7), July (n=17), August (n=12), September (n=11), October (n=18), November (n=8) and December (n=6). Maximum outbreaks were recorded in the district of Bengaluru rural (n=12) followed by Ramnagara (n=7), Bengaluru urban (n=6), Tumkuru (n=6), Hasan (n=6), Davengere (n=6), Chikaballapur (n=5), Myosre (n=5), Shivamoga (n=5), Chikmangalore (n=4), Kolar (n=4), Uttarkanada (n=4), Dakshinakanada (n=4), Koppal (n=3), Chitradurga (n=3), Gagag (n=3), Ballari (n=2), Mandya (n=2), Raichur (n=2), Kalburgi (n=2), Udupi (n=1), Vijayanagara (n=1) and Haveri (n=1). The disease was recorded in cattle, pig and buffalo with a morbidity and mortality rate of 1.59% and 0.03%, respectively.

FMD outbreak investigation and sample collection in Karnataka

Kerala: Fifty two FMD outbreaks were recorded in the state and all of those were caused by FMDV serotype O. Nine outbreaks each were reported in the month of March, June, August followed by six in January, four in December, three each in February and September, and two in May. In the

month of April, October and November, one outbreak each was reported.The disease was recorded all over the state in the districts of Kollam (n=7), Alapuzha (n=6), Kozhikode (n=6), Ernakulam (n=6), Idukki (n=5), Kasargod (n=5), Wayanad (n=5), Trivendrum (n=3), Thrissur (n=2), Mallapuram (n=2), Kannur (n=1), Kattayam (n=1), Pathanamthitta (n=1), Vijayapuram (n=1) and Thodupuzha (n=1). The disease was recorded in cattle, pig and buffalo with a morbidity and mortality rate of 0.35% and 0.02%, respectively

Tamilnadu: Twenty one FMD outbreaks were serotype confirmed during the period. All the three serotypes of FMDV were reported from the state wherein maximum outbreaks were caused by serotype O (n=17) followed by serotype A (n=3) and Asia1 (n=1). The outbreaks were widespread and recorded in several districts of the states viz; Thanjavur (n=2, serotype O), Thiruvarur (serotype O), Sivagangai (serotype O), Ramanathampuram (serotype O), Karur (n=2, serotype O), Erode, Trichy (serotype O), Cuddalore (serotype O), Villupuram (serotype O), Kancheepuram (serotype O), Tiruvannamalai (n=2, serotypes O & Asia1)), Tiruvallur (serotype A), Coimbatore (serotype O), Salem (serotype O), Krishnagiri (serotype A), ,Ranipet (serotype A), Madurai (serotype O) and Dindigul (serotype O). Maximum outbreaks were recorded in the month of December (n=8) followed by November (n=6), September (n=3), October (n=2) and one each in February and July. The disease was recorded in cattle, buffalo and goat with a morbidity and mortality rate of 0.93% and 0.01%, respectively.

Telangana: Seven FMD outbreaks due to serotype O was reported from the state. The outbreaks were recorded in the months of September (n=4) and October (n=3). Maximum of four outbreaks were recorded in the district of Karimnagar followed by one each in Khammam, Peddapalli and Jangaon. The disease was recorded only in cattle with a morbidity and mortality rate of 3.4% and 0.09%, respectively. .

Puducherry: One large scale FMD outbreak was recorded in the state which started in the month of October and lasted till December. The outbreak was caused by serotype O. Though no mortality was observed, morbidity rate was found to be 8.5%.

Central Region

Central region comprises of two states (Madhya Pradesh and Chhattisgarh) and has about 10% of the FMD susceptible livestock of the country. The region shares no international border. The entire central region was covered under FMDCP and now NADCP.

Madhya Pradesh: FDMV serotype O caused three outbreaks in the state in the months of November (n=1) and December (n=2). One outbreak each was recorded in the districts of Bhopal, Betul, Barwani. The disease was recorded in cattle, buffalo, sheep and goat with a morbidity and mortality rate of 3.5% and 0.21%, respectively.

Chhattisgarh: Three outbreaks due to FMDV serotype O was recorded in Bemetara, Durg and Gaurela-Pendra-Marwahi districts. The outbreaks were recorded in the months of February (n=1) and September (n=2)

Western Region

Western region comprises of three states (Maharashtra, Rajasthan and Gujarat) and about 22% of the FMD susceptible livestock of the country. The region shares international border with Pakistan. All the three states in the western region were covered under FMDCP since the year 2010-11.

Maharashtra: The state reported 36 FMD outbreaks wherein majority of the outbreaks were caused by serotype O (n=35) and one outbreak was due to serotype A. Maximum outbreaks were recorded in the month of November (n=20) followed by October (n=14), and one each in July and August. Maximum outbreaks were recorded in the district of Pune (n=18) followed by Ahmednagar (n=9), Osmanabad (n=4), Latur (n=2) one each in Sangli, Solapur and Yeotmal. An outbreak due to serotype A was recorded in Ahmednagar. The disease was recorded in cattle, buffalo and goat with a morbidity and mortality rate of 1.6% and 0.14%, respectively.

FMD outbreak investigation and sample collection in Maharashtra

Gujarat: Four FMD outbreaks due to serotype O was reported from the state in which two occurred in the month of November and one each in September and October. One outbreak each was recorded in the districts of Valsad, Surat, Gandhinagar and Junagadh. The morbidity and mortality rate was determined to be 3.1 and 0.48% and the disease was reported only in cattle and buffalo.

Rajasthan: During the period, nine FMD outbreaks were serotype confirmed in the state and all were found to be serotype O. The outbreaks were recorded in the months of April (n=1), July (n=1), August (n=3), September (n=1), October (n=1) and November (n=2). The outbreaks were reported from the districts of Hanumangarh (n=1), Sriganganagar (n=1), Jaipur (n=4), Bhilwara (n=1) and Alwar (n=2).

Goa: Two outbreaks due to serotype O were recorded in the states, one each in the month of October and November.

Northern Region

Northern region comprises of five states and two UTs (Haryana, Punjab, Himachal Pradesh, Uttarakhand, Uttar Pradesh, Jammu & Kashmir and Ladakh) and about 19% of the FMD susceptible livestock of the country. The region shares international borders with Pakistan, Afghanistan, Nepal and China. The entire Northern region was covered under FMDCP.

Uttar Pradesh: Twenty FMD outbreaks were serotype confirmed during the period in which serotype O caused 17 outbreaks and serotype A was responsible for 3 outbreaks. Maximum numbers of outbreaks were recorded in the month of August (n=10) followed by February (n=5), December (n=3) and one each in March and April. Maximum outbreaks were reported from Meerut (n=10) followed by Bulandshahar (n=5), Muzaffarnagar (n=3) and one each in Badayun and Mathura. Outbreaks due to serotype A were recorded in Meerut and Muzaffarnagar.

Uttarakhand: The state recorded fourteen serotype confirmed FMD outbreaks. All the outbreaks were caused by serotype O and the disease was recorded in cattle, buffalo and small ruminants. Four outbreaks each were recorded during the months of March, September and December and one each was reported in the months of Augus and November. Maximum numbers of outbreaks were recorded in the districts of Haridwar (n=6) and Almora (n=5) followed by one each in Nainital, Pauri and Pithoragarh.

Haryana: One outbreak due to serotype O was recorded in the district of Hisar in the month of December. There were no mortality and the disease was observed only in two goats which were not vaccinated previously.

Punjab: During the period FMD outbreaks were recorded in the districts of Amritsar (n=1), Ludhiana (n=2), SM Sahib (n=1), Moga (n=1), Faridkot (n=1), Patiala (n=1), Sangrur (n=1) and SAS Nagar (n=1). Out of nine outbreaks, eight were due to serotype O and one was caused by serotype A. The outbreaks were recorded in the months of July (n=3), August (n=3), November (n=2) and June (n=1). The disease was recorded in cattle, buffalo and pig with a morbidity and mortality rate of 22.3% and 6.8%, respectively.

Himachal Pradesh: Five outbreaks due to FMDV serotype O was type confirmed during the period. The outbreaks were recorded in the months of July (n=3), August (n=1) and September (n=1) in the districts of Kangra (n=3) and Bilaspur (n=2). The disease was reported in cattle and pigs

Jammu & Kashmir: The UT uniquely recorded all the three FMDV serotypes during the reporting period. FMDV serotype O was found in 10 outbreaks followed by serotype Asia1 in 3 outbreaks and serotype A in 2 outbreaks. The disease spread widely in several districts including Bandipora, Budgam, Ganderbal, Kulgam, Kupwara, Pulwama, Shopian, Srinagar, Udhampur and Leh,Khaltsi & Nubra. The disease incidences were reported throughout the year

Ladakh: Two outbreaks due to serotype O was recorded in the months of July and November in Leh district

Delhi: Two outbreaks due to serotype O was recorded in the month of September in New Delhi and West Delhi district. The disease was recorded in cattle and buffalo

Eastern Region

Eastern region comprises of four states (West Bengal, Odisha, Bihar and Jharkhand) and about 22% of the FMD susceptible livestock of the country. This region shares international border with Bangladesh and Nepal. The entire region is covered under FMDCP since 2017.

Odisha: During the period, six FMD outbreaks which occurred in the months of January (n=2), June (n=1), August (n=1), September (n=1) and October (n=1) were serotype confirmed. Four outbreaks were caused by serotype O; two each in the districts of Khurda and Keonjhar, and two by serotype A in the district of Jharsuguda and Kalahandi.

Collection of sample from an outbreak recorded in Odisha

West Bengal: Twenty Seven FMD outbreaks were recorded in the state in the districts of Paschim Medinipur (n=8), Howrah (n=6), P Bardhaman (n=4), Hoogly (n=1), Nadia (n=2),

Darjeeling (n=2), South 24 Parganas (n=2) and Birbhum (n=1).Maximum numbers of outbreaks were reported in the month of April (n=8) followed by March (n=7), January (n=4), May (n=4), December (n=2), July (n=1) and September (n=1). Bovines and Caprines were affected with an overall morbidity rate of 10.36% and mortality of 0.58%. FMDV serotype O was responsible for all the recorded outbreaks.

Bihar: Twelve FMD outbreaks due to serotype O was recorded in the state. Five each were recorded in the months of October and November followed by two in December. Maximum outbreaks were reported in the district of Patna (n=5) followed by Vaishali (n=2) and one each in Saran, Muzaffarnagar, Samstipur and Darbhanga. The disease was recorded in cattle and buffalo with a morbidity and mortality rate of 21.8% and 0.12%, respectively.

Jharkhand: One outbreak was serotype confirmed during the period which occurred in the district of Ranchi in September. The disease was caused by serotype O.

North Eastern Region

North eastern region comprises of seven states (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura) and about 6% of the FMD susceptible livestock of the country. This region shares international borders with China, Myanmar, Bangladesh and Bhutan.

Assam: Seven outbreaks of FMD were recorded in the state during the period. Serotype O accounted for all the outbreaks. The disease was recorded only in cattle and goat in the months of August (n=4) and December (n=3). Maximum of four outbreaks were recorded in Kamrup (M) followed by one each in Darang, Bajali and Sonitpur. The morbidity rate and mortality rate was observed to be 17.6 % and 0.06%, respectively.

Arunachal Pradesh: Four serotype confirmed outbreaks were recorded in cattle and mithun. All the four outbreaks were due to serotype O. Maximum of three outbreaks were recorded in the month of June and one in July. The disease was recorded in the districts of Papumpare, Upper Subansiri, Lower Subansisir and West Siang

Meghalaya: Two outbreaks of FMD caused by serotype O was recorded in cattle during the period. The outbreaks were recorded in Ribhoi and Khasi Hills districts in the months of January and November.

Mizoram: FMD virus serotype O was responsible for the two FMD outbreaks reported in the state. The outbreaks were reported in Aizwal and Champai districts in the months of September and November, respectively. Only cattle were affected.

Manipur: Four outbreaks due to serotype O were recorded in the state in cattle. Maximum of two outbreaks occurred in the month of April and one each in August and September. Two outbreaks were recorded in Imphal East and one outbreak each was reported from Imphal West and Ukhrul The morbidity rate and mortality rate was observed to be 20.3% and 0.69%, respectively.

Nagaland: FMDV serotype O and A were responsible for 4 and 3 outbreaks, respectively. The outbreaks were recorded in cattle and mithun in the months of January, March, June, August, September and November. Maximum of four outbreaks were recorded in Kohima followed by one each in Peren, Medziphema and Dimapur districts. The morbidity rate and mortality rate was observed to be 1.37% and 0.05%, respectively.

Sikkim: One FMD outbreak due to serotype O was recorded in the district of South Sikkim during the month of October

Tripura: During the period, two outbreaks were serotype confirmed as type O. The outbreaks were reported in the months of March and July in Mandwai district

2.1.2 FMD Serosurveillance under NADCP

In India, vaccination with inactivated vaccine is the primary mode of FMD control. There is challenge to identify the infected animals among the vaccinated population for appropriate

implementation of the control programme. Differentiation of these two categories of animals is important during serological surveys to detect evidence of infection, as a follow up to ring vaccination and for import/ export serology. During active viral replication following FMD virus infection, arrays of nonstructural proteins (NSPs) are produced that elicit anti-NSP antibodies, which is not the case in animals which are vaccinated against FMD with inactivated virus vaccine. Use of DIVA assay is therefore essential in identification of potential disease free zones (DFZs) with vaccination in India.

For 3AB3-NSP based sero-surveillance activity, a two-stage sampling strategy with a minimum design prevalence of 1% between the first-stage level (village) and 5% between the villages was followed. The sampling design was developed jointly by ICAR-NIVEDI and ICAR-DFMD. For NSP sero-surveillance, the study design usually focuses on younger animals (**6-18 months age**) since repeated vaccination even with good quality vaccine can generate positive signal in NSP ELISA that may provide false positive NSP reactors.

During the year 2021, a total of **98,185** bovine serum samples collected at random from various parts of the country were tested using r3AB3 NSP-ELISA for assessing NSP-antibody (NSP-Ab) response, which is an underlying indicator of FMD virus exposure regardless of vaccination status. The test revealed overall seropositivity (DIVA positive) in ~ 16.0% samples or animals (Table 3). In compared to DIVA reactivity in 2020 (13.8%), a hike is observed in 2021. The reduction in 2020 could be due to overall lower social activities on account of COVID-19 lockdown and movement restrictions (both human and animals). Several FMD outbreaks were reported during 2021 which might have contributed for increase in NSP antibody prevalence. Percent NSP antibody prevalence in different states are depicted in (Fig 6). In general, over the year though there has been a fluctuation in number of outbreaks, a decline in NSP antibody prevalence was observed in the country (Fig 7). In addition, screening of serum samples from Yak, Cattle-Yak hybrid and Mithun revealed higher NSP positivity in Yak hybrid and Mithun (Table 4).

Table 3. NSP Positivity/ Reactivity during the year 2021 in cattle and buffalo of India

S No	State/UT	No of samples tested	Total positive	%3AB3 reactors
1	A & N Islands	728	28	3.84
2	Arunachal Pradesh	136	15	11.0
3	Assam	8151	1730	21.22
4	Chhattisgarh	3668	550	14.99
5	Gujarat	5260	525	9.98
6	Himachal Pradesh	3420	658	19.23
7	Jammu & Kashmir	2423	639	26.37
8	Jharkhand	825	137	16.61
9	Karnataka	2099	435	20.72
10	Kerala	8295	1749	21.08
11	Madhya Pradesh	4864	889	18.3
12	Maharashtra	10539	1666	15.81
13	Meghalaya	378	104	27.5
14	Manipur	3248	1317	40.54
15	Mizoram	360	44	12.22
16	Pondicherry	960	569	59.3
17	Punjab	3919	594	15.15
18	Tamilnadu	522	90	17.24
19	Telangana	9036	451	4.99
20	Uttar Pradesh	9379	1093	11.65
21	Uttarakhand	4049	811	20.03
22	West Bengal	810	332	41.1
23	Odisha	6076	1280	21.07
24	Haryana	9040	619	6.81
	Total	**98185**	**16325**	**16.63**

Table 4. DIVA Positivity/ Reactivity during the year 2021 in Mithun and Yak of India

Species	No of samples tested	Total positive	%3AB3 reactors
Mithun	330	35	10.6
Yak	261	10	3.83
Cattle-Yak hybrid	30	5	16.67

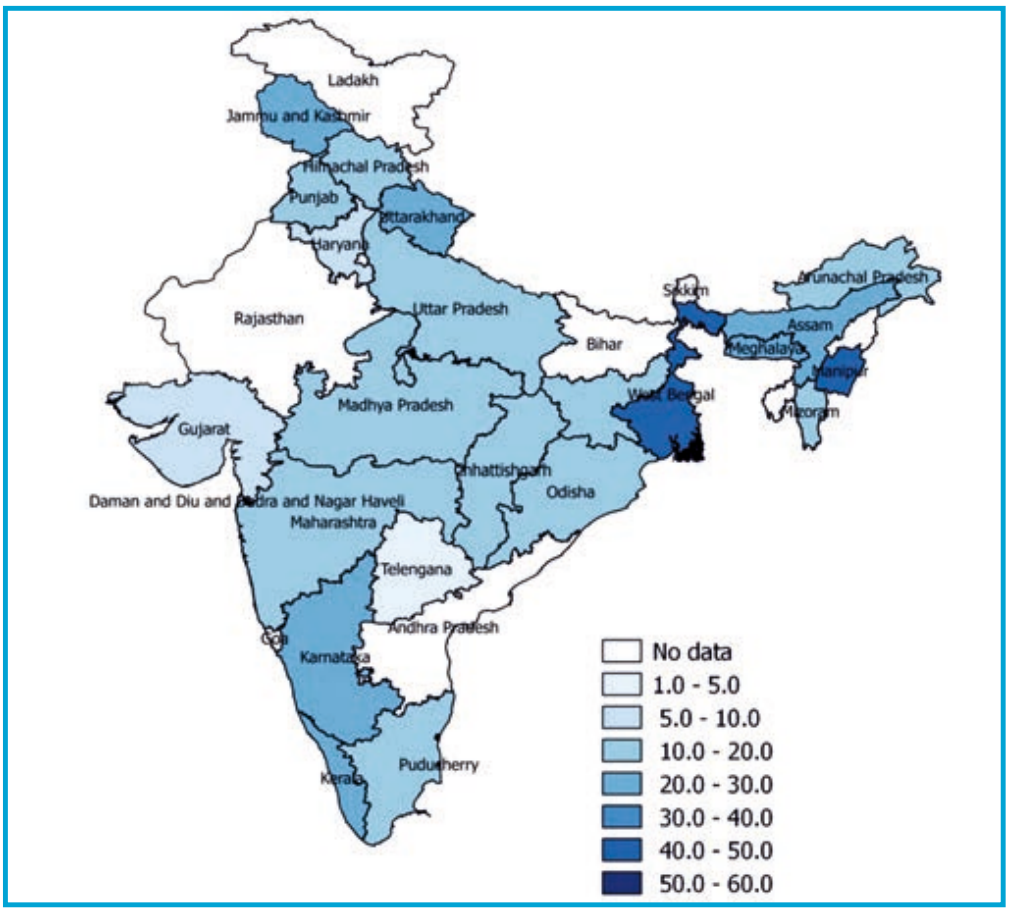


Fig 6. State-wise percent NSP antibody prevalence in cattle and buffalo

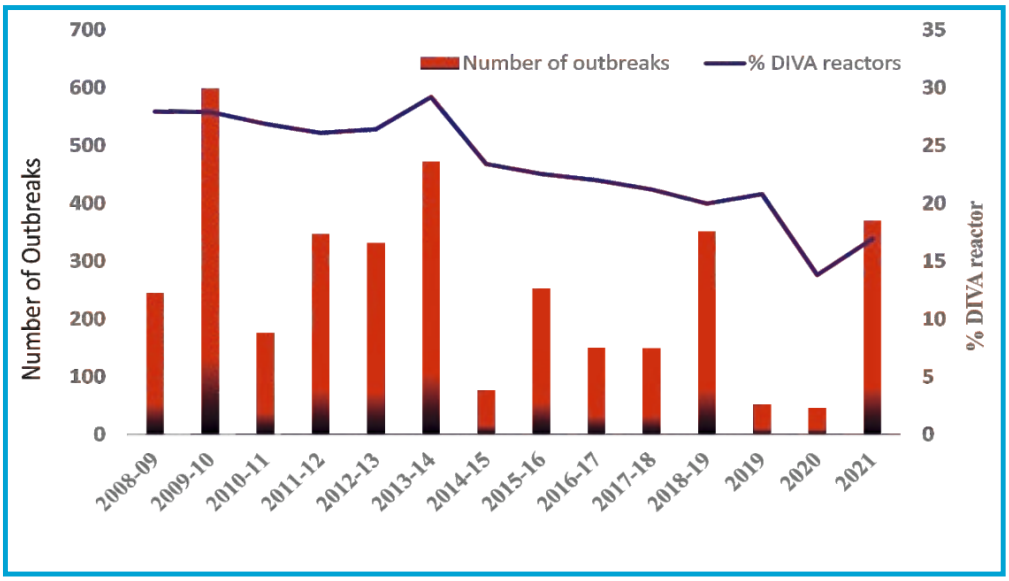


Fig 7. DIVA Positivity/ Reactivity over the years in Bovine of India and number of FMD outbreaks

DIVA positivity in outbreak samples

A total of 746 serum samples collected during FMD outbreaks were also tested using DIVA ELISA and 52% of the serum samples were found positive for NSP antibodies.

Table 5. NSP ELISA testing of samples referred from outbreaks and for screening against FMDV antibodies.

State	Species	Total no. of samples	3AB3 NSP ELISA Positive results
Arunachal Pradesh	Cattle	4	0
Bihar	Cattle	37	16
	Buffalo	4	1
Chhattisgarh	Cattle	37	34
	Buffalo	2	1
Goa	Cattle	34	27
Gujarat	Cattle	18	14
Jammu & Kashmir	Cattle	13	13
Jharkhand	Cattle	116	43
Kerala	Cattle	6	3
Ladakh	Cattle	2	1
Madhya Pradesh	Cattle	6	2
	Buffalo	1	0
Maharashtra	Cattle	42	11
Odisha	Cattle	228	140
	Buffalo	1	0
Punjab	Cattle	6	6
Sikkim	Cattle	67	22
	DZO (Cattle-Yak hybrid)	2	1
	Buffalo	1	0
Tamilnadu	Cattle	25	16
Telangana	Cattle	20	10
	Buffalo	10	5
Uttarakhand	Cattle	2	1
UttarPradesh	Cattle	42	18
	Buffalo	20	1
Grand Total		**746**	**386 (52%)**

FMD Serosurveillance in small ruminants and pigs

FMD surveillance in small ruminants and pigs are critical for understanding their role in FMD epidemiology and providing support for FMD control strategies, notably vaccination. The serum samples collected randomly and during the course of outbreaks from sheep, goats and pigs were analysed to estimate the NSP antibody prevalence. In both the scenario, apparently higher NSP antibody prevalence (more than national average in bovine population) was observed in sheep (Table 6 and 7). Higher NSP antibody prevalence observed in randomly collected samples than outbreak samples in goats suggest that the serum samples might have been collected during acute stage when no antibodies could be detected in majority of the samples. Pigs in organized farms are mostly reared in bio-secured environment or in segregation practices therefore low antibody level was observed. Average of random samples from sheep and goat showed 19.5% NSP prevalence. Therefore these could be taken as sentinel animals or indicator of virus cattle and buffalo population. In India, routine FMD vaccination is practiced in bovine population under FMD Control Programme, but not in small ruminants and pigs. Evidence of FMD virus exposure in sheep, goat, and pig at a higher rate than in bovine is observed in some states. In a mixed/integrated animal husbandry practices, it is largely established that small ruminants might play a limited role in the transmission of FMDV than cattle and buffalo. Higher NSP-Ab prevalence in small ruminants indicates probable spill-over of virus from bovine population. This scenario warrants a more intensive surveillance and follow up in bovine population of these states.

Table 6. NSP Positivity/ Reactivity during the year 2021 in small ruminants and pigs (random samples)

S No	State/UT	Species	No of samples tested	Total positive	%3AB3 reactors
1	Odisha	Goat	2333	551	23.62
2	Maharashtra	Goat	115	61	53.04
3	Andaman & Nicobar Islands	Goat	343	15	4.37
4	Telangana	Goat	1074	119	11.08
5	Madhya Pradesh	Goat	1100	125	11.36
6	Rajasthan	Goat	1800	517	28.72
7	Mizoram	Goat	43	0	0.00
8	Haryana	Goat	871	223	25.60
Total			**7679**	**1611**	**20.98**
1	Odisha	Sheep	467	37	7.92
2	Jammu & Kashmir	Sheep	1580	277	17.53
3	Telangana	Sheep	576	149	25.87
4	Madhya Pradesh	Sheep	208	8	3.85
5	Rajasthan	Sheep	1800	372	20.67
6	Haryana	Sheep	881	120	13.62
Total			**5512**	**963**	**17.47**
Small ruminants			**13191**	**2574**	**19.5**
1	Madhya Pradesh	Pig	148	15	10.14
2	Mizoram	Pig	50	0	0.00
3	Haryana	Pig	433	40	9.24
Total			**631**	**55**	**8.72**

Table 7. NSP Positivity/ Reactivity during the year 2021 in small ruminants and pigs (outbreak samples)

S No	State/UT	Species	No of samples tested	Total positive
1	Tamilnadu	Goat	2	2
2	Sikkim	Goat	4	0
3	Ladakh	Goat	88	3
4	Goa	Goat	4	1
5	Madhya Pradesh	Goat	5	0
6	Uttarakhand	Goat	1	1
Total			**104**	**7 (6.73%)**
1	Tamilnadu	Sheep	26	4
2	Jammu & Kashmir	Sheep	77	31
3	Ladakh	Sheep	11	1
4	Madhya Pradesh	Sheep	3	1
Total			**117**	**37 (31.62%)**
1	Tamilnadu	Pig	2	0
2	Sikkim	Pig	3	1
3	Assam	Pig	13	0
Total			**18**	**1 (5.56%)**

FMD Serosurveillance (around national parks of NEH region)

Under NEH, serum samples were collected from Fringe areas of different national parks and tested to assess the NSP antibody prevalence. A high NSP antibody prevalence was observed which is of major concern. Bovine population in the fringe areas of national parks needs to be vaccinated properly to prevent any disease outbreaks and possible spill over of infection to wild life population (Table 8).

Table 8. NSP antibody prevalence in different national parks

Name	Species of animals	Total no of serum samples tested	No of Samples Positive for DIVA test	Percentage positive
Fringe areas of Kaziranga National Park, Assam	Bovine	624	102	16.35
Fringe areas of Pobitora National Park, Assam	Bovine	382	73	19.10
Fringe areas of Manash National Park, Assam	Bovine	294	41	13.94

Status of NSP seroreactors at Livestock-wildlife interface

During the year 2021, FMD virus serosurveillance was carried out at livestock-wildlife interface in the buffer zone of Sanjay Tiger Reserve/ Bandhavgarh Tiger Reserve in collaboration with Wildlife Trust Conservation (WTC), Mumbai. A total of 903 serum samples were collected from cattle, buffaloes and goat and it was found that 19.01%, 2.27% and 14.33% of cattle, buffaloes and goat, respectively were found positive for 3AB3 antibody of FMD virus (Fig 8).

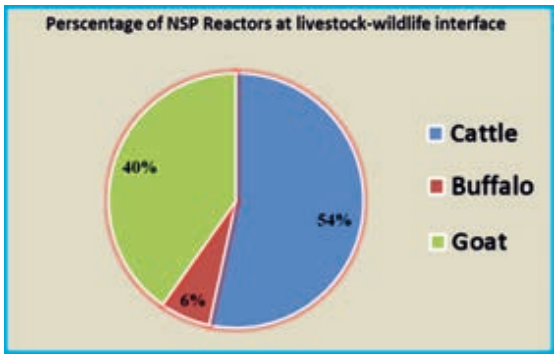


Fig 8. NSP antibody prevalence in domestic livestock at livestock-wild life interface

2.1.3 FMD Seromonitoring under NADCP

A bi-annual vaccination based FMD Control Programme (FMDCP) was started by the Government of India in 2004, initially covering 54 districts in the country. This involves 6 monthly FMD vaccinations, with an inactivated trivalent FMD vaccine, of all cattle and buffaloes for protection against FMD. The scheme was progressively expanded to cover the entire country by 2018-19. In 2019, Hon'ble Prime Minister launched National Animal Disease Control Programme (NADCP), a flagship scheme in September, 2019 for control of FMD and Brucellosis by targeting 100% cattle, buffalo, sheep, goat and pig population for FMD and 100% bovine female calves of 4-8 months of age for brucellosis. The overall aim of the NADCP is to control FMD by 2025 with vaccination and its eventual eradication by 2030. This will result in increased domestic production and ultimately in increased exports of milk and livestock products. NADCP for FMD and Brucellosis is a Central Sector Scheme where 100% of funds shall be provided by the Central Government to the States / UTs.

ICAR-NIVEDI in collaboration with ICAR-DFMD developed a post-vaccination sero-monitoring sampling strategy which has been followed under NADCP. For each round, a new sampling frame is generated and distributed to the state AH departments for sample collection. Under new sampling scheme, meta-data related to age of the animal, species, sex, location are being collected. The samples are collected form three different age groups of animals viz 6-12 months, 13-24 months and >24 months at a ratio of 5:4:1 as per OIE guidelines.

Under FMDCP and NADCP, serum samples before vaccination and 21 to 30 days post vaccination are collected by the respective state AH departments and tested by ICAR-DFMD and its state FMD laboratories for estimation of level of serotype specific antibodies. Globally, there are three tests to screen FMDV structural protein (SP) antibodies including SPCE (Solid-phase competitive ELISA), LPBE (Liquid-phase blocking ELISA), and VNT (Virus neutralization test). The gold standard method VNT has certain practical limitations, such as high costs in terms of time and labour. In India, LPBE for monitoring of herd immunity following each round of vaccination was used till the year 2015. Later, SPCE has been adopted as a screening method for evaluating herd immune status since 2016 till NADCP round 1. Initially, up to NADCP round 1, protective titre cut-off was fixed at $\geq 1.8 \log_{10}$ (@ 50 PI) based on literature evidence and correlation with LPBE. In 2021, SPCE was correlated with the gold standard method VNT. Based on the results, the antibody titre of $\geq 1.65 \log_{10}$ (@ 35 PI) was found deemed to be protective at herd level. This cut off has been adopted since then and used for estimation of protective titre from NADCP round 2.

2.1.3.1 NADCP Round 1

Under NADCP round 1, a total of **1,03,262** serum samples (pre-vac: 53,922 and post vac: 49,340) from various states were tested to determine the antibody titre against FMD virus serotypes O, A and Asia1 using Solid Phase Competitive ELISA (Table 9). A total of 90,154 serum samples (pre-vac: 47,967and post vac: 42,187) were tested during the year 2020 and rest of the samples were processed during 2021. The testing was carried out at National FMD-CP Seromonitoring Laboratory (ICAR-DFMD), Bengaluru and state FMD regional and collaborating centres. The serum samples were collected as per new

sampling frame developed jointly by ICAR-DFMD and ICAR-NIVEDI. The antibody titre of ≥1.8 log_{10} (@ 50 PI)was considered deemed to be protective at herd level. In pre-vaccination samples, the protective titre was found in **17.3, 14.1 and 15.5** percent of animals against serotypes O, A and Asia1, respectively. In post-vaccination samples, the protective titre of ≥1.8 log_{10} was found in **38.6, 31.2 and 33.7** percent of animals against serotypes O, A and Asia1, respectively (Table 9).

Table 9. State wise number of samples tested and percentage of animals showing protective titre against FMD virus serotypes O, A and Asia1 (NADCP-1)

S No	States/UTs	No of pre vac samples	No of post vac samples	Serotype O		Serotype A		Serotype Asia 1	
				Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	Andhra Pradesh	2119	2116	9.0	29.2	5.6	23.8	9.2	27.2
2	Tamilnadu	2246	2246	37.0	70.3	27.5	60.8	27.8	61.8
3	Karnataka	2300	2303	16.3	45.2	12.3	33.3	13.2	37.6
4	Kerala	2145	2145	47.4	70.9	39.5	60.1	45.7	67.6
5	Telangana	2210	2210	20.7	52.4	14.5	49.1	20.5	55.0
6	Maharashtra	4346	4359	17.5	36.3	14.4	29.5	16.2	32.3
7	Gujarat	2223	2223	18.8	44.2	16.4	42.4	20.1	46.5
8	Madhya Pradesh	4589	4589	10.0	28.4	8.7	21.4	9.3	24.1
9	Chhattisgarh	2152	2011	17.0	35.6	10.9	22.9	11.5	22.7
10	Odisha	2262	2262	12.7	36.0	8.8	20.5	7.3	17.8
11	Jharkhand	1506	492	9.0	29.1	3.4	13.2	4.7	16.7
12	Haryana	2267	2271	24.2	59.2	24.0	60.8	28.4	63.8
13	Punjab	2198	886	11.5	22.7	18.9	16.7	18.1	23.6
14	Uttar Pradesh	7468	5975	9.9	28.7	7.5	18.2	8.6	22.1
15	Himachal Pradesh	1504	2301	2.9	9.0	3.5	7.3	1.2	4.0
16	Jammu Kashmir	1525	1276	17.4	35.3	9.2	23.1	10.3	19.3
17	Uttarakhand	1320	1291	4.2	24.3	3.8	17.5	3.0	23.1
18	Mizoram	838	838	10.5	30.4	8.9	26.5	10.9	28.8
19	Assam	1989	1401	9.3	16.0	2.0	6.9	1.3	6.2
20	Manipur	807	807	9.7	45.8	7.1	40.8	7.2	36.8
21	Sikkim	999	743	2.7	22.2	3.9	14.9	2.8	16.6
22	Meghalaya	586	586	14.0	41.6	7.0	34.5	16.9	32.4
23	Arunachal Pradesh	186	-	2.7	-	14.0	-	1.1	-
24	Nagaland	726	419	13.2	6.0	6.2	12.9	4.3	9.5
25	Goa	735	735	34.1	49.1	27.6	43.3	34.4	42.7
26	Andaman	328	516	19.8	39.3	9.8	34.9	24.4	45.3
27	Delhi	200	191	39.5	81.2	47.5	74.9	40.5	77.5
28	Rajasthan	1188	1188	44.9	57.1	44.6	54.0	38.6	52.9
29	Pondichery	960	960	84.1	89.3	78.6	80.3	84.8	89.2
	Total	**53922**	**49340**	**17.6**	**39.0**	**14.4**	**31.6**	**15.8**	**34.0**

2.1.3.2 NADCP Round 2

Vaccination under round 2 of NADCP was delayed due to several reason. During later part of 2021, vaccination in selected states/regions was started. The serum samples were collected as per the sampling frame developed jointly by ICAR-DFMD and ICAR-NIVEDI. During 2021, a total of 17,029 serum samples (pre-vac: 9450 and post vac: 7579) collected under NADCP round 2 was processed. Testing of remaining samples is under progress. The protective titre was found in **30.9, 26.7 and 31.5** percent of animals against serotypes O, A and Asia1, respectively in pre vaccination samples, and **57.5, 58.4 and 61.4** percent of animals against serotypes O, A and Asia1, respectively, in post-vaccination samples. The results are presented in the Table 10.

Table 10. State/UT wise percentage of animals showing protective titre against FMD virus serotypes O, A and Asia1 (NADCP-2)

State/UT	Pre-vac samples	Post-vac samples	Serotype O		Serotype A		Serotype Asia1	
			Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Haryana	2289	2285	36.4	68.8	34.7	67.9	43.2	72.9
Maharashtra	1079	611	14.1	67.9	18.8	68.2	16.5	65.3
Delhi	234	230	73.1	88.7	65.0	86.1	65.0	89.6
Uttar Pradesh	879	-	38.0	-	18.1	-	36.5	-
Karnataka	1196	1213	60.3	88.1	56.0	88.1	55.4	86.3
Jammu Kashmir	487	-	38.4	-	26.1	-	17.5	-
Chandigarh	200	200	35.5	75.5	32.0	68.0	40.0	79.0
Andhra Pradesh	2722	2716	19.7	41.5	19.5	46.5	22.9	49.2
A&N Island	364	-	16.8	-	7.1	-	17.6	-
Himachal Pradesh	-	324	-	71.6	-	65.4	-	72.8
Total	**9450**	**7579**	**30.9**	**57.5**	**26.7**	**58.4**	**31.5**	**61.4**

Haryana

- In Haryana, FMD+HS combined vaccine was used and a total of 2289 pre and 2285 post vaccination serum samples were collected.
- In pre-vaccination samples, the protective titre ≥1.65 $\log_{10}$ was found in **36.4, 34.7 and 43.2** percent animals against serotypes O, A and Asia1, respectively.
- In post-vaccination samples, the protective titre of ≥1.65 $\log_{10}$ was found in **68.8, 67.9 and 72.9** percent animals against serotypes O, A and Asia1, respectively.
- Overall seroconversion was found to be satisfactory as shown in Fig 9a, b and c

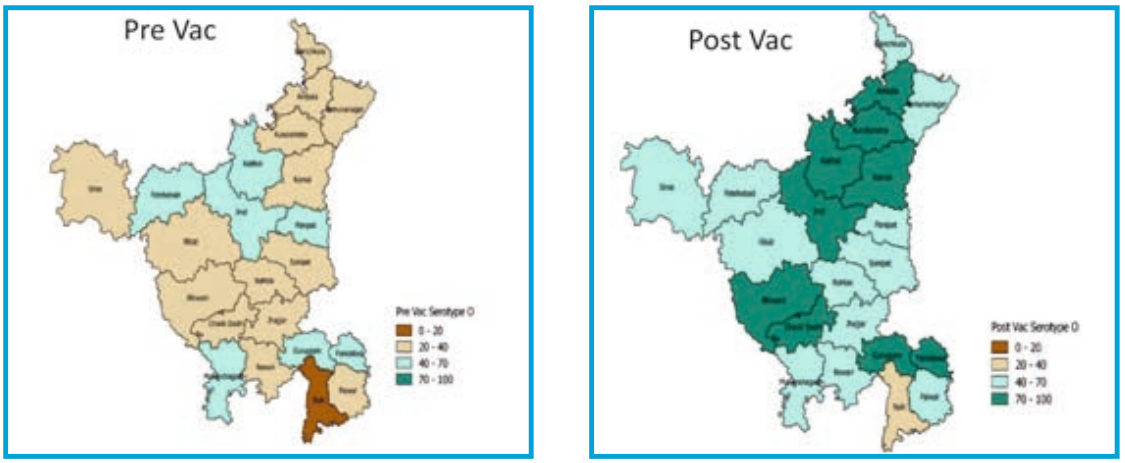


Fig 9a. District wise percent protective antibody titre against FMD virus serotype O

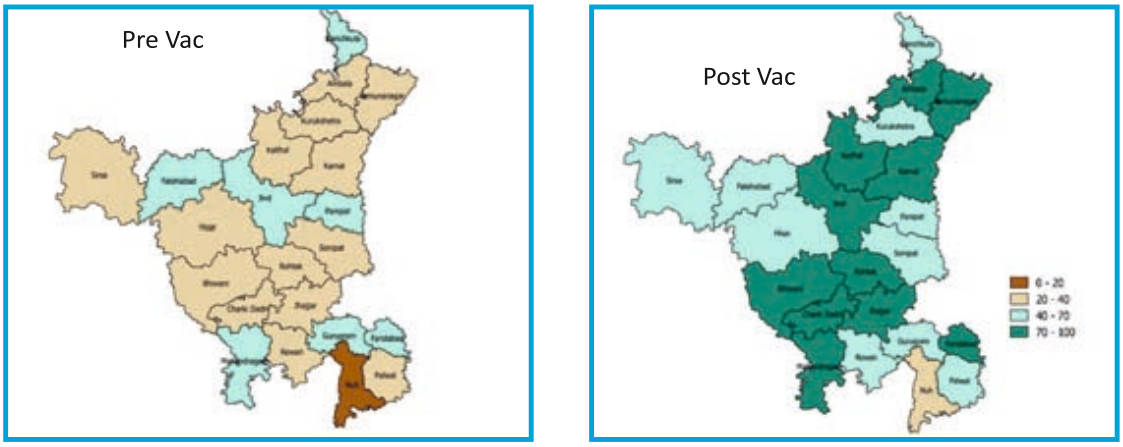


Fig 9b. District wise percent protective antibody titre against FMD virus serotype A

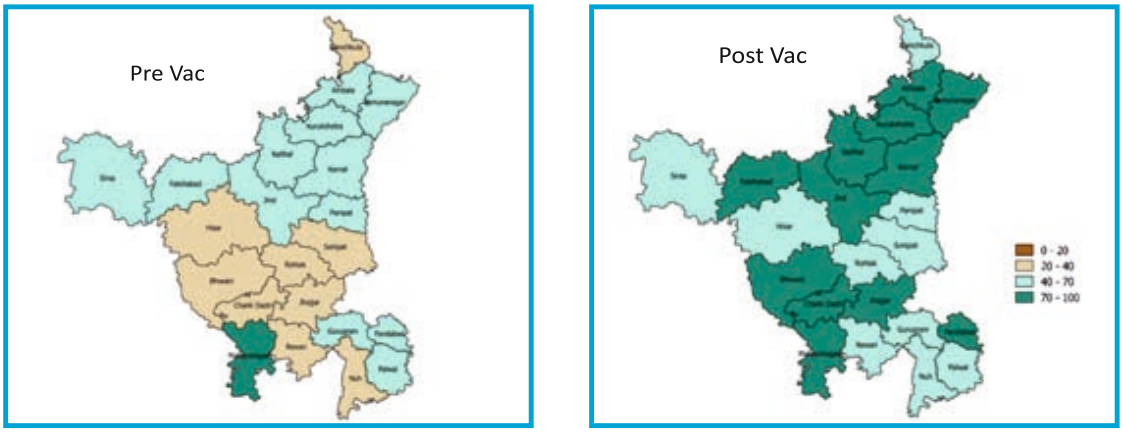


Fig 9c. District wise percent protective antibody titre against FMD virus serotype Asia1

Percent antibody response in different age categories

- As per new plan, samples were collected from three different age groups viz; 6-12M (Category I), 13-24 M (Category II) and >24 M (Category III) in the ratio of 5:4:1
- All the three groups showed good seroconversion and better antibody response in post vac samples. Interestingly, young age category animals (up to 2 years) showed slightly better immune response than that of adult category (> 24 m) (Fig 10)

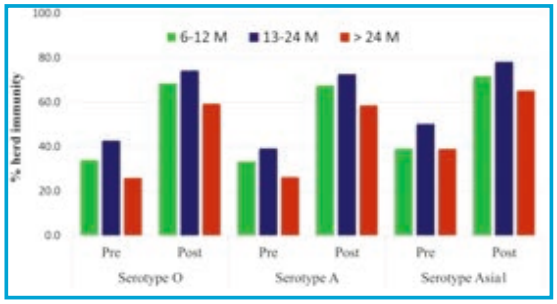


Fig 10. Percent protective antibody titre in different age categories of cattle and buffalo

Percent antibody response in cattle and buffalo

- Serum samples from cattle and buffalo represent 33% and 67% of the total samples tested
- Both the species showed good seroconversion and antibody titre in post vac samples (Fig 11)

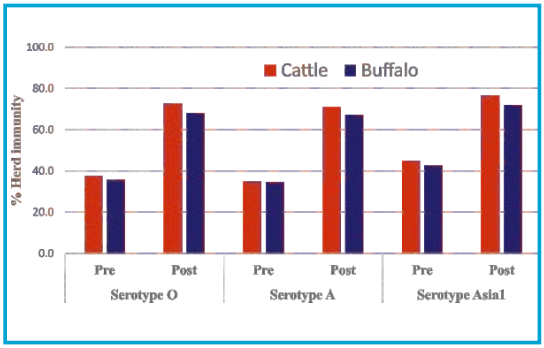


Fig 11. Percent protective antibody titre in cattle and buffalo

Andhra Pradesh

- A total of 2722 pre and 2716 post vaccination serum samples were collected.
- In pre-vaccination samples, the protective titre ≥1.65 $\log_{10}$ was found in **19.7, 19.5 and 22.9** percent animals against serotypes O, A and Asia1, respectively.
- In post-vaccination samples, the protective titre of ≥1.65 $\log_{10}$ was found in **41.5, 46.5 and 49.2** percent animals against serotypes O, A and Asia1, respectively.
- Overall seroconversion was found to be satisfactory. Herd immunity needs to be improved by regular six-monthly vaccination without fail (Fig 12 a,b and c)

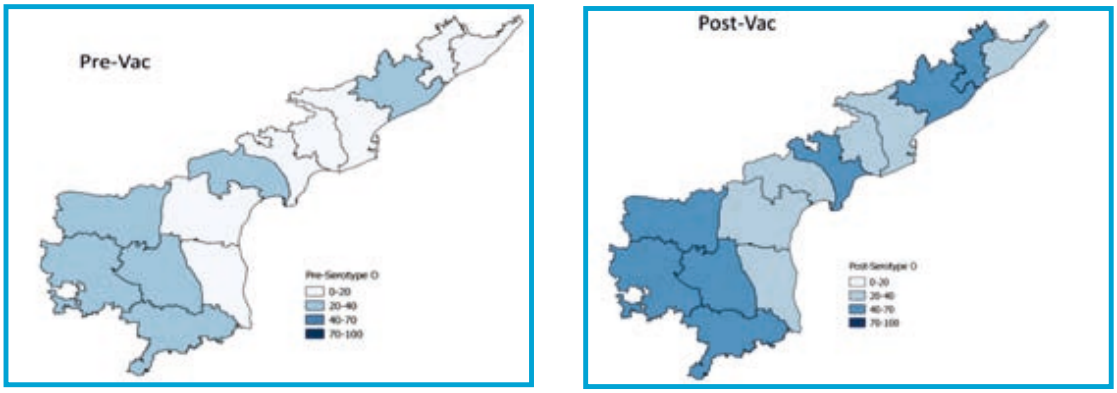


Fig 12a. District wise percent protective antibody titre against FMD virus serotype O

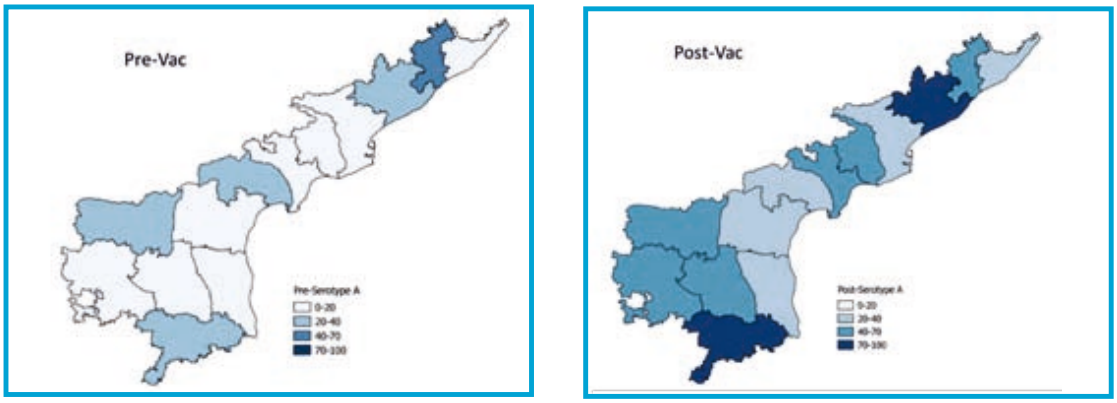


Fig 12b. District wise percent protective antibody titre against FMD virus serotype A

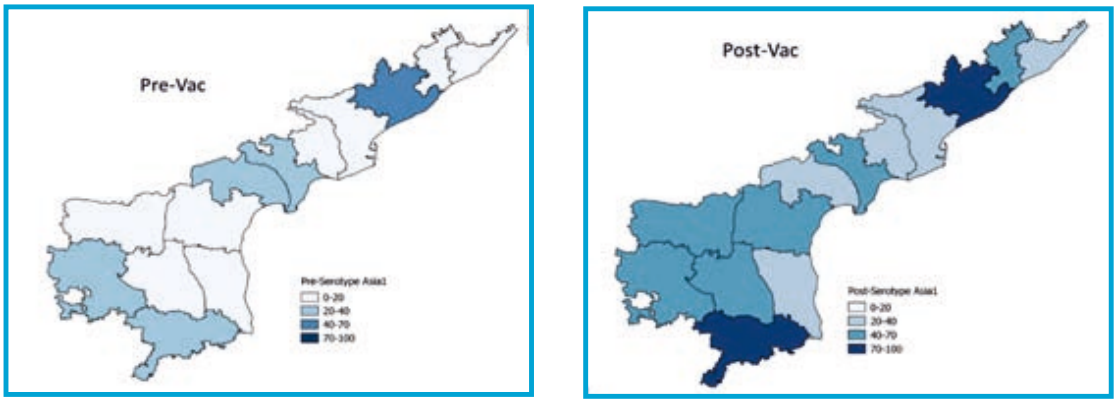


Fig 12c. District wise percent protective antibody titre against FMD virus serotype Asia1

Percent antibody response in different age categories

- As per new plan, samples were collected from three different age groups viz; 6-12M (Category I), 13-24 M (Category II) and >24 M (Category III) in the ratio of 5:4:1
- All the three groups showed good seroconversion and better antibody response in post vac samples. Similar to Haryana , young age category animals showed slightly better response than that of adult category (Fig 13)

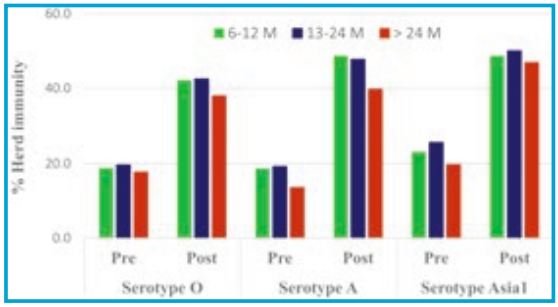


Fig 13. Percent protective antibody titre in different age categories of cattle and buffalo

Percent antibody response in cattle and buffalo

- Serum samples of cattle and buffalo represent almost equal proportion of total serum samples collected
- Cattle showed good seroconversion and antibody titre than buffalo in both pre and post vac samples (Fig 14)

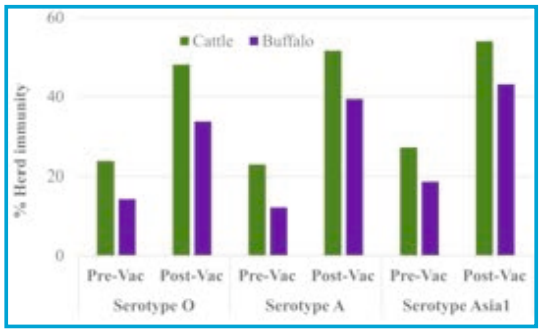


Fig 14. Percent protective antibody titre in different age categories of cattle and buffalo

FMD seromonitoring in organized farms

DFMD and its network laboratories undertakes testing of samples from organised government farms. During 2021, a total 8183 (pre-vac: 3938 and post vac: 4245) serum samples received from various Breeding Bull stations and random samples from surrounding villages were tested to assess the protection level. The antibody titre cut-off of ≥1.8 $\log_{10}$(@ 50 PI)was used for calculation as mostly, the samples were tested before the adoption of new cut-off. The antibody titre and post vaccination seroconversion were found to be excellent (>90%) in most of the farms (Table 11). In most of the organized farms, regular vaccinations have been practised without fail. In order to bring FMD to zero level with vaccination, similar efforts need to be adapted in whole of the nation.

Table 11. Farm wise percent animals showing protective titre against FMD virus serotypes O, A and Asia1

State/UT	Pre-vac samples	Post-vac samples	Serotype O		Serotype A		Serotype Asia1	
			Pre	Post	Pre	Post	Pre	Post
Haryana	1283	1574	89.9	95.8	79.7	92.4	89.0	95.7
HP	64	64	84.4	92.2	53.1	81.3	32.8	54.7
AP	429	480	83.9	96.3	72.5	86.9	84.8	92.3
MP	402	601	66.7	90.7	61.2	79.0	78.4	91.2
Chhattisgarh	83	82	65.1	79.3	61.4	87.8	57.8	67.1
UP	240	169	72.1	83.4	69.6	72.8	89.2	87.6
Gujarat	340	159	63.2	95.0	53.5	79.2	63.2	77.4
Tamilnadu	105	105	87.6	97.1	69.5	96.2	77.1	93.3
Kerala	882	901	84.5	92.6	73.0	86.8	85.5	91.6
West Bengal	110	110	88.2	94.5	91.8	97.3	93.6	97.3
Total	**3938**	**4245**	**81.5**	**93.5**	**71.9**	**87.4**	**82.7**	**91.6**

2.1.4 Evaluation of efficacy of disinfectants and cleaners against FMDV

The virucidal efficacy of disinfectants against FMD virus was evaluated in vitro on simulated non-porous environmental surfaces. It was performed as per standard guideline of OEDC with few modifications in BHK 21 cell line against FMD virus serotype O (stock virus titre= 7.8 Log10 TCID50/ ml). The assay was conducted in duplicate using interfering substance (BSA 0.3%) on plastic and stainless-steel carriers. Sodium Carbonate (4%), Citric acid (2%), mixture of citric acid (2%) and Sodium Chloride (10%) were used in the study at 25°C temperature. The virus recovery from simulated steel and plastic carrier surfaces was optimized. The mixture of citric acid (2% W/V) and Sodium Chloride (10% W/V) showed significantly higher reduction of FMDV serotype O virus titre in 5 minutes contact time on plastic and stainless-steel surface in vitro (Fig 15). It could be explored for disinfection of FMDV contaminated plastic and steel surface in livestock farm setting

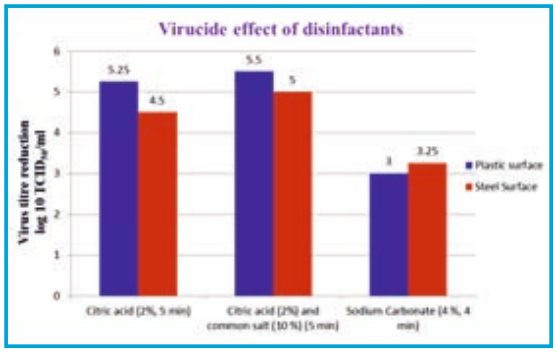


Fig 15. Bar Char indicating virucidal effect of disinfectants on non-porous surface (plastic and steel) in simulated environment

2.1.5 FMD vaccine quality control testing under NADCP

Under NADCP, ICAR-DFMD participated in the quality control testing of FMD vaccines to be used for the vaccination. The vaccine quality assessment tests were carried out in various state and central government farms in Odisha, Andhra Pradesh and Uttarakhand. The coded vaccine batches selected randomly by standardization division, ICAR-IVRI, Bareilly were tested for four basic attributes of quality vaccine viz; potency, safety, purity and sterility. For each individual batch, the calves were first screened for sero-negative status with respect to FMD antibody. A group of 20 FMD sero-negative calves were selected for each batch of vaccine consisting of non-vaccinated control (02), safety testing (02) and potency test (16). From potency test group, the pre vaccination (0 day) as well as 28 days post vaccination serum was collected and evaluated for serotype specific FMD antibody titer using VNT. For purity testing, a booster was administered to 8 calves in the potency group at 28 days post primo vaccination and animals were sampled at 28 days post booster (56 days post primovaccination) and tested using 3AB3 NSP ELISA for NSP antibody purity. During 2021, eight coded vaccine batches were tested (Table 12). For that about 200 animals were screened at CCBF (Chiplima), CCBF (Sunabeda), NKBC (Nellore), CBF (Junagadh), CBF (Imlikheda), CLF (Nellore) and Dairy farm, GBPUAT using VNT to select sero-negative animals. Under each batch the safety, sterility, purity and potency tests were conducted as per the standard operative procedure laid down by DAHD.

Table 12. Various batches of FMD vaccine tested by ICAR -DFMD with bovine calves of various farms

Sl no.	Vaccine Batch	Date of start of testing	Place
1.	BS/056C07X/2020	17-11-2020	CBF, Junagadh
2.	BS/136L09X/2020	13-01-2021	CCBF, Sunabeda
3.	BS/077G09X/2020	18-01-2021	CCBF, Chiplima
4.	005-175-CC15U-26	15-03-2021	NKBC, Nellore
5.	007-170-CC15U-26	18-03-2021	SPSR , Nellore
6.	01FUT00921	06-08-2021	GBPUAT, Patnagar
7.	129-213-JJ29U-26	04-12-2021	CBF, Imlikheda
8.	012-215-LL02U-22	04-12-2021	CBF, Imlikheda

2.2 Development and Improvement of Diagnostics

Development of sensitive diagnostics and refinement of existing diagnostic tests is important mandate of the institute. During the reported period, comparative efficacy of Solid Phase Competitive ELISA (SPCE) with that of Virus Neutralization Test (VNT) for post vaccination protective antibody assessment was optimized. The technique for regeneration of silica-based viral-RNA purification column for the extraction of FMDV RNA without the risk of carryover contamination and TaqMan-probe-based real-time RT-PCR assays (RT-qPCR) for pan-serotype detection of FMDV in India was developed. In addition, FMDV serotype O specific monoclonal antibodies (mAb) were generated and analysed, and monoclonal antibodies already available were checked to explore their use in diagnostics and other applications.

2.2.1 Determination of comparative efficacy of SPCE with that of VNT for protective antibody assessment

Solid Phase Competitive ELISA (SPCE) developed at this Institute is adopted countrywide in all the testing laboratories involved in FMD post-vaccination seromonitoring activity under NADCP-FMD since the year 2017. The test provides semi-quantitative structural antibody titre estimate in the serum sample against Indian vaccine strains for three serotype such as O, A and Asia 1 and final interpretation categorizes the serum antibody titres in a dichotomous manner as 'protective' titre and 'unprotective' titre based on 50 % inhibition of OD_{max} values in 'no-inhibition' antigen control wells and cut-off $\geq \log_{10}$ titre of 1.8. The test was adopted with limited comparative data generated on serum antibody titre values in SPCE vis a vis Liquid Phase Blocking ELISA (LPBE). An attempt was made to draw a qualitative correlation of antibody titres obtained in SPCE with those obtained in VNT (considered as gold standard alternative *in vitro* test) with respect to protective antibody titre cut-off as being generally followed in VNT (Log_{10}titre of 1.8, 1.65 and 1.65 for serotype O, A and Asia 1, respectively) and thought to be a correlate of *in vivo* vaccine potency.

A set of 198 serum samples (119 judged protective and 79 as unprotective in VNT) were tested both in VNT and SPCE and the antibody titres in SPCE at a range of % inhibition values (30%, 35%, 40%, 50%) were determined. The relative diagnostic sensitivity (DSn) and specificity (DSp) of SPCE at various $\log_{10}$titre cutoffs ($\log_{10}$ 1.5, $\log_{10}$ 1.65 & $\log_{10}$ 1.8) over a range of % inhibition values based on concordance with respect to 'protective' and 'unprotective' titre in VNT were estimated (Table 13). For all three serotypes, a reasonably balanced higher sensitivity and specificity was observed at 35% inhibition & $\log_{10}$ 1.65 titre cutoff criteria. Without losing much of diagnostic specificity, the diagnostic sensitivity could be significantly improved from 36% to 90% for serotype O, from 39% to 84% for serotype A and from 41% to 78% for serotype Asia1 at the revised interpretation criteria as compared to the earlier criteria of 50% inhibition and $\log_{10}$ titre cut-off 1.8. Accordingly, the criteria of interpretation for SPCELISA was suggested to be changed from 50% inhibition & titre cut-off $\log_{10}$ 1.8 to 35% inhibition & titre cut-off $\log_{10}$ 1.65 for assessment of protective antibody titre and be applied for sero-monitoring under NADCP-FMD. However, more serum samples need to be tested to further fine tune the criteria of interpretation particularly including samples collected from vaccine potency-challenge studies. Also, the uniform cutoff criteria suggested for all three serotypes for now may be refined on serotype to serotype basis for better accuracy once more relevant data is available for analysis in the time to come.

Table 13. SPCELISA vs VNT: Relative Diagnostic Sensitivity & Specificity Matrix of SPCELISA over a range of % inhibition and Log_{10} titre cutoff for estimation of FMD post-vaccination protective antibody titre

SPCE log10 titre cut off → / % Inhibition ↓	FMD Serotype O					
	Log 1.5		Log 1.65		Log 1.8	
	DSn %	DSp %	DSn %	DSp %	DSn %	DSp%
30%	94	88	92	90	84	98
35%	90	93	**90**	**94**	68	100
40%	88	97	88	97	56	100
50%	64	100	64	100	**36**	**100**

SPCE log10 titre cut off → / % Inhibition ↓	FMD Serotype A					
	Log 1.5		Log 1.65		Log 1.8	
	DSn %	DSp %	DSn %	DSp %	DSn %	DSp %
30%	87	90	85	93	72	98
35%	84	94	**84**	**95**	55	100
40%	72	100	72	100	45	100
50%	50	100	50	100	**39**	**100**

SPCE log10 titre cut off → / % Inhibition ↓	FMD Serotype Asia1					
	Log 1.5		Log 1.65		Log 1.8	
	DSn %	DSp %	DSn %	DSp %	DSn %	DSp%
30%	88	82	84	86	65	98
35%	80	88	**78**	**93**	60	100
40%	68	98	64	98	57	100
50%	61	100	61	100	**41**	**100**

Relative DSn and DSp values at revised interpretation criteria (Log_{10} titre cutoff $\geq$ 1.65 and 35 % inhibition) are filled with yellow while those at earlier criteria (Log_{10} titre cutoff $\geq$ 1.8 and 50 % inhibition) are filled with red

2.2.2 TaqMan-probe-based real-time RT-PCR assays (RT-qPCR) for pan-serotype detection of FMDV in India

FMDV-serotype specific antigen-ELISA, agarose-gel electrophoresis-based RT-multiplex PCR assays, and virus isolation are routinely being used for the diagnosis of FMD virus in the suspected field samples. However, these assays are time consuming and may not be used in high throughput manner while screening large number of clinical samples during active epidemiological surveillance of FMDV under field condition. Therefore, two previously reported and OIE approved TaqMan-probe based FMDV-pan-serotype RT-qPCR assays such as FMDV 3D polymerase gene-specific RT-qPCR and 5'-un-translated region (FMDV-5'UTR) specific RT-qPCR assays were evaluated under Indian condition using a variety of clinical samples. Initially the assays were validated with known FMDV isolates collected and deposited during the last 30 years at the FMDV-repository maintained at ICAR-DFMD. When these RT-qPCR assays were evaluated alongside the established RT-multiplex PCR using the archival FMDV cell-culture isolates and known clinical samples from FMDV field outbreaks, a perfect concordance observed between the RT-qPCR assays and multiplex PCR. Using the FMDV full-genome RNA it was determined that the limit of detection (LOD) of the RT-qPCR assay was 20 copy numbers of viral genome/PCR reaction. In addition, when both these assays (3Dpol RT-qPCR and 5'UTR RT-qPCR) were analysed in parallel with a set of diversified clinical samples (n=712) a good correlation (0.955) was determined between these assays (Fig. 16).

Both these assays were combined together in a single tube along with primers-probe for 18S rRNA house-keeping gene as internal quality control for the development of FMDV pan-serotype one-step multiplex RT-qPCR (Fig. 17). RNA extracted from 900 diversified clinical samples (Oro-pharyngeal fluids, milk samples, serum samples, vesicular fluids, saliva, oral-swabs, tongue-epithelial suspension and post-mortem samples) were screened by the new multiplex RT-qPCR. Therefore, the newly developed FMDV pan-serotype one-step multiplex RT-qPCR can be used in a high-throughput manner for rapid analyses of clinical samples during active virus surveillance procedures.

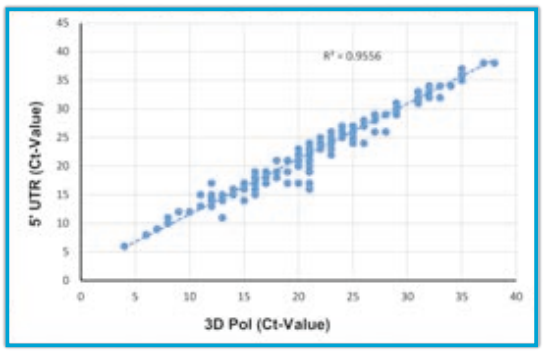


Fig 16. Scatter Plot Showing the co-relation between TaqMan probe-based 5'UTR RT-qPCR and 3D Pol RT-qPCR.

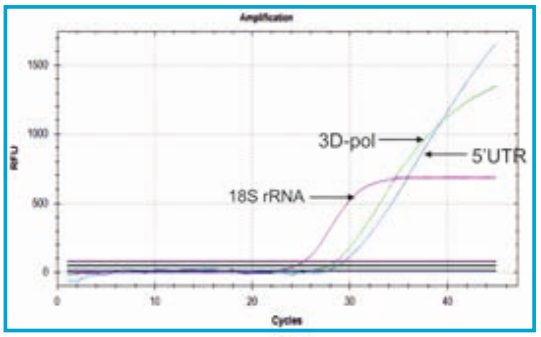


Fig 17. FMDV pan-serotype one-step multiplex RT-qPCR simultaneously amplifying 3D-polymerase, 5'UTR coding regions along with 18S rRNA housekeeping gene as internal control

2.2.3 Generation and analyses of FMDV serotype O specific Monoclonal antibodies (mAb)

Monoclonal antibody can contribute towards the better understanding of the antigenic epitopes of the FMD Virus, as a result precise and useful diagnostic assays can be developed for the diagnosis of FMDV and vaccine quality control purpose. Since serotype O has been responsible for the majority of FMDV outbreak in India, a study has been undertaken to generate FMDV serotype O specific monoclonal antibodies with an ultimate aim of the development of better diagnostic assays. Approximately, 6-8 weeks old Balb/c mice were immunized with purified FMDV serotype O 146S antigen intraperitoneally with FCA adjuvant, followed by three booster immunization at 28 days interval. The final booster without any adjuvant was administered intravenously for three days before harvesting the splenocytes and their fusion with mouse myeloma

cell line. The primary screening of hybridoma was carried out by FMDV serotype specific Antigen-ELISA and the Cell-ELISA. From primary screening 20 serotype O specific mAbs (Fig. 18a) and 21 serotype-independent mAbs (Fig. 18b) were identified. Subsequently these monoclones were further selected through limiting-dilution single cell-cloning procedure.

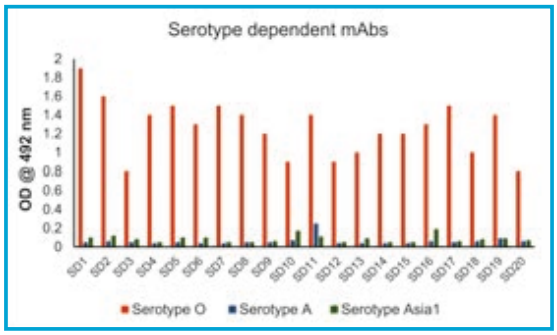


Fig 18a. O.D values serotype O specific monoclonal antibodies as determined by serotype-specific antigen-ELISA.

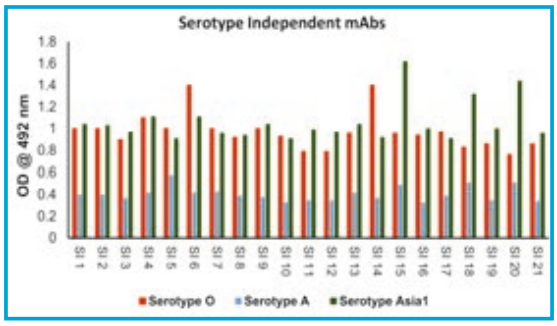


Fig 18b. O.D values serotype-independent monoclonal antibodies as determined by serotype-specific antigen-ELISA

2.2.4 Regeneration and use of silica-based viral-RNA purification column

Silica-based RNA purification columns are commonly used for the extraction of viral nucleic acids owing to their ability for extraction of good-quality of viral RNA in a user-friendly manner. However, the major limitation associated with the RNA extraction columns is their cost. Furthermore, single-time use design of RNA-columns can generate plastic wastes that have an environmental pollution effect. The re-use of RNA extraction column though desirable, has not been recommended because of residual carry-over contamination of viral RNA that have been trapped in the silica matrix which might be released during further re-use. Therefore, recycling silica-based RNA purification columns require complete removal of any detectable previous RNA traces. To address the issue, a rapid decontamination of used RNA columns has been developed using warm alkaline solution containing Triton-X-100 for complete removal of the residual FMD viral RNA from the used RNA-binding silica column. Used silica columns regenerated using the warm alkaline solution have the viral RNA purification capability that is similar to the fresh silica-based RNA purification columns as determined by the quantitative RT-qPCR targeting the 3D polymerase coding region of FMD virus. In addition, through RT-qPCR assay, it has been demonstrated that used RNA-binding silica columns can be used for at least five-times. Therefore, used RNA-binding columns can be regenerated and re-used for the extraction FMD viral RNA and diagnosis of FMD virus infection though nucleic-acid recognition methods with no compromise in quality. This technique is likely to help in screening of probang samples during follow up of NSP reactors.

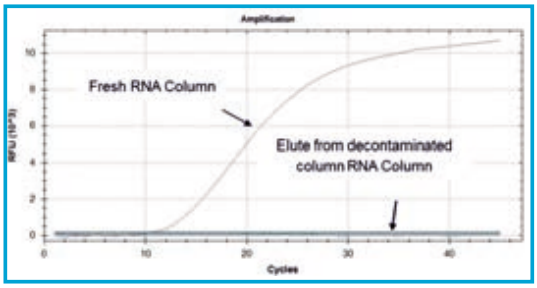


Fig 19. Elimination of residual FMDV RNA from the used silica-binding RNA purification column by heated alkaline solution treatment. FMDV 3Dpol-based RT-qPCR analysis showed the complete removal of residual viral RNA in the elute from the used RNA-binding column that has been treated with heated alkaline solution.

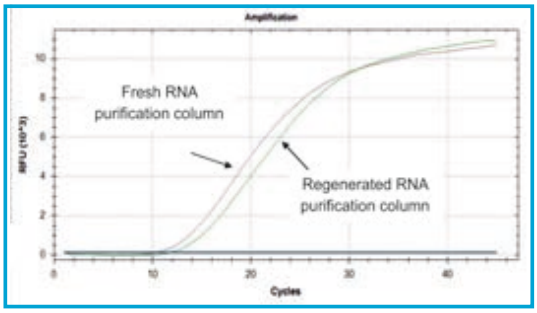


Fig 20. FMDV 3Dpol-based RT-qPCR analysis showed that the regenerated Viral-RNA purification column has the comparable capacity for FMDV RNA purification as the fresh column.

2.2.5 Screening of serotype O specific monoclonal antibodies (MAbs)

A total (n= 10) monoclonal antibodies (MAbs) supernatant out of 47 were found to show reactivity against inactivated serotype O antigen in modified sandwich ELISA format. Out of ten clones; Mab58, Mab68 and Mab99 (2) were found to be specific for Trypsin sensitive (Ts) epitopes of serotype O FMDV. Additionally, the Mab58, Mab68 and Mab99 (2) were also found to neutralize serotype O strain IND/R2/1972 FMDV in vivo. These Mabs can be further explored for development of species independent SP antibody detection system for FMD (Fig 21).

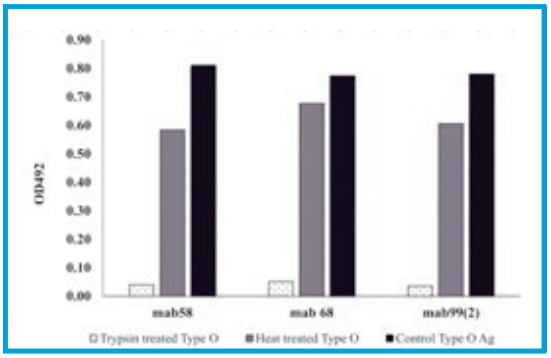


Fig 21. Characterization of MAbs against inactivated FMDV serotype O antigen (treated/ control) by modified sandwich ELISA

2.2.6 Comparative codon usage analysis of RGD binding integrins

Integrins are principle receptors for recognition of conserved RGD amino acid motif of FMDV. Varieties of integrin (αvβ1, αvβ3, αvβ6, αvβ8 etc) are known to bind to the conserved RGD amino acid motif from host or pathogen. Classically, integrin αvβ6 has highest binding affinity and is the principal receptor for binding wild-type FMD virus. These native receptors can be explored for development of recombinant protein based diagnostic assay for specific identification of FMDV. The synonymous codon usage analysis of RGD binding integrins was done to assess evolutionary pressure on gene function, tissue specific expression and to ascertain the suitable host for expression of recombinant integrin. Codon preference analysis shows codon usage for αVβ6 integrin closely resembles [52 codons] to that of *Baculovirus* host. Further it is speculated that to express αVβ6 integrin in E coli/ Yeast host codon optimization is required.

2.3 Development and Improvement of Vaccines

2.3.1 Development of thermostable vaccine candidates for FMDV serotype A

The capsid coding sequence and 3D-structural model of the vaccine strain for FMDV serotype A was analysed through an *in-silico* approach to identify the crucial amino acids located at the inter-pentameric interface of the FMDV capsids which may be responsible to for enhanced thermostability of FMDV serotype A. The putative amino acid residue which may be responsible for enhanced thermostability was identified, and subsequently it was modified to the stabilized version by site-directed mutagenesis on the full-genome FMDV cDNA clone FMDV serotype A. Through reverse genetics technology genetically defined recombinant FMDV serotype A was rescued in cell culture. The rescued recombinant FMDV serotype A viruses (*n*=2) was studied for the growth kinetics, plaque morphologies, genetic-stabilities by sequential passages in cell-culture. Furthermore, thermal inactivation kinetic study was conducted by incubating the recombinant viruses and parental virus at 50°C for 1 hour. After incubating the parental and the mutants at 50°C for 1 hour, a drop in log titre of 0.5 TCID50 was observed for Mutant-2 as compared to a drop in log titre of 1.75 TCID50 for parental FMDV A vaccine strain (Fig. 22).

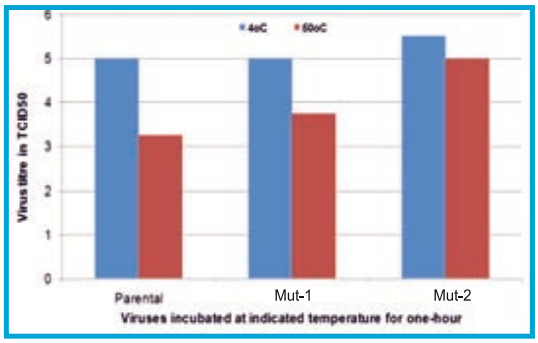


Fig 22. Thermal Inactivation kinetics of parental and mutant FMDV vaccine strains after incubating at 50°C for 1 hour.

2.3.2 Development of DIVA-compatible live-attenuated vaccine candidate strain for FMDV serotype O.

The major problems associated with the conventional FMD vaccine are; instability of antigen outside the range of 2-8°C and inability to stimulate long-lasting antibody response, and inability to induce high cell-mediated immunity. Therefore, it could be argued that new, improved, vaccines against FMDV should be developed. The research project on the "development of DIVA-Compatible live-attenuated vaccine candidate for FMDV serotype O", would be useful for the generation of low-price unit costs vaccine against FMDV with a potential to induce long-lasting immunity. The benefits would be (i) very low production/distribution costs and (ii) better efficacy, since attenuated vaccine would elicit the full repertoire (both humoral and cellular) of host's immune responses.

Recently, a new strategy has been developed to attenuate RNA viruses by altering their genome evolutionary potential. The genomes of the RNA viruses could be engineered by synthetic biology approach to harbour codons with nonsense mutation targets (i.e codons that could generate stop mutations after a single nucleotide substitution). Studies with Coxsackie B3 and influenza A viruses reported that the modified viruses generated more stop codon mutations both *in vitro* and *in vivo*, thereby, accompanied with a significant losses in viral fitness. *In vivo*, these viruses were attenuated, generated high levels of neutralizing antibodies and protected against lethal challenge. In lights of such development in the technology, a similar methodology was used to generate live-attenuated FMDV serotype O vaccine candidate.

101 amino acid codons located on the P1-coding region of the FMDV serotype O viral genome were mutated to codons that could generate stop mutations after a single nucleotide substitution through the synthetic biology approach. Subsequently, using reverse genetics technology recombinant genetically defined virus was rescued in cell culture. After rescuing the modified virus, the growth characteristics and plaque morphologies were studied on the cell monolayer. The result from this study suggested that the rescued recombinant virus 10-100 times slower to replicate in growth kinetics study as compared to the parental virus (Fig. 23)

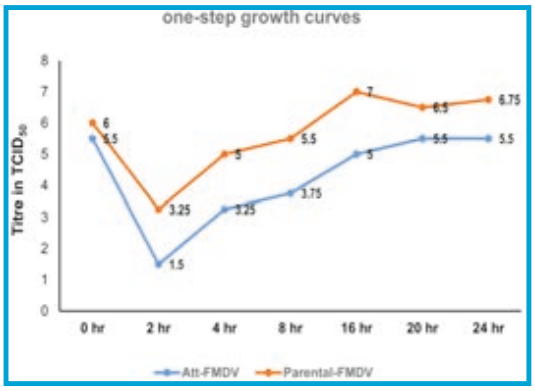


Fig 23. Replication kinetics of attenuated and parental FMDV serotype O in BHK-21 cell monolayer.

To determine the virulence of the developed attenuated vaccine candidate *in vivo*, mouse-model experiment was conducted. 3-5 days old suckling BALB/c mice (n=6) were inoculated with about $10^{6.3}$ $TCID_{50}$/ml of either attenuated or parental FMDV serotype O virus intraperitoneally, and checked for survival and general physical appearance for 5 days. All the suckling mice inoculated with parental FMDV died by 24 hours post-inoculation, while the suckling mice (*n*=6) inoculated with attenuated virus died on 4-5 days post-inoculation.

2.3.3 Use of calcium phosphate nanoparticles for the generation of thermostable vaccine candidate against FMDV serotype O

The crucial component of FMDV vaccine is the intact viral antigen (146S particles), and any degradation of the intact viral antigen would lead to a significant loss in the potency of the FMDV-vaccine. Since the 146S particles are thermolabile in nature, in important component of FMDV-vaccination programme is the maintenance of continuous and fault-less cold chain of the vaccine from the site of production until the end use. However, maintenance of fault-less cold chain is not so easy task owing to the lack of resources and

logistics. Therefore, thermostability of FMDV vaccine is essentially required to tackle the need of fault-less/continuous cold-chain requirement.

Among the different biogenic mineral Calcium Phosphate (CaP), an important component of bones & teeth, is of interest because of its unique biocompatibility and adjuvant properties. Recently, it has been shown that CaP can be introduced on the surfaces of some viruses in the presence of high concentration of calcium ions. Therefore, it has been hypothesized that CaP coated FMDV antigen can provide enhanced thermostability to the FMD vaccine, and hence, such possibility was explored in the current research project.

In this project the sequence-encoding the calcium-binding peptide (CaP) was introduced into the capsid coding region of FMDV serotype O vaccine strain. The genetically defined recombinant FMDV serotype O encoding the CaP was rescued in cell culture through reverse genetics approach. The recombinant virus was characterised through 2D-MNT assay and sequencing of the capsid coding region. Both the recombinant CaP-tagged and parental FMDV were grown in cell culture and inactivated using BEI. The CaP-tagged inactivated antigen was coated with CaP microparticles and coated antigen was incubated at 37°C for 3-days in parallel with non-coated parental FMDV serotype O antigen. After incubation at 37°C the amount of left-over antigen was determined by antigen-ELISA (Fig.24). From the initial analyses, it could be concluded that the CaP coat could provide an advantage of thermostability to the FMDV serotype O.

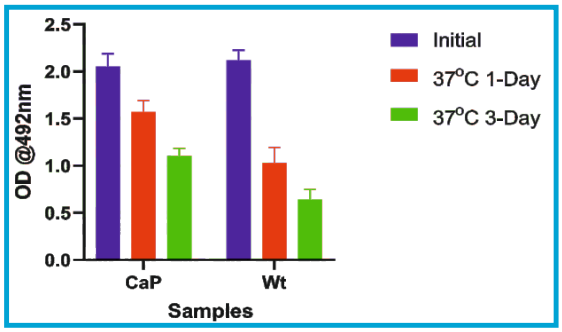


Fig 24. OD value at 492nm in antigen-ELISA for both CaP-coated recombinant and parental (Wt) FMDV serotype O antigen.

2.4 Characterization of Pathogens and Epidemiology

2.4.1 National FMD virus repository

The National FMD virus repository maintained by ICAR-DMFD has world largest collection of FMD virus. Every year, the report is updated with well characterized new FMD virus sampled in India. A total of 113 FMD virus isolates (102 'O', 10 'A' and 1 'Asia 1') revived in BHK-21 cell system were added to the ever growing **National Repository of FMD Virus** maintained at International Centre for FMD, Bhubaneswar and Mukteswar Laboratory (Table 14). At present the National FMD virus Repository holds a total of 2391 isolates (O-1676, A-333, C-15 and Asia 1-367). The repository serves purpose of retrospective analysis, selection of vaccine strains, development of diagnostics etc. FMDV serotype C isolates are being kept at bio-containment laboratory of ICFMD, Bhubaneswar.

Table 14. Year-wise details of the virus isolates added to National FMD Virus Repository during last five years.

Year	O	A	Asia1	Total
2017-18	121	-	-	121
2018 (Apr-Dec)	76	-	-	76
2019	15	-	-	15
2020	-	-	-	-
2021	102	10	1	113

2.4.2 Molecular Epidemiology FMDV Serotype O

Eleven geographically restricted topotypes have been identified globally, namely Europe-South America (EURO-SA), Middle East-South Asia (ME-SA), South East Asia (SEA), China, Indonesia (ISA), ISA-2, East Africa (EA)-1, EA-2, EA-3, EA-4, and West Africa (WA). In India, several genetic groups (lineages/sub-lineages) of the ME-SA topotype virus have been found, each having more than 5% nucleotide difference in the 1D region. The Indian vaccine strain

(INDR2/1975) is a member of the Branch B lineage. In South Asia including India, the O/ME-SA/PanAsia and O/ME-SA/Ind2001 strains have been identified as the most dominant lineages within the ME-SA topotype.

Since its first report in 2001, the O/ME-SA/Ind2001 lineage got branched into at least five sub-lineages (Ind2001a, b, c, d, and e). The appearance of sub-lineage O/ME-SA/Ind 2001e during the year 2015 in India was identified by phylogenetic comparison of serotype O isolates with representative strains. During the period 2015–2017, the sub-lineage O/ME-SA/Ind2001e was responsible for sporadic cases before causing epidemic outbreaks in 2018. Since its first appearance in 2008, the O/ME-SA/Ind2001d lineage has been a major contributor to FMD outbreaks in the country. The circulation of the O/ME-SA/Ind2001d lineage has been reduced since the emergence of lineage O/ME-SA/Ind2001e. During the period 2015–2017, both lineages co-circulated for three years before O/ME-SA/Ind2001d was eventually phased out of the field. The emergence of a new cluster in 2018, labelled as the O/ME-SA/2018 lineage was previously recorded. This lineage showed considerable genetic divergence from both O/ME-SA/Ind2001 and O/ME-SA/PanAsia lineages.

During the year 2021, a total of 54 FMD virus serotype O field isolates were sequence determined and subjected to phylogenetic analysis. The analysis revealed four important epidemiological events (Fig 25).

1. In the field, lineage O/ME-SA/Ind2001d is completely absent. Since 2018, this lineage has not been recorded in any outbreaks, indicating its likely extinction from the field.
2. The O/ME-SA/2018 lineage has resurfaced after its discovery in 2018. This lineage was only identified in a few states in 2019 and 2020, but numerous states reported it in 2021.
3. The dominance of O/ME-SA/Ind2001e was maintained in 2021 as well.
4. The reappearance of lineage O/ME-SA/Pan Asia related isolates in Jammu & Kashmir

The majority (n=39) of the 54 isolates were determined to belong to the O/ME-SA/Ind2001e sub-lineage, which was scattered throughout eight states indicating its widespread dominance in the field. The lineage O/ME-SA/2018 had 13 isolates sampled in 2021, indicating that it was on the rise. Most importantly, this lineage was discovered in at least six states/UTs, indicating a widespread distribution. Surprisingly, two samples from Jammu & Kashmir clustered close to lineage Pan-Asia, with 96 percent sequence identity with a Pakistan strain (Pak/O/LHR-12/19, GenBank: MT996509) collected in 2019. Virus transmission between India and Pakistan is unusual due to animal transportation restrictions according to previous research and strict border control. However, the recent detection of O/ME-SA/Ind2001e in Pakistan and Pan Asia-like viruses in India suggests that the two nations may be exchanging FMD viruses. Fortunately, we have not documented continuation of such a lineage, which normally vanishes after a few isolated rare incidents. As previously stated, the intra lineage sequence homology within O/ME-SA/Ind2001e and O/ME-SA/2018 was found to be quite high, implying a significant epidemiological relationship and virus transmission between states. Both O/ME-SA/Ind2001e and O/ME-SA/2018 were discovered to circulate in the states of Karnataka and Maharashtra. Furthermore, in Jammu & Kashmir, where all three lineages were documented, there was a high level of epidemiological complexity (Fig 25 and 26). FMD outbreaks were especially widespread and intense in the UTs of Jammu & Kashmir and Ladakh in 2021.

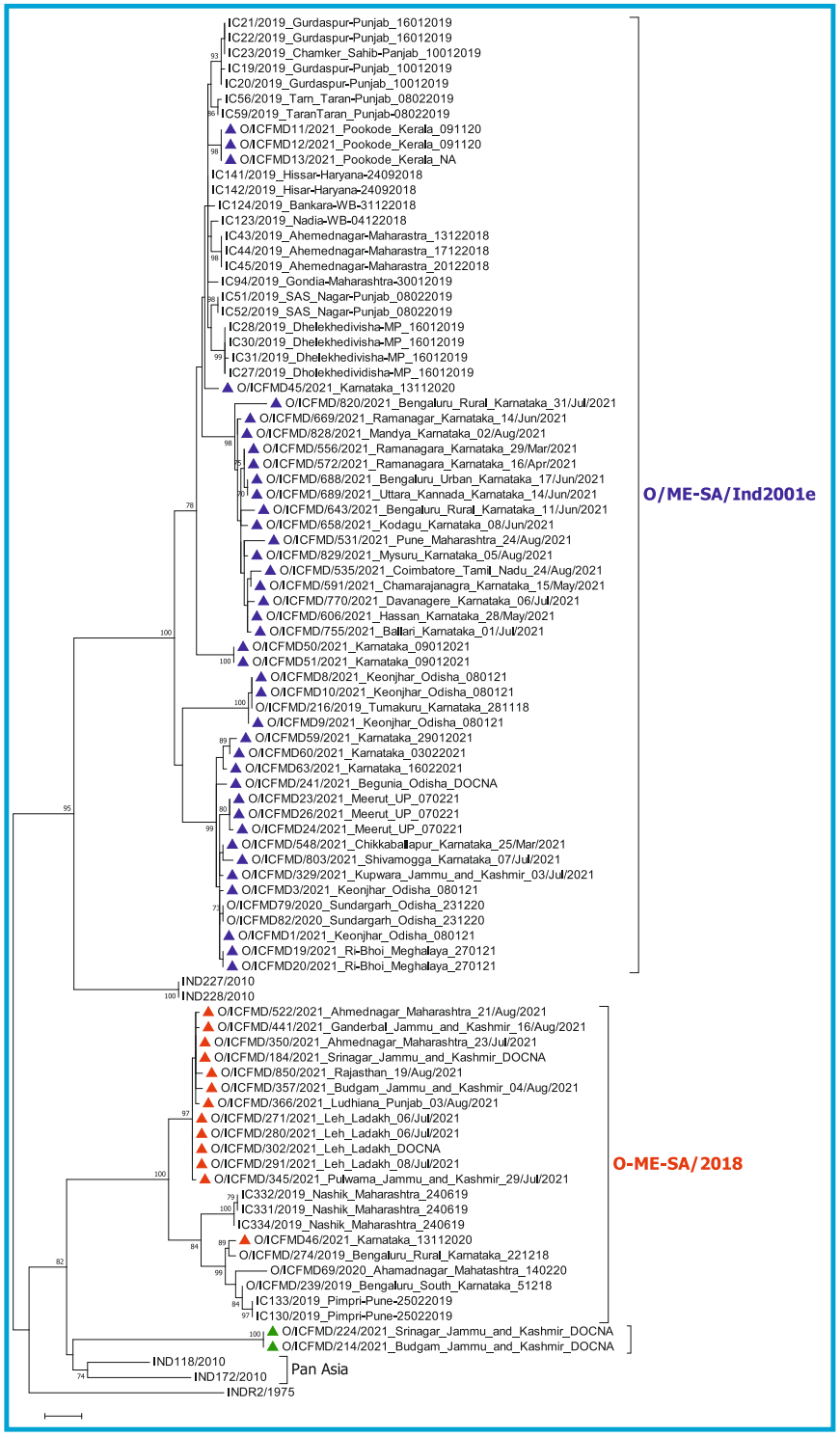


Fig 25. Maximum Likelihood phylogenetic tree at VP1 coding region of Indian FMD virus serotype O isolates during 2021. The analysis showed dominance O/ME-SA/Ind2001e lineage in India during the period.

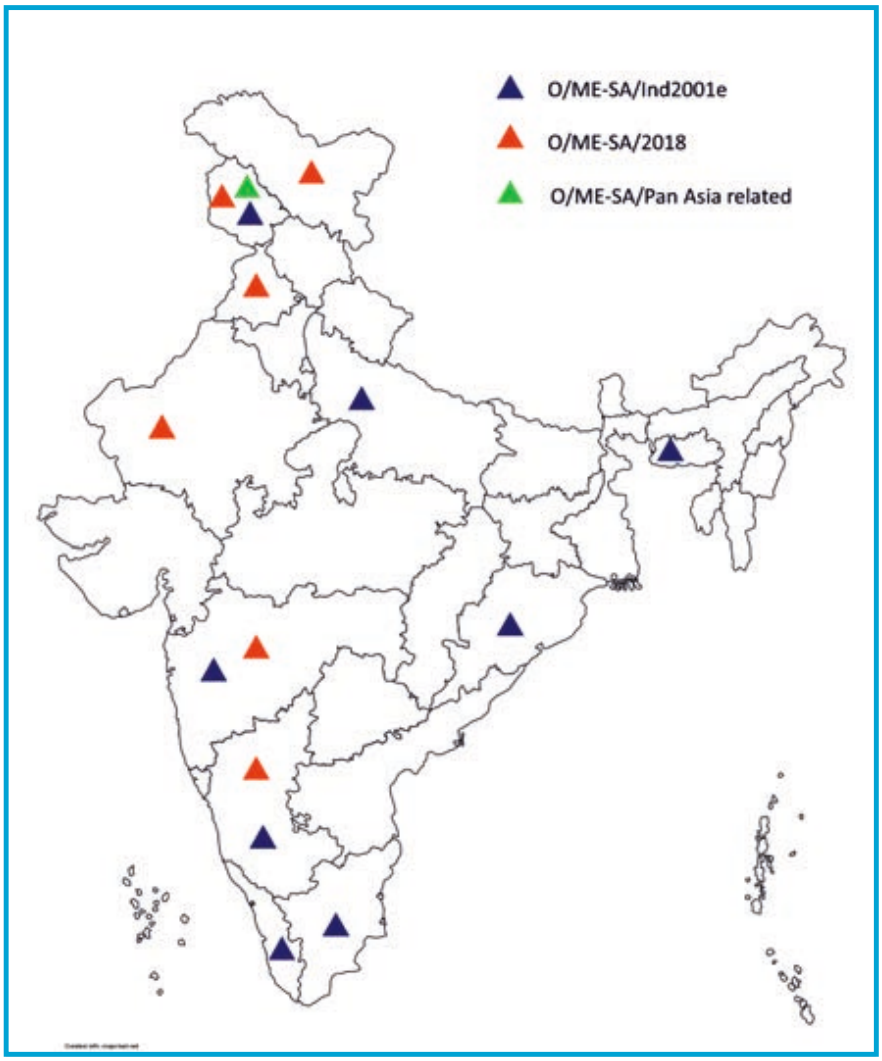


Fig 26. Distribution of different lineages of FMD virus serotype O isolates during 2021.

2.4.3 Molecular Epidemiology FMDV Serotype A

Serotype A virus population is genetically and antigenically most heterogeneous in nature among the three serotypes prevalent in India. Molecular phylogeny has established circulation of four genotypes (2, 10, 16 and 18) showing more than 15% nucleotide (nt) divergence among them at 1D region of serotype A so far in India. Since 2001, genotype 18 has been exclusively responsible for all the field outbreaks and has outcompeted all other genotypes. Within the currently circulating genotype 18, a divergent and unique lineage emerged in late part of 2002, which showed an amino acid (aa) deletion at 59th position of VP3 (VP3^{59}-deletion group) and dominated the field outbreak scenario in 2002-03. Ever since then sporadic outbreaks due to this lineage has been identified. During the year 2021, FMD outbreak due to serotype A was recorded in Karnataka, Maharashtra, Tamilnadu, UP, Punjab, Odisha, Nagaland and Jammu & Kashmir. A total of 13 isolates sampled from Jammu & Kashmir, UP, Punjab, Nagaland, Karnataka and Odisha were sequence determined. Phylogenetic analysis based on Maximum Likelihood method revealed clustering of all the isolates within G-18/non-deletion/2019 lineage (Fig 27), which was first identified during the year 2019 in the state of Maharashtra. The analysis further confirms the strong establishment of the lineage in India.

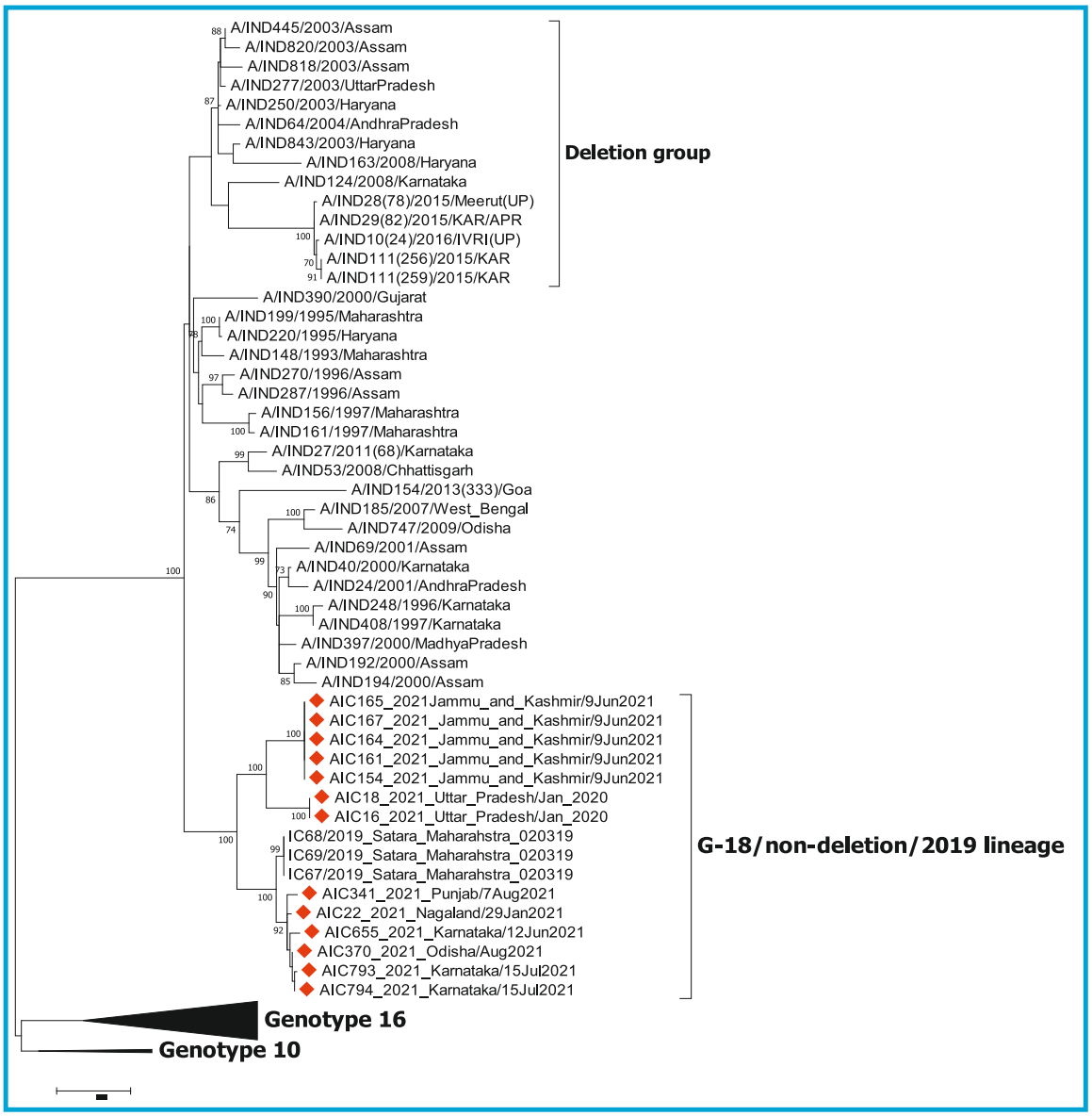


Fig 27. Maximum Likelihood phylogenetic tree at VP1 coding region of Indian FMD virus serotype A isolates during 2021. The analysis showed circulation of G-18/non-deletion/2019 lineage

2.4.4 Molecular Epidemiology FMDV Serotype Asia1

Previous studies on 1D/VP1 gene based phylogeny demarcated Indian serotype Asia1 field isolates into three major lineages namely B, C and D. Lineage B which includes the currently used serotype Asia1 vaccine strain IND63/1972, was last recorded in the year 2000. The isolates of lineage D emerged late in 2001 and dominated the period between 2002 and 2004. The lineage C dominated the Asia1 field outbreaks between 1998 and 2002, although disappeared between year 2001 and 2004, and re-emerged as the predominating lineage from 2005 onwards (sub-lineage CII). FMD virus serotype Asia1 isolated since 2004 are classified in nine different genetic groups (G I-IX) globally. On global scale, isolates collected from India during 2001-2004 (termed earlier as lineage D) clustered within Group III. Isolates collected after 2005 from India, (termed earlier sub-lineage CII) and clustered with in Group VIII.

One FMDV serotype Asia1 isolate collected during 2021 from the state of Jammu & Kashmir clustered within Group-IX (BD-18) whose

emergence has been described recently in January, 2018 in Bangladesh and in Tamilnadu during the month of January 2020 (Fig 28). The Asia1/G-IX apparently shares recent common ancestry with Asia1/G-VIII, and as suggested earlier key founder events in the transmission pathway of G-VIII might have triggered the emergence of G-IX. The analysis indicates extended dominance of Group-IX in India.

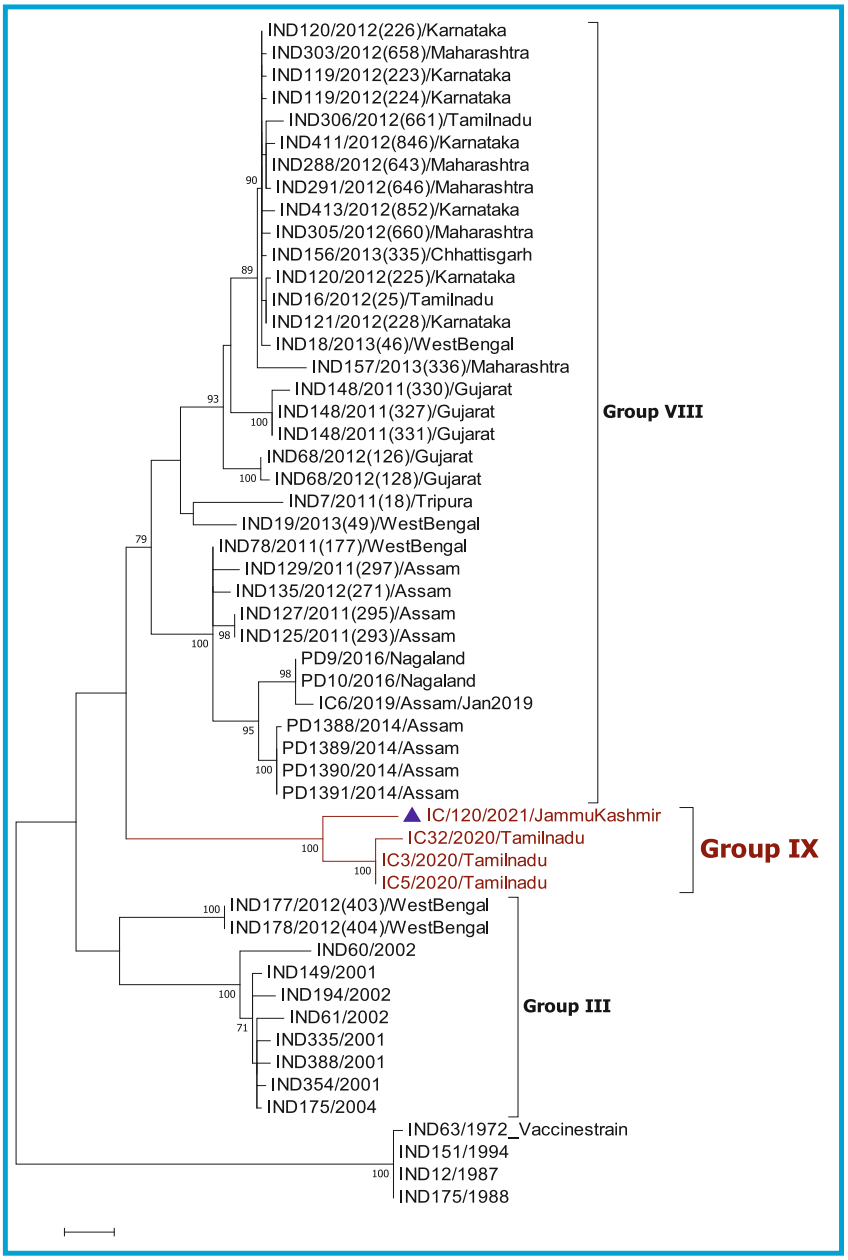


Fig 28. Maximum Likelihood phylogenetic tree at VP1 coding region of Indian FMD virus serotype Asia1 isolates during 2021. The analysis showed emergence of G-IX

2.4.5 Vaccine matching studies of FMD virus field isolates

Vaccine matching analysis employing bovine vaccinate serum (BVS) against respective vaccine strain with field isolates was carried out to assess the appropriateness of the in-use vaccine strains. The antibody titre was determined as the reciprocal of the last dilution of serum that neutralizes 100 $TCID_{50}$ in 50% of the wells. The relationship value was calculated as a ratio of antibody titre against field isolates to that against the vaccine strain. The r-value of >0.3 indicates sufficient antigenic

homology between field isolates and vaccine strain. Conversely r-value of <0.3 is suggestive of antigenic deviation. The test was repeated three times and the $\log_{10}$ titre were averaged for calculation of r-value.

FMDV Serotype O

A total of 53 FMDV serotype O field isolates collected during the year 2021 were subjected to vaccine matching using BVS against in-use serotype O vaccine strain INDR2/1975. The isolates were collected from different states and species of the animals. From the analysis, it was found that all the isolates (100%) showed an r-value of >0.3 with the vaccine strain INDR2/1975 showing good antigenic match (Fig 29). In Indian vaccine formulations, the current serotype O vaccine strain can continue to be used.

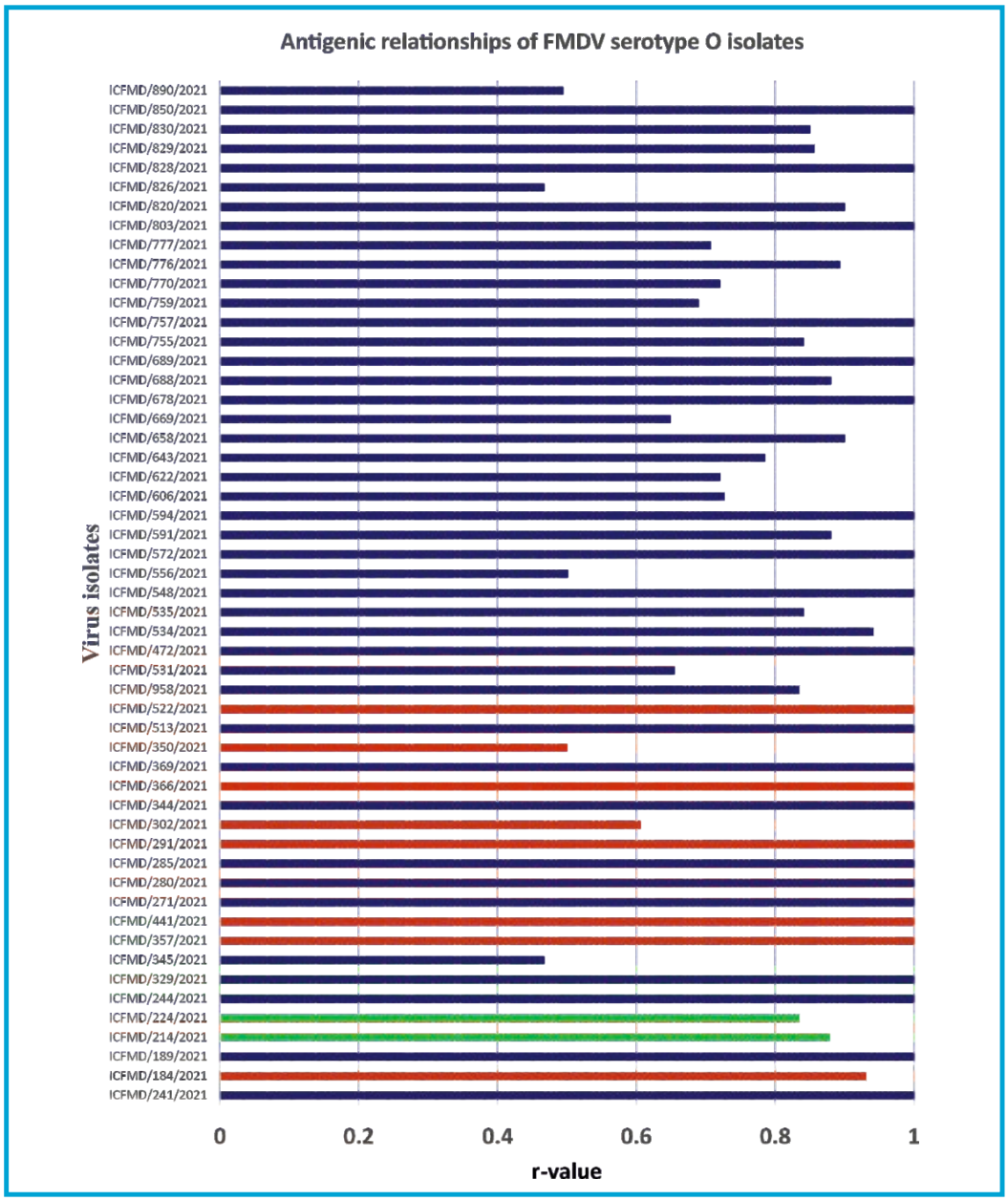


Fig 29. The antigenic relationship values of 53 FMDV serotype O field isolates collected during the year 2021 (Blue-O/ME-SA/Ind2001e, Red-O/ME-SA/2018 and Green-Pan Asia like)

FMDV Serotype A

FMDV Serotype A virus strains circulating in India since 2012-13 have been found to be antigenically divergent from the currently used vaccine strain (IND40/2000), thereby warranting selection of a new candidate vaccine strain that can cover this diversity in antigenic spectrum. Taking into account the studies carried out by ICAR-DFMD regarding selection of suitable (alternate) FMDV serotype A vaccine strain, A/IND27/2011 emerged to be the appropriate candidate strain of choice out of a panel of 8 strains selected initially based on its widest antigenic relatedness with the circulating field strains. The candidate strain A/IND 27/2011 showed all the vaccine worth attributes as evaluated by IVRI, Bengaluru. During the year 2021, a total of ten serotype A isolates were subjected to vaccine matching with A/IND/40/2000 and the new candidate vaccine strain A/IND27/2011. Only 40% of the serotype A field isolates had an antigenic match (r value > 0.3) with the currently used vaccine strain A/IND/40/2000 indicating its weak antigenic match with the serotype A field isolates. The new candidate vaccine stain A/IND/27/2011, on the other hand, demonstrated great antigenic match (100%) with the recent serotype A field isolates. Hence, A/IND/27/2011 would be a preferable alternative for inclusion in the Indian vaccine formulation under the current situation (Fig 30).

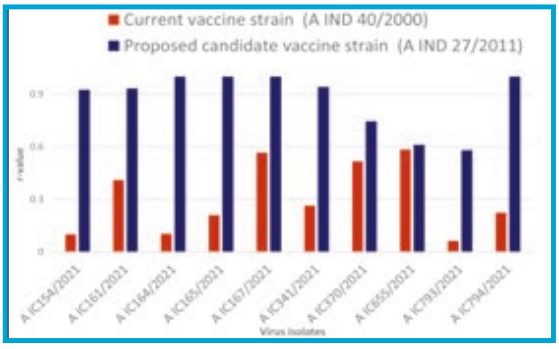


Fig 30. The antigenic relationship value of 10 FMDV serotype A field isolates collected during the year 2021

FMDV Serotype Asia1

The relationship value for four FMDV serotype Asia1 field isolates sampled during the year 2020-2021was determined using BVS against in-use vaccine strain IND63/1972. All the four isolates showed very good antigenic match with the current vaccine strain (Fig 31).

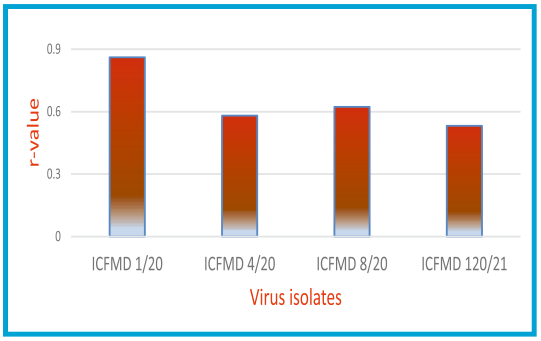


Fig 31. The antigenic relationship value of 4 FMDV serotype Asia1 field isolates collected during the year 2020 -2021

2.5 Production and Standardization of Biologicals

ICAR-DFMD has produced, optimized critical regents and supplied 3AB3 indirect DIVA ELISA and Solid Phase Competitive ELISA (SPCE) kits to carry out FMD serosurveillance seromonitoring, and Sandwich ELISA kit for serotyping of FMD viruses to the state FMD centres, ICAR-IVRI, Bengaluru and CCS-NIAH, Baghpat. The details of supplies made are given below. Besides supply, the diagnostic kits were also used at ICAR-DFMD laboratories at Bhubaneswar, Mukteswar and Bengaluru for seromonitoring and serosurveillance under NADCP (Table 15).

Table 15. Diagnostic kits supplied and used at DFMD during 2021 for number of samples

Institute/Organization	3AB3 indirect DIV A ELISA kit (Number of samples)	Solid Phase Competitive ELISA kit (Number of samples)	Serotyping ELISA kit (Number of samples)
FMD centre, Telangana	10900	5000	–
FMD centre, Karnataka	4300	5000	–
FMD centre, Tamilnadu	1960	–	300
FMD centre, Pondicherry	1500	3000	100
FMD centre, Kerala	20940	9000	200
FMD centre, Odisha	6700	–	300
FMD centre, Maharashtra	11000	18000	100
FMD centre, Gujarat	7000	5000	–
FMD centre, Haryana	11800	15000	–
FMD centre, Punjab	4500	9400	100
FMD centre, Rajasthan	4700	–	–
FMD centre, Uttarakhand	11860	–	–
FMD centre, Uttar Pradesh	10450	3500	100
FMD centre, Nagaland	3100	–	–
FMD centre, Himachal Pradesh	1500	2000	–
FMD center, West Bengal	2000	–	200
FMD centre, Jammu & Kashmir	6000	3500	–
FMD centre, Assam	11000	–	500
FMD centre, Manipur	7200	–	100
NRC Mithun, Nagaland	–	1500	–
FMD centre, A&N Island	3000	–	–
FMD centre, Arunachal Pradesh	1500	–	–
FMD centre, Madhya Pradesh	7000	–	100
VBRI, Andhra Pradesh	3000	–	100
C.C.S.NIAH, Baghpat,	–	1000	–
ICAR-IVRI, Bengaluru, Karnataka	–	1000	–
ICAR-DFMD	22673	74878	1693
Total	**1,75,583**	**1,56,778**	**3893**

During last 5 year, a sum of Rs. 180 crores could be saved by substituting import cost. The details of supplies of diagnostic kits made are given below.

Table 16. Savings made by production and supply of FMD kits (number of samples) during last 5 years.

Year	Solid Phase Competitive ELISA kit	Serotyping ELISA kit	3AB3 indirect DIVA ELISA kit
2017-18	1,70,000	4,000	75,280
2018 (Apr-Dec)	2,50,000	5,000	70,000
2019	3,20,000	4,000	65,000
2020	92,600	500	48,480
2021	1,56,778	3893	1,75,583
Total	**9,89,378**	**17,393**	**4,34,343**

2.6 Outreach Programmes Organized

The state FMD centres organized several FMD awareness programs, health and treatment camp throughout the country. Many programmes were organized online or though TV. In such scenario, details of number of participants were not available completely. Over all, more number of stake holders than mentioned in the below table might have benefited through the awareness activities of FMD centres

2.6.1 Under NADCP-FMD

Under the NADCP for FMD, state collaborating units carried out various extension activities for stakeholders in different states of the country. Seven units organized 12 trainings for veterinary officers, students and farmers on various aspects of FMD prevention and control. A total 593 stakeholders participated. National wide 63 awareness programme on the thematic area of FMD control were organized and two technology exhibition cum interaction programmes were also organised. A total 14039 farmers get benefited from such programme. Besides, a total 10 animal health camps were organized for goats, pig, and yak of 610 farmers. Total 10 digital outreach programme love also been organized in different languages for prompt popularization of the NADCP project (Tables 17, 18, 19 and 20).

Table 17. Details of FMD Trainings/ Workshops/ Meetings (n=12)organized by FMD centres.

Description	Organizer	Venue and date/ Month	No of Participants/ Beneficiaries
Virtual training on new sampling plan for sero-surveillance of FMD virus (DIVA strategy) and SOP for collection and dispatch of serum samples	RRC on FMD, LUVAS, Hisar, Haryana	Hisar; 12 August 2021	24 field Veterinary Surgeons
Training cum demonstration on Probang sampling	RRC on FMD, LUVAS, Hisar, Haryana and ICAR-DFMD Mukteswar	Hisar;29.11.21 and 30.11.21	13 participants (Veterinary Surgeons and LUVAS faculty)
Training cum FLD on "Humpsore treatment to improve reproduction and production performances in cattle"	ICAR-CIARI, Port Blair & KVK, South Andaman	Sippighat, South Andaman; October 2021	25
Training on Scientific management of pigs in the thematic area of FMD prevention and control	RRC, AAU, Guwahati, Assam	Sonapur, Kamrup (M); September, 2021	60
Regional level Workshop cum training programme on Diagnosis, Prevention and Control of FMD	RRC, AAU, Guwahati, Assam	Khanapara, Guwahati; November 2021	28 (Veterinary officer)
Training on NADCP control/ Sero monitoring/ Sero surveillance	State collaborating unit, Bhopal, AH Department, Madhya Pradesh	Bhopal; September, 2021	140 newly joined Veterinary officers
Virtual Training on NADCP control/ Seromonitoring/ Sero surveillance	State collaborating unit and SIAET (Agri. Department, Madhya Pradesh	Bhopal; September, 2021	30 Veterinary officers

Description	Organizer	Venue and date/ Month	No of Participants/ Beneficiaries
One Day State Level Seminar on FMD	State collaborating unit, Manipur, KVK and MMPCU) Porompat , Manipur	Veterinary Directorate, Manipur; 20.11.21	105 farmers
Training on FMD - Clinical Material collection and dispatch during outbreak	State FMD collaborating unit, TSVBRI, Hyderabad	Hederabad; October 2021	20 Internship students of College of Veterinary Science, Korutla
Hands on training programme on "Oropharyngeal Fluid collection and transport" for systematic follow-up investigation of FMD NSP reactors	State FMD collaborating unit, TSVBRI, Hyderabad and ICAR DFMD	Hederabad; November 2021	28 Veterinary officers
Refresher training on "Collection and transport of serum samples for seromonitoring of FMD"	State FMD collaborating unit, Mathura, COVSc, DUVASU, UP	Mathura, March 2021	20 Veterinary officers
Online workshop for FMD Sero-surveillance and Sero-monitoring for UP state AHD official	State FMD collaborating unit, Mathura, COVSc, DUVASU, UP	Mathura, November 2021	100 animal husbandry officials (CVO, VO and district FMD nodal officers
Laboratory training and sample collection	State FMD collaborating unit, Itanagar, Arunchal Pradesh	Itanagar, November 2021	72

Table 18. Details of FMD Awareness camp/ Kisan Gosthi/ Technology Exhibition (n=65) organized by FMD centres.

Awareness camp/ Kisan Gosthi/ Technology Exhibition			
Technology exhibition and interaction with farmers at two kisan mela	RRC on FMD, LUVAS, Hisar, Haryana	Hisar, March 9-10 and September 8-9, 2021	10000
FMD awareness cum health/ vaccination camp at Arunachal Pradesh -6 nos	State FMD collaborating Unit, ICAR-NRCY	Different villages of Sikkim and Arunachal Pradesh	257
Field outbreak investigation and FMD awareness camp at Maharashtra-7 nos	State FMD collaborating Unit, Pune	Different villages of pune, Raigad, Sangali districts, MS	392

Awareness camp/ Kisan Gosthi/ Technology Exhibition			
Awareness camp on FMD control and importance of vaccination at Karnataka state – 6 nos	State FMD collaborating Unit, Karnataka	Different villages of Bangalore and Hassan, Karnataka	220
Awareness camp on FMD vaccination at Assam state -9 nos	RRC, AAU, Guwahati, Assam	Different villages of kamrup, Darrang and Lakhimpur districts, Assam	359
FMD awareness programme at Bihar state – 4 nos	State FMD collaborating Unit, Bihar	Different villages of Bihar	143
NADCP for FMD awareness camp at Himachal Pradesh- 5 nos	State FMD collaborating Unit, Bihar	Different villages regions of Simla and Kangra districts of Himachal Pradesh	581
FMD awareness camp at Nagaland 2 nos	State FMD collaborating Unit, Kohima	Jotsoma and Viswema villages, Kohima, Nagaland	30
FMD awareness camp at Uttar Pradesh -4 nos	State FMD collaborating unit, Mathura, COVSc, DUVASU, UP	Different villages of Mathura, Meerut and Bulandshahar	138
Awareness programme on importance of FMD vaccination at Tripura-3 nos	State FMD collaborating units Tripura	Different villages of Sepahijala, Gomati and Unakoti districts of Tripura	1000
Awareness camp on Economic Importance of Foot and Mouth Disease at Gujurat - 01 No	State FMD collaborating units Gujarat	Dingucha, Gandhinagar, Gujarat	419
Awareness programme on FMD and sampling at Andaman and Nicobar -3 nos	SCU of ICAR-CIARI, Port Blair, South Andaman	South and Middle Andaman	66
Awareness Camp regarding control & Vaccination of FMD at J&K -4 nos	FMD Collaborating Unit, Jammu	Different villages of Jourian and Jammu districts of J& K	199

Table 19. Details of Animal health Camps (n=10) organized by FMD centres.

Name of programme	Organizers /Hosted by	Media	Remarks/ Language
Yak Health cum vaccination camp at Leh-01	State FMD collaborating Unit, ICAR-NRCY and Animal Husbandry Department, LAHDC, Leh	Durbuk, Leh district, Ladakh	100
Animal Health Camp cum Diagnostic Service at Assam -5 nos	RRC, AAU, Guwahati, Assam	Khannapara, Burha, Bajali, Moranodipar and Gongapukhari villages of Assam	279
FMD vaccination programme in Goats-1 no.	RRC, AAU, Guwahati, Assam	Changsari, Kamrup, Assam	25
Serosurveillance programe at domestic-wild life interface at Assam -1 No	RRC, AAU, Guwahati, Assam	Fringe areas under Kaziranga National Park, Manash National Park, Orang National Park and Pabotora National Park, Assam	Collected 1300 sera samples from bovine, 169 samples from ovine and 74 samples from Porcine
Veterinary Aid camp cum Awareness programme on FMD at Manipur- 2 nos	State FMD Collaborating Unit Manipur & MMPCU	Tangkham and Bishnupur villages of Manipur	206 farmers

Table 20. Details of Digital outreach programme (n=10) organized by FMD centres.

Name of programme	Organizers /Hosted by	Media	Remarks/ Language
T.V Live programme on TSAT Channel on Diseases & FMD in Sheep and Goat	Dr. K. Vijaya Praveen, Deputy Director(VAH) cum PI State FMD collaborating unit, Hyderabad	TSAT CHANNEL (https://youtu.be/31W29wvbU8w)	Broadcasted in Telugu in July 2021
Raithunestam Phone-in-Live"Programme on DD YadagiriTelangana Channel on Viral Diseases in Sheep and Goat - FMD	Dr. K. Vijaya Praveen, Deputy Director(VAH) cum PI State FMD collaborating unit, Hyderabad	DD Yadagiri Channel (https://youtu.be/hf5GCZWysm4)	Broadcasted in Telugu in August 2021
FMD+HS combined vaccination drive in the state of Haryana	RCC, Hisar, LUVAS	Nov. 7-9, 2021 https://youtube/_9GpjcIo4-s https://www.facebook.com/226190444921778/posts/981870752687073/?d=n	Social media coverage during July and August In Hindi

Name of programme	Organizers /Hosted by	Media	Remarks/ Language
Video was prepared for Guidelines of Serum sample collection and was uploaded on youtube	State FMD collaborating Unit, Pune	https://youtube/JSkUhde6-DU	Prepared in marathi
SOP for prevention and Control of FMD is prepared and published on web site as well as circulated to field officers. (Electronic version)	State FMD collaborating Unit, Pune	Circulated through website and email.	Prepared in marathi
Control And containment of FMD	State FMD collaborating Unit, Pune	shekaruTv	Broadcasted in marathi during October 2021
Importance of Control of FMD	State FMD collaborating Unit, Pune	Door Darshan Mumbai and on Youtube	Broadcasted in marathi during December 2021
Live Telephonic interaction programme on Prevention and control of foot and mouth disease in livestock	State FMD Collaborating Unit ICAR-CIARI, Port Blair and Doordarshan, Port Blair	Doordarshan, Port Blair	Broadcasted in Hindi during September 2021
TV programme on FMD control	State FMD Collaborating Unit, BASU, Patna, Bihar	Doordarshan, Patna (Krishi Darshan)	Broadcasted in Hindi during July 2021
Radio Talk on Impact of Foot and Mouth Disease on Animal Production	State FMD Collaborating Unit, Gujurat	Prasar Bharti, Vadodara	Broadcasted in Gujarati during December 2021

FMD awareness camp at Lachen, North Sikkim in January, 2021

FMD Vaccination cum serum sampling from yaks at Kyala, Tawang in June, 2021

FMD vaccination camp at Bodhkharbu, Kargil in October, 2021

FMD awareness camp at Jangda, Tawang in in December, 2021

FMD Vaccination at Bakie village, Senapati, Manipur

TSP input distribution and vaccination camp at Nzau village, Peren, Nagaland

FMD awareness and vaccination cum mithun health camp under NEH activity at Porba village

2.6.2 Under Tribal Sub-Plan

Tribal Sub Plan (TSP) programme was implemented at three states and one UT in collaboration with State FMD units for better outreach of activities. The operational area included in tribal dominated villages of Assam, Gujarat, Uttarakhand and Jammu & Kashmir. It was implemented by conducting baseline survey cum sensitization programme, animal health camp, skilled development programme and demonstration. In addition, the need based critical inputs for livestock health management were distributed among tribal families. During this period, a total 999 tribal farmers and farm women benefited through various interventions (Table 21, 22 and 23).

Table 21. Activities under Tribal Sub-Plan by ICAR-DFMD Mukteswar, Nainital

Description of activity	Venue	Beneficiaries (no)
Training organized (04)	Sunkhari kala and Kaundha Khera, Sitarganj, US Nagar	125
Method demonstration on animal solid waste management through portable vermibed (01)	Kaundha Khera, Sitarganj, US Nagar	32
Kisan gosthi (02) and awareness camp (01) **Interactive meetings (virtual)-01**	Sunkhari kala village, Sitarganj, US Nagar	73
Technical guidance provided through mobile advisory service	Both villages	22
Inputs distribution • **Cattle feed** • **Disinfectants** • **Plastic crate** • **Muti-purpose Tray** • **Vermibed**	Kaundha Khera and Sunkhari kala village, Sitarganj, US Nagar	 109 35 124 53 64

Table 22. Activities under Tribal Sub-Plan in collaboration with State FMD Units

Description of activity	Organizer	Venue	Beneficiaries (no)
Training organized (02) **a) Scientific goat farming** **b) Scientific pig farming**	State FMD collaborating centre, Department of Microbiology, CVS, AAU, Assam	Goriaghuli, Dimoria, Kamrup, Assam. Bishnupur, Sipajhar Darang, Assam	75
Demonstration on FMD vaccination in small ruminants with deworming (Covering 110 goats)	State FMD collaborating centre, Department of Microbiology, CVS, AAU, Assam	Bishnupur, Sipajhar Darang, Assam	47

Description of activity	Organizer	Venue	Beneficiaries (no)
Awareness camp **a) In the theme of FMD control programme**	State FMD collaborating centre, Deptt. of Microbiology, CVS,AAU, Assam	Gongapukhuri, Sarabari, Assam	100 members of 10 SHGs
b) In the theme of animal health care	State FMD collaborating Unit, Rishikesh, Uttarakhand	Bannakheda sani, Bajpur, US Nagar, Uttarakahnd	70 farmers and farm women
Inputs distribution • **Milk can** • **Calcium and Feed Supplements**	State FMD collaborating Unit, Rishikesh, Uttarakhand	Bannakheda sani, Bajpur, US Nagar, Uttarakahnd	70

Table 23. Trainings organized under TSP

Title of training	Date and duration	Venue	Participant numbers
Infectious diseases in animal and its management	09.02.2021 (One day)	Kaundha-Khera village, U. S. Nagar, Uttarakhand	23
Vaccination schedule for livestock and bio-containment practices	22.02.2021 (One day)	Sunkharikala village, U. S. Nagar, Uttarakhand	33
Foot and Mouth Disease : Prevention and national control programme	23.02.2021 (One day)	Kaundha-Khera village, U. S. Nagar, Uttarakhand	37
Identification of illing animals and primary care	06.03.2021 (One day)	Sunkharikala village, U. S. Nagar, Uttarakhand	32

2.6.3 Under Scheduled Caste Sub- Plan

ICAR-DFMD Mukteswar identified two villages of Kumaon hill region for conducting various interventions during this year. The operational area included two villages (Diyari and Jaipur Bisa) of Nainital districts. The details of interventions were summarized in Table 24.

Table 24. Activities under Schedule Caste Sub Plan

Programme/ Activities	Venue	Date	Beneficiaries (numbers)
Organization of awareness camp for FMD and PPR control at hill region	Diyari, Dist. Nainital, UK	30.09.2021	27
Distribution of inputs among SC families a) Hand sanitizer and hand soap b) Disinfectants and hand soap	Diyari, Dist. Nainital, UK Jaipur Bisa, Dist. Nainital, UK	30.09.2021 23.12.2021	27 41
Health camp cum FMD awareness programme Mineral mixture and de-wormer was distributed	Barakuda, Odisha	03.03.2021	46
FMD awareness programme Mineral mixture and de-wormer was distributed	Padanpur and Bhimpur, Uparabasta,Odisha	25.03.2021	59

2.6.4 Under NEH scheme

NEH programme of ICAR-Directorate of Foot and Mouth Disease was implemented with the aim to support surveillance & epidemiology of FMD in terms of FMD awareness as per the institute mandate as well as to support NADCP on FMD activities. For the year 2021, there were 7 participating centres such as NRC on Mithun, NRC on Yak (ICAR institutes), Regional research Centre at C.V.Sc., A.A.U., Khanapara (SAU) as well as State FMD collaborative centres at Imphal, Aizwal, Kohima, Itanagar, Agartala under Animal Husbandry Departments of respective Governments. The collaborating centres conducted various activities such as FMD awareness camp, animal health camps, vaccination and training programmes for farmers as well as for the professionals on FMD surveillance at international border areas etc. in collaboration with ICAR-DFMD as a part of the programme.

The FMD research centre Guwahati, Assam being a major partner and regional centre conducted a total 13 activities including 3 awareness programmes on FMD, 5 animal health camps, 2 FMD prevention and control programme, 2 training on FMDCP to the youths and women of various region of the state. A regional level workshop on diagnosis, prevention and control of FMD was carried out at Guwahati for the veterinarians during the period. Imphal FMD collaborating centre of Manipur had organized 3 individual programmes throughout period which consisted of 2 numbers of awareness programme. One day state level seminar on FMDCP was organised among the veterinary practitioners of the state. The Aizawl FMD collaborating centre of Mizoram conducted three programmes on FMD at various parts of the state including two animal health camps and one awareness programme against the disease. At Tripura, Agartala FMD collaborating centre organized three awareness camps, one training programme among the rural tribal women and one day sample collection, as a whole a total five activities were conducted during the period. For the state of Arunachal Pradesh Itanagar FMD collaborating centre located at Nirjuli organized a one day training programme on sample collection of FMD among the state veterinary practitioners. Also ICAR-NRC on Yak located at western part of the state conducted three FMD awareness camps among the yak rearing farmers. On the other hand, ICAR-NRC on Mithun located at Jharnapani, Nagaland organised one animal health & FMD vaccination camp on Mithun and spread awareness against the disease among the Mithun farmers of the state. As a whole a total 29 programmes were organised by the 7 NEH centres during the year 2021 in terms FMD awareness activity at north-eastern hill region to spread awareness about the disease among the people of that region.

FMD Awareness Camps at NEH Region

Tripura

Mizoram

Assam

Manipur

NRC on Mithun

NRC on Yak

3.0 AWARDS AND RECOGNITION

3.1 National/International Awards

1. Dr J K Mohapatra, Dr Saravanan S and Dr R Ranjan awarded NABL Assessor certificate by National Accreditation Board for Testing and Calibration Laboratories (NABL), Gurugram.
2. Dr Rajeev Ranjan received Research Excellence Award 2021 for the work entitled "Foot and Mouth Disease Virus Associated Abortion and Vertical Transmission following Acute Infection in Cattle under natural conditions". Institute of Scholars.
3. Dr C. Jana, Pr Scientist received Excellence Award as Reviewer of Indian Journal of Animal Research (ARCC Journal)
4. Dr C. Jana, Pr Scientist Received Best Reviewer Award from Indian Journal of Animal Health, Kolkata, West Bengal
5. Dr C. Jana, Pr. Scientist Received Certificate of Appreciation from National Agriculture Development Cooperative Ltd. (for deliberation in 21 days Training)

3.2 Editor/Associate Editor of Research Journals

1. Dr C. Jana, Pr Scientist recognized as Editorial Board Member of International Journal of bio-resource and stress management
2. Dr Rajeev Ranjan recognized as Editorial Board Member and Associate Editor of Journal Frontiers in Veterinary Science and Board Member of Acta Scientific Veterinary Sciences Journal
3. Dr. J K Biswal Scientist (SS) recognized Review Editor for the journal "Frontiers in Bioengineering and Biotechnology" and "Frontiers in Veterinary Science"

4.0 LIST OF PUBLICATIONS

a) Research articles

1. Biswal JK, Ranjan R, Dahiya SS, Mallick S, Mohapatra JK (2021). Regenerated silica-based RNA purification columns to address the short supply of RNA purification kits for COVID-19 diagnosis. **Mol Biol Rep.** 48(10):6871-6877. doi: 10.1007/s11033-021-06688-0.
2. Mallick S, Subramaniam S, Biswal JK, Ranjan R, Mohapatra JK, Sahoo AP (2021). Preliminary observations on the serum levels of HSP70 and its correlation with serum cortisol, thyroid hormones, and acute-phase protein concentration in cattle naturally infected with foot-and-mouth disease virus. **Trop Anim Health Prod**. 22;53 (4):408. doi: 10.1007/s11250-021-02814-z.
3. Mahajan S, Sharma GK, Subramaniam S, Biswal JK, Pattnaik B (2021). Selective isolation of foot-and-mouth disease virus from coinfected samples containing more than one serotype. **Braz J Microbiol.** 52(4):2447-2454. doi: 10.1007/s42770-021-00604-1.
4. Biswal JK, Nardo AD, Taylor G, Paton DJ, Parida S (2021). Development and Validation of a Mucosal Antibody (IgA) Test to Identify Persistent Infection with Foot-and-Mouth Disease Virus. **Viruses**. 1;13 (5):814. doi: 10.3390/v13050814.
5. Govindaraj G, Ganesh Kumar B, Krishnamohan A, Hegde R, Kumar N, Prabhakaran K, Wadhwan VM, Kakker N, Lokhande T, Sharma K, Kanani A, Limaye, K N, Pn A, De AK, Khan TA, Misri J, Dash BB, Pattnaik B, Habibur R (2021). Foot and Mouth Disease (FMD) incidence in cattle and buffaloes and its associated farm-level economic costs in endemic India. **Prev Vet Med**. 190:105318. doi: 10.1016/j.prevetmed.2021.105318.
6. Sreenivasa BP, Mohapatra JK, Jumanal V, ValiaValappil D, Subramaniam S, Patel BHM, Basagoudanavar SH, Hosamani M, Pattnaik B, Singh RK, Sanyal A (2021). Assessment of fitness of foot-and-mouth disease virus A IND 27/2011 as candidate vaccine strain. **Transbound Emerg Dis**. doi: 10.1111/tbed.14166.
7. Lalzampuia H., Elango S.,Biswal J.K., Krishnaswamy N., Selvan R.P. et al., (2021). Infection and protection responses of deletion mutants of non-structural proteins of foot-and-mouth disease virus serotype Asia1 in guinea pigs. **Applied microbiology and biotechnology**. 1-14, 2021-22.
8. Rajeev Ranjan and Jitendra Kumar Biswal (2021). "Foot and Mouth Disease: Carrier Status". Acta Scientific Veterinary Sciences 3.11 (2021): 01-02.

b) Abstracts/papers presented in conferences/ symposia

1. Rout M., Pargai K., Hegde R., Gautham N., Subramaniam S., Byregowda SM, Mohapatra JK and Singh RK (2021) A comprehensive seroprevalence of Foot-and-Mouth disease in sheep population of Karnataka state in India. *Global Foot-and-Mouth Disease Research Alliance 2021 Scientific Meeting;* 1-3 November 2021, Argentina
2. Jitendra Kumar Biswal, Sudha Rani Kripal, Biswa Ranjan Jena, Rajeev Ranjan, Jajati Keshari Mohapatra, Rabindra Prasad Singh (2021). Serotype and species independent detection of Foot-and-Mouth disease virus sero-positive animals using recombinant VP0 protein. Global Foot-and-Mouth Disease Research Alliance (GFRA) 2021, Scientific Meeting, Buenos Aires 2021, Argentina, 1- 3 November 2021. Pp-66

c) Popular articles

1. Smrutirekha Mallick. Biosecurity for prevention and control of Foot and Mouth Disease: A farmer's guide. Indian Farmer. Volume 8, Issue 09, 2021, Pp. 474-476.
2. Sagar A Khulape and Chandrakanta Jana (2021) Milk fever in dairy cattle and its

management. Just Agriculture e-Magazine Vol. 1, Issue 7, March 2021 Edition

3. Sagar A Khulape, Shriniwas Wattamwar and Chandrakanta Jana (2021). लाळ्या-खुरकूत रोगाचे जनावरांत दीर्घकालीन परिणाम' Marathi Newspaper 'नवराष्ट्र' 28 December, 2021 Page 6

d) Technical documents

1. Ranjan R., Biswal JK, Subramaniam S., Mohapatra JK., Jana C and Singh RP (2021). Training Manual for Systematic follow-up investigation of FMD NSP reactors by testing of oropharyngeal fluid. ICAR-DFMD
2. Suresh KP., Patil SS., Heamdri D., Subramaniam S, Mohapatra JK and Singh R P (2021) Sampling Plan for Seromonitoring of FMD in India under National Animal Disease Control Programme (NADCP 2021)
3. Suresh KP., Patil SS., Heamdri D., Subramaniam S, Mohapatra JK and Singh R P (2021) Sampling Plan for Serosurveillance of FMD in India under National Animal Disease Control Programme (NADCP 2021)

e) Book chapters

1. Biotechnology for Animal Health' by Sagar A Khulape in 'Emerging Trends in Life Sciences' Edition 1st, Page 80-84 ISBN: 978-81-955557-2-7

f) Radio / TV talks

1. Dr J K Mohapatra delivered a talk on FMD control for Animal Husbandry Development in a special programme (DISHA) on Science & technology of CSIR/ICAR/ DBT/ICMR /IIT on 18th April 2021 at 2.30 PM in Naxatra News
2. Dr. S A Khulape delivered a radio program on 'Prevention and Control of animal diseases' in Kumaonwani community radio, The Energy and Resources Institute, Nainital on 02nd February, 2021.

5.0 INTELLECTUAL PROPERTY MANAGEMENT

a) Patent applications filed

Indian Patent Application no. 202111037282, Invention for: "Thermotolerant foot-and-mouth disease virus (FMDV) serotype O Indian vaccine strain O IND R2/1975 with enhanced immunogenicity in Cattle". Date of Filing: 17th August 2021.

Inventors: Dr Biswal JK, ICAR-DFMD, Dr Mohapatra JK, ICAR-DFMD, Dr Subramaniam S , ICAR-DFMD, Dr Ranjan R, ICAR-DFMD, Dr Pattnaik B, ICAR-DFMD, Dr Sreenivasa BP, ICAR-IVRI, Dr Sanyal A, ICAR-IVRI, Dr Basagoudanavar SH, ICAR-IVRI, Dr Hosamani M, ICAR-IVRI and Dr TamilSelvan RP, ICAR-IVRI

b) Revenue generated

Multiplex PCR for FMD virus serotype differentiation (serotytpes O, A and Asia 1) since its development during 2005 has been extensively used at ICAR-DFMD for confirmation of FMDV serotypes in sandwich ELISA negative samples. During 2021, a committee was constituted to fix fees of RT-mPCR testing service for FMD virus serotype identification. Consequent to recommendation of committee, mPCR testing service is being offered through which the institute has been able to generate revenue to the tune of Rs 8024/- during 2021. In addition, the institute has been offering testing service for FMD Seromonitoring using SPCE and serosurveillance using DIVA ELISA to private dairy farms and also supplying SPCE and DIVA Kits to vaccine manufactures since the year 2019. The details of revenue generated is depicted in the Table 25.

Table 25 : Details of revenue generation during last three years

Year	Testing of serum sample using SPCE	Testing Service using DIV A	Testing Service using m PCR	Supply of DIVA Kit	Supply of SPCE Kit	Total (In Rupees)
2019	6,48,906	-	-	-	-	6,48,906
2020	23,65,438	-	-	80,439	-	24,45,877
2021	21,99,633	8294	8024	-	82,396	22,98,347

6.0 LIST OF RESEARCH PROJECTS

Table 26. List of institutional funded research projects carried out during 2021

S. No.	Title	PI	Co-PI	Duration
1	Development of DIVA-compatible live-attenuated vaccine candidate strain for FMDV serotype O	Biswal JK	Saravanan S Ranjan R	2019-22
2	Development and in vitro characterization of thermostable vaccine candidates for FMDV serotypes Asia1 and A	Biswal JK	Saravanan S Khulape SA	2019-22
3	Generation of monoclonal antibodies against recombinant FMDV polyprotein 3AB and their application in immunodiagnosis	Mallick SR	Mohapatra JK Biswal JK S.S. Dahiya	2019-22
4	Use of calcium phosphate nanoparticles for the generation of thermostable vaccine candidate against FMDV serotype O	Biswal JK	-	2020-22
5	Host genetic factors affecting FMD vaccine response in calves	Sahoo NR	Mohapatra JK Biswal JK Rout M	2020-22
6	Association of Foot and Mouth disease virus vaccine induced immune response with reproductive status and production performance of bovines in organized herd.	Mallick SR	Mohapatra JK	2020-22
7	Antigenic and Genetic characterization of foot and mouth disease virus serotype O from India during 2020-21	Dahiya SS	Saravanan S Mohapatra JK	2020-22
8	Antigenic and Genetic characterization of foot and mouth disease virus serotype A from India during 2020-21	Mohapatra JK	Rout M	2020-22
9	Surveillance of FMD and vaccine effectiveness study within 20 km radius of ICFMD, Arugul, Bhubaneswar	Rout M	Mohapatra JK Sahoo NR Saravanan S	2020-22
10	Transmission Electron Microscopy as a tool in diagnostic pathology and research for Foot-and-mouth disease virus	Ranjan R	Jitendra K Biswal	2020-22
11	Evaluation of efficacy of disinfectants and cleaners against Foot and Mouth Disease virus on environmental surfaces	Jana C	Khulape SA Saravanan S	2020-22
12	Development and validation of nucleic acid technologies-based molecular diagnostic assays in real-time format for detection and differentiation of FMDV virus serotypes circulating in India.	Biswal JK	Khulape SA	2021-23
13	Screening and comparisons of genetic targets for devising reverse transcription multiplex PCR (RT-mPCR) assay to detect FMD virus serotypes O, A and Asia1	Mohapatra JK	Rout M Saravanan S S.S. Dahiya	2021-23

S. No.	Title	PI	Co-PI	Duration
14	Production and characterization of monoclonal antibodies against recombinant capsid polyprotein (rP1) of FMD virus serotype O	Mallick SR	Biswal JK Khulape SA	2021-23
15	Epidemiology of Foot and Mouth Disease in Small Ruminants and Pigs in India	Rout M	Mohapatra JK Saravanan S	2021-24
16	Sero-clinical Surveillance of FMD-like Vesicular Diseases in Susceptible Animals in India	Rout M	Mohapatra JK Saravanan S S.S. Dahiya	2021-23
17	Hemato-Biochemical and Acute Phase Protein Profiling in Animals Naturally Infected/Recovered from Foot-and-Mouth Disease in Field Scenario	Rout M	Mohapatra JK Sahoo NR Mallick SR	2021-22
18	Understanding FMD virus ecology in livestock wild life interface in buffer zone of Sanjay Tiger Reserve/Bandhavgarh Tiger Reserve	Ranjan R	Khulape SA Mohapatra JK Biswal JK Prashant Deshmukh (WCT) Vinay Pandey(WCT) Himanshu Joshi(WCT)	2021-23
19	Genetic and antigenic characterization of Foot and Mouth Disease virus serotype Asia1	Rout M	S.S. Dahiya Mohapatra JK Saravanan S	2021-24
20	Comprehensive analyses of codon usage bias of Foot and Mouth Disease virus vis-à-vis adaptation to the hosts	Sahoo AP	Saravanan S Sahoo NR	2021-22

Table 27. List of externally funded research projects carried out during 2021

S. No.	Title	PI	Co-PI	Duration	Funding agency
1	Seromonitoring of pre and post vaccinal immunity against Foot and Mouth Disease under NADCP during 2021-2024	Saravanan S	Sahoo AP Mohapatra JK	2021-24	DAHD
2	Serosurveillance in bovines under NADCP during 2021-2024	Mohapatra JK	Saravanan S Rout M Sahoo AP Ranjan R Mallick SR	2021-24	DAHD
3	Investigation of NSP seroreactors for the presence of FMD virus by oropharyngeal fluid testing	R Ranjan	Jana C Rout M Biswal JK Khulape SA Mohapatra JK Saravanan S	2021-24	DAHD

S. No.	Title	PI	Co-PI	Duration	Funding agency
4	Production, standardization and supply of diagnostic reagents for FMD virus diagnosis and surveillance during 2021	Mohapatra JK	Sahoo AP Khulape SA Dahiya SS Biswal JK Jana C Saravanan S	2021-24	DAHD
5	FMD vaccine quality control under NADCP	Sahoo NR	Mohapatra JK Saravanan S Sahoo AP Rout M Dahiya SS	2021-24	DAHD
6	Production of anti-FMDV Hyper-immune sera in rabbits and guinea pigs for FMD virus diagnosis and seromonitoring	Sahoo AP	Sreenivasa B P Saravanan S Mohapatra JK Khulape SA	2020-22	DAHD
7	Establishment of Institute Technology Management Unit	Biswal JK	-	2021-22	ICAR
8	FMD Vaccine Quality Testing and Enhancing India's Animal Vaccine Testing Capabilities	Mohapatra JK	R.P.Singh Biswal JK Khulape SA Dahiya SS Sahoo AP Saravanan S	2021-23	DAHD
9	Understanding FMD viral ecology and landscape epidemiology towards control and eradication	R. Ranjan	Mohapatra JK J.K. Biswal Saravanan S. M. Rout Sagar A. Khulape	2014-18 (extended)	PIADC, USA
10	Generation and analyses of mRNA vaccine against foot-and-mouth disease (FMD)	J.K. Biswal	R Ranjan	2022-25	DST-SERB

Table 28. List of service projects carried out during 2021

S. No.	Title	PI	Associates
1	FMD virus isolation and maintenance of virus repository	Dahiya SS	Rout M Mohapatra JK Khulape SA
2	FMD virus diagnostic service and serotype identification	Mohapatra JK	Biswal JK Dahiya SS Rout M Jana C
3	Production of monovalent BVS against vaccine strains for antigenic characterization	Mohapatra JK	Jana C Dahiya SS Rout M
4	Revenue generation by offering testing service using SPCE	Saravanan S	Sahoo AP
5	Revenue generation by offering testing service using DIVA	Mohapatra JK	Rout M

7.0 CAPACITY BUILDING AND TRAINING PROGRAMMES

ICAR-DFMD organized several training/capacity building programs on FMD diagnosis, serosurveillance, seromonitoring and follow up of NSP DIVA reactors (Table 29)

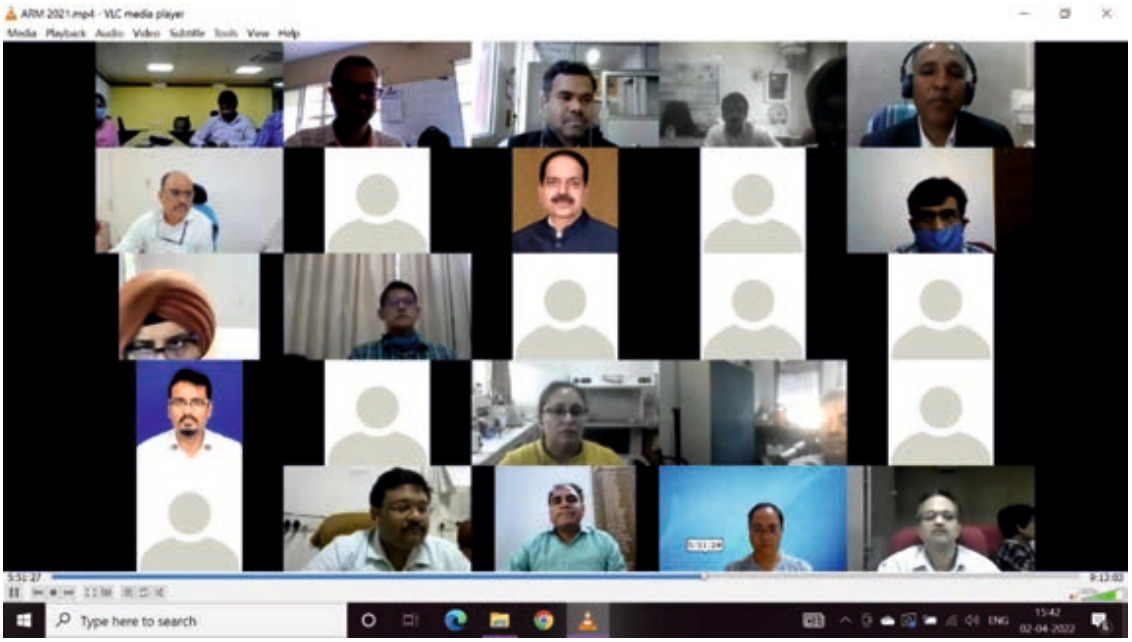
Table 29. Details of training provided during 2021 by ICAR-DFMD

Institute/Organization	No. of persons trained	Period of training	Duration (Days)	Type of training
Staff of FMD Collaborating Centre, Mathura, UP	2	13-10-2021 to 18-10-2021	6	FMD PVM and hands on training on SPCE
Staff of FMD Collaborating Centre, Thiruvandapuram, Kerala	2	26-01-2021 to 30-01-2021	5	FMD serosurveillance and hands on training on DIVA ELISA
Staff of FMD Collaborating Centre, Rishikesh, UK	1	23-02-2021 to 25-02-2021	3	FMD serosurveillance and hands on training on DIVA ELISA, and Serotype detection by sandwich ELISA
Staff of FMD Collaborating Centre, Ranipet, Tamilnadu	1	13-09-2021 to 18-09-2021	6	FMD serosurveillance and hands on training on DIVA ELISA, and Serotype detection by sandwich ELISA
Staff of FMD Collaborating Centre, Cuttack, Odisha	2	28-01-2021 to 30-01-2021	5	Serotype detection by sandwich ELISA
Staff of FMD regional and collaborating centres and field veterinary doctors from state AH department	60	08-07-2021	1	Workshop cum training program on "systematic follow-up study of NSP reactors using testing of oropharyngeal fluid (Online)
Staff of FMD collaborating centres and field veterinary officers of Telangana	28	24-11-2021 to 25-11-2021	2	Capacity Building for Oropharyngeal fluid (OPF) collection to the Veterinary Officer of State of Telangana
Staff of FMD regional centres and field veterinary officers of Haryana	13	29-11-2021 to 30-11-2021	2	Capacity Building for Oropharyngeal fluid (OPF) collection to the Veterinary Officer of State of Haryana
Staff of FMD regional and collaborating centres	15	26.10.2021 to 29.10.2021	4	Detection and Serology of FMD virus

8.0 WORKSHOPS, SEMINARS, SUMMER/ WINTER SCHOOLS, SHORT COURSES, TRAININGS, ETC. CONVENED AT THE INSTITUTE

Table 30. Details of Conference/Workshop/Seminar organized during 2021

S No	Name of Conference / workshop / seminar	Date of Start/Close	Number of Participants
1	29th Annual Review Meeting (ARM) of State FMD Regional and Collaborating centres and ICAR-DFMD (Virtual)	03-08-2021	~70
2	Effective Health Management during COVID-19 Pandemics	19-06-2021	~50
3	Lecture Series # 01 on 'Biologicals for FMD Control and Eradication' as part of Azadi Ka Amrit Mahotsav through virtual platform by Dr V A Srinivasan	02-11-2021	~50
4	Brainstorming Session on Foot-and-Mouth Disease Control: Issues and Possible Solutions through video conferencing under the Chairmanship of Dr. B N Tripathi, DDG (Animal Sciences), ICAR	15-05-2021	~20



29th ARM of state FMD centres

8.1 Systematic follow-up investigation of the NSP reactors

ICAR-DFMD and state FMD regional and collaborating centres, and state AH departments was working together for systematic follow-up investigation of the FMD NSP seroreactors by collection and testing of oropharyngeal fluid (OPF). Based on laboratory test report ICAR- DFMD has identified three state/UT (1) Haryana, (2) Telangana, and (3) Andaman and Nicobar having 10 % FMD NSP seroreactors and will be targeted for OPF collection. ICAR- DFMD has asked from the identified state to provide animal ids of NSP seroreactors. All the three Identified state/UT provided the animal ids of individual NSP seroreactors animal. A virtual sensitisation workshop cum training program on "systematic follow-up study of NSP reactors using testing of oropharyngeal fluid (OPF)"on July 8, 2021 was organized by ICAR-DFMD for 27 state FMD regional and collaborating centres and field veterinary doctors from state AH department.

Telanagana: ICAR-DFMD in collaboration with Collaborating Centre on FMD, Hyderabad, Telangana organized two days 'Training cum demonstration on Probang sampling' from November 24-25, 2021. Hands on training have given for the collection of Probang samples or oropharyngeal fluid collection and its dispatch to the Veterinary Officers of state of Telangana and Haryana. A total of 28 Veterinary Surgeons participated in the training.

Capacity Building for Oropharyngeal fluid (OPF) collection to the Veterinary Officer of State of Telangana, November 24-25, 2021.

Haryana: ICAR-DFMD in collaboration with Regional Research Centre on FMD, Dept. of Vety. Microbiology, LUVAS, Hisar organized two days 'Training cum demonstration on Probang sampling' by virtual and offline mode from November 29-30, 2021. A total of 13 Veterinary Surgeons participated in the training. During the demonstration time 13 and 5 numbers of OPF samples were collected from the cattle from State of Telangana and Haryana, respectively. In State of Telangana, out of 13 OPF samples collected 4 were found positive for FMDV while in the state of Haryana, out of 5 OPF samples collected 3 were found positive for FMDV. This follow-up will continue in the coming year also.

Capacity Building for Oropharyngeal fluid (OPF) collection to the Veterinary Officer of State of Haryana, November 29-30, 2021.

8.2 Refresher training on 'Detection and Serology of FMD virus'

ICAR-DFMD, Mukteswar organized 4 days refresher training on 'Detection and Serology of Foot and Mouth Disease Virus' from 26.10.21 to 29.10.21 under the project on 'NADCP for Foot and Mouth Disease'. The objective of training was to update/ refresh knowledge and professional skills in diagnosis of FMD. Officers and academicians from state FMD centres, Disease Investigation Laboratory and State Agriculture/ Veterinary Universities participated in the training. A total of 11 trainees from Uttarakhand, Uttar Pradesh, Haryana, Gujarat, Maharastra and Nagaland

attended. Trainees are associated with NADCP project and/or Animal Disease investigation of concern states. Eight lectures and 6 practical sessions were conducted to cover basic diagnostic aspects of this economically important viral disease. Sample preparation for diagnosis, Serotyping ELISA, SPC ELISA, DIVA ELISA, RT-mPCR and probang sampling were included in practical classes. Queries like FMD DIVA reactors, detection and importance of carrier animals in FMD epidemiology, Post outbreak SOP for vaccination, post FMD management at field and sampling plan for seromonitoring/ serosurveillance were addressed by the experts during interaction. Expectation from future training and feedbacks were taken from the participants.

9.0 PARTICIPATION OF SCIENTISTS IN CONFERENCES, WORKSHOPS, SYMPOSIA, TRAININGS, ETC.

A. Symposium/Seminar

International

S No	Name of Symposium/Seminar	Name of Scientists Attended
1	1.5 hrs of medical continuing education at the following symposium: "Bone Biopsies: the basics and beyond", Davis Thompson DVM Foundation, 22nd January 2021. RACE Provider No.: 50-26457, RACE Program No.: 805484	Dr. R Ranjan
2	First Regional Virtual Gross Seminar of Animal Disease" organized by Davis-Thompson Foundation and Arab Association of Veterinary Pathologist (AAVP), between 17-20th June 2021	Dr. R Ranjan
3	International Virtual Conference" on "Emerging Challenges to Veterinary Profession" IVACON-2021 organized by The Indian Veterinary Association in association with Confederation of Indian Industry (CII) during 19-20th June, 2021.	Dr. R Ranjan
4	6 hrs of continuing education at the following symposium: "Standardizing Tumor Pathology Reporting, Part 1", Davis Thompson DVM Foundation, 7th September 2021. RACE Provider No.: 50-26457, RACE Program No.: 20-880416	Dr. R Ranjan
5	16th Annual Meeting of the OIE/FAO FMD Reference Laboratory Network OIE/FAO representative, laboratory leaders for Regional Roadmaps. 23rd and 24th November 2021 using virtual platform	All Scientists

National

S No	Name of Symposium/Seminar	Name of Scientists Attended
1	Interactive webinar on "Effective Health management during COVID-19 Pandemics' organized by ICAR- DFMD, HRD-cell on 19th June 2021	All scientists
2	One day national webinar on "Important animal diseases and their control program in India" on 23 October 2021 conducted by ICAR-National Research Complex for Eastern Region, Patna.	Dr. S A Khulape Dr S Mallick
3	Two day 'Dairy Ruminant online symposium' organized by USSEC on 6th and 7th, December, 2021	Dr. S A Khulape
4	Dr C.M. Singh Birth Centenary Year Celebrations (30-11-2021 to 30-11-2022) cum International Webinar on 'Advances of Veterinary Sciences during Platinum Jubilee Year of India's Independence (1947-2022)', on 30th November, 2021	Dr R P Singh Dr. S A Khulape
5	Virtual webinar series on 'Respiratory Pathogens' Organized by Bioinformatics Resource Centre (BARC) as - "Picornaviridae, Enteroviruses and ViPR" on 18th May 2021 and "Bacterial Respiratory Pathogens and the PATRIC database" on 01st June 2021	Dr. S A Khulape
6	Webinar 'Vaccination against foot-and-mouth disease - Principles and practice' organized by GFRA Regional Asia on 25th March 2021	Dr. S A Khulape
7	Ovum pick up In-vitro fertilization, future impact on livestock improvement on 19/06/21	Dr N R Sahoo
8	Nutritional security in India: Issues and way forward on 04/09/21	Dr N R Sahoo

B. Training/Workshop

International		
S No	**Name of Training/Workshop**	**Name of Scientists Attended**
1	Tenth Interactive Session for Awareness-Raising of Member Secretaries of Institutional Biosafety Committee (IBSC)", https://global.gotomeeting.com/join/306870445, Thu, Jan 28, 2021 11:00 AM (IST).	Dr. R Ranjan
National		
S No	**Name of Training/Workshop**	**Name of Scientists Attended**
1	DST sponsored online training program from January 18-22, 2021 on "Integrated Scientific Project Management for Women Scientists/Technologists" conducted by Centre for Organization Development, Hyderabad.	Dr S Mallick
2	11 days online training programme from 10th to 20th September 2021 on the topic "Application of Intellectual Property Rights (IPR) for different aspects of animal genetic resources in India" conducted by College of Veterinary Science and Animal Husbandry, Mhow	Dr S Mallick
3	Online workshop from 19th to 20th July 2021 on "prevention of sexual harassment of women at work place" conducted by ISTM, New Delhi	Dr S Mallick
4	NABL-Assessors Training Program organized by National Accreditation Board for Testing and Calibration Laboratories (NABL) during 25-27th August, 2021 through online line platform (Level 1).	Dr. JK Mohapatra Dr. Saravanan S Dr. R Ranjan
5	NABL Laboratory Assessor Training Course (LEVEL II) as per ISO/IEC 17025:2017 held during 23rd to 25th September 2021 at New Delhi	Dr. JK Mohapatra Dr. Saravanan S Dr. R Ranjan
6	5th PTP/ RMP Conclave 2021" organized by National Accreditation Board for Testing and Calibration Laboratories (NABL) during 30th – 31st August, 2021 through online line platform.	Dr R P Singh Dr. JK Mohapatra Dr. Saravanan S Dr. R Ranjan
7	03 day workshop on Data analysis and statistics using PAST statistical software software from 19-21 July, 2021 by Simple Statistics Solution and Training Provider, Tirunelveli, Tamilnadu (Virtual mode)	Dr. S A Khulape
8	21 day National level workshop on SPSS for research and data analysis from 08th- 30th December 2021 by ESSGEE Digiskill India Pvt Ltd Mumbai	Dr. S A Khulape
9	05 days Online training programme on "Advances in web and mobile application development" from December 6-10, 2021 organized by ICAR-NAARM, Hyderabad	Dr. Aditya P. Sahoo

NABL Laboratory Assessor Training program

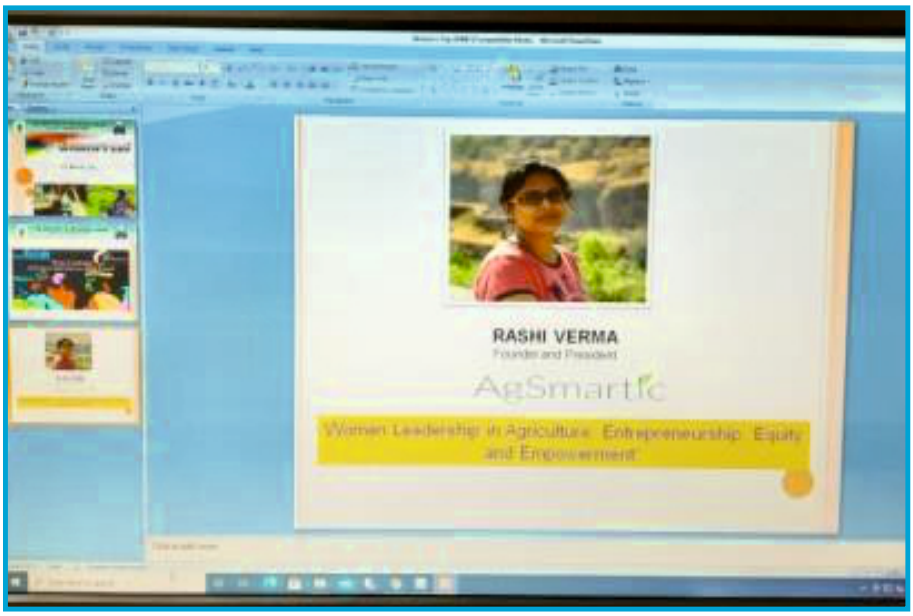
10.0 DISTINGUISHED VISITORS

1) **Mr. Sanjoy Singh, Secretary ICAR and Additional Secretary DARE visited the ICAR-DFMD Mukteswar on 28.03.2021**

2) **Visit to Central laboratory FMD, Mukteswar by distinguished QRT –team to review/ draft report preparation during 31-08-2021 and 01-09-2021**

11.0// EMPOWERMENT OF WOMEN AND MAIN-STREAMING GENDER ISSUES

ICAR-DFMD celebrated International Women's Day on 08.03.2021 through virtual platform. In the context of ICAR theme for this year's women's day *"Women Leadership in Agriculture: Entrepreneurship, Equity and Empowerment*" Ms. Rashi Verma, founder and president of AgSmartic technologies private limited, New Delhi joined as the chief guest and highlighted the importance of technology driven sustainable agriculture in the face of climate change. She emphasized that more startups should come up in the near future in agriculture and dairy sector with a vision to bring positive change in farmers life.



12.0 MISCELLANEOUS ACTIVITIES

12.1 Swachh Bharath Abhiyan

ICAR-Directorate of Foot and Mouth Disease conducted outdoor special swachhata campaign from 2nd to 31st October 2021 and swachhata pakhwada from 16-31 December 2021. The institute organized various events like swachhata awareness among school children, farmers and farm women, organized different competitions on swachhata, carried plantation of saplings, campus cleaning activities, sanitization of office premises, polythene free drives and mass media coverage of the campaigns. Swachhata banners are placed at prominent places including entrance gate for public awareness. Swachhata pledge was taken by the staff members. E-banner was displayed in the institute website. Mask, sanitizer, phenyl, disinfectants and soaps were distributed among farmers.

12.2 Poshan Vatika Maha Abhiyan and Tree plantation campaign

ICAR-DFMD organized Poshan Vatika Maha Abhiyan on 17th September, 2021 at ICFMD, Arugul campus. Under this program millet flour packets and millet cookies were distributed to 75 girl students and children. Girl children were made aware about the nutritional value and health benefits of different millets. In additions to this Guava and Jackfruit saplings were distributed to twenty five farmers. 102 saplings of Karanja, Sheesham, Guava and Jackfruit were planted at ICFMD, Arugul campus of ICAR-DFMD.

12.3 Honourable Prime Minister's interface programme on climate resilient varieties, technologies and practices

ICAR-DFMD organized the telecasting of Honourable Prime Minister's interface programme on climate resilient varieties, technologies and practices at International Centre for Foot and Mouth Disease, Arugul. A total of 104 Farmers and farm women participated in the event to listen to the honourable Prime Minister and his vision for the future of agriculture in the interest of farming community. A "Farmers- Scientist Interaction Meet" was also organized on important aspects of animal production, common livestock diseases, health management, vaccination and control of FMD in animals.

12.4 Vigilance awareness week

The period from 26th October to 1st November 2021 was observed as "Vigilance Awareness Week" by ICAR-DFMD This year the main focus of Vigilance Awareness Week was "Independent India @75: Self Reliance with Integrity". It commenced with an integrity pledge administered to all officials and support staff by the hon'ble Director, DFMD through online platform with all the staff of 3 campuses of the institute on 26th October 2021 at 11.00 AM. The scientists and staff participated in the vigilance awareness week following COVID-19 guidelines e.g., keeping social distancing and wearing masks during the time. A total of 1082 persons from ICAR-DFMD and different schools, colleges and villages during the awareness week were administered integrity pledge by the vigilance officer as per the instructions. A signature campaign was also organized with the present year's theme of vigilance awareness week - 2021, where all the staff signed expressing their support for the noble and great cause. As per the instructions from CVC and ICAR Vigilance Cell, a banner on vigilance awareness week along with awareness on Public Interest Disclosure of Protection of Informers (PIDPI) banner in English was printed and the same was also translated in Odia language for the local people that was used in schools, colleges and in villages during the awareness programmes. The

banners were displayed in two entrance points of the institute. As per the instruction, sensitization outreach programmes in 3 schools, 2 colleges and awareness gram sabha in 3 villages were organized during the week. A debate (extempore speech) was organized on 11.11.2021 among the scientists, and support staff of the institute on different topics. A debate competition was also conducted on 13.11.2021 among all the support staff of the institute and prizes were distributed on the same day. On the same day, all staff were administered integrity pledge in Odia language.

Integrity pledge administered by the Vigilance Officer to all the support staff of DFMD on 13.11.2021

Vigilance Officer administering integrity pledge to the citizens of Arugul village of Haripur GP during awareness gram sabha on 02.11.2021

Vigilance Officer administering integrity pledge to students and teachers of Shakuntala Devi Govt. High School, Taraboi, Khordha, Odisha during observance of VAW on 02.11.2021

12.5 Hindi Pakhwada

राजभाषा हिन्दी अनुभाग

विवरण अवधि: 1 जनवरी 2021 से 31 दिसम्बर 2021

विवरण अवधि के दौरान, राजभाषा अनुभाग द्वारा हिन्दी भाषा का दैनिक कार्यों में प्रभावी उपयोग को बढ़ावा देने हेतु विभिन्न गतिविधियों का आयोजन किया गया।

साल के प्रथम तिमाही मे , दिनांक 31-03-2021 को ड़ा सीमा चोपड़ा, निदेशक (राजभाषा) भाकृअनुप द्वारा संस्थान के हिन्दी अनुभाग के कार्यो की समीक्षा की गयी। महोदया ने संस्थान के हिन्दी अनुभाग के कार्यकलाप की सरहना करते हुए हिन्दी भाषा को सुगम तरीके से कार्यालयीन कामकाज मे उपयोग लाने हेतु आवश्यक निर्देश दिये।

प्रस्तुत अवधि मे राजभाषा कार्यान्वयन समिति की बैठकोका (n=04) आयोजन हर तिमाही मे किया गया। वर्ष मे हिन्दी के कार्यालयीन प्रगामी प्रयोग संबंधी हर तिमाही की प्रगति रिपोर्ट (n=04) का अनुपालन प्रतिवेदन परिषद को प्रेषित किया गया। साथ ही संस्थान के सभी कर्मचारियोका हिन्दी-ज्ञान पर आधारित रोस्टर बनाने के संदर्भ मे सूचनाए दी गयी।

हिन्दी दिवस (14 सितंबर) के शुभ अवसर पर भारत सरकार की राजभाषा कियान्नवयन नीति के तहत गत वर्ष की भांति, इस वर्ष भी संस्थान मे दिनांक 14- 30 सितंबर 2021 तक हिन्दी- पखवाड़ा हर्ष- उल्हास के साथ मनाया गया। इसी क्रम मे विविध कार्यक्रम/ प्रतियोगिताओ [n= 06] को आयोजन किया गया, जिसमे संस्थान के वैज्ञानिक, तकनीशियन, अधिकारी तथा पारिवारिक सदस्य सहभागी हुए। सभी प्रतियोगिताओ का मूल्यांकन निष्पक्ष जूरी मण्डल द्वारा किया गया। प्रतिभागियोको हिन्दी सप्ताह समापन कार्यक्रम (०६ **अक्टूबर**, २०२१) मे राजभाषा विभाग के निर्देशानुसार पुरस्कृत किया गया।

12.6 Celebration of Important Day/ Events

Important Day	Name of Events	Date of Celebration and Venue	Participants
World Water Day	• Competition among school students at IVRI-K V Mukteswar • Awareness cum interaction • Exposure visit of farmer to Institute	22.03.2021; Mukteswar, Nainital	121
World Veterinary Day (Jointly organized with ICAR-IVRI Mukteswar, Nainital)	• Quiz competition • Scientists - farmers interaction session (through kisan call centre/ mobile/whatsapp) • Expert lecture on theme	24.04.2021 Mukteswar, Nainital	64
World Zoonosis Day	• Awareness cum interaction programme for farmers • Webinar on Zoonosis: Risk management among stakeholders of National Animal Disease Control Programme on Foot and Mouth Disease	06.07. 2021 Hosted by ICAR-DFMD, Mukteswar, Nainital (virtually)	52
Farmer's Day	• Awareness cum interaction programme for farmers on Animal Health and swachh Bharat Abhiyan	23rd December 2021 hosted by ICAR-DFMD Bhubaneswar at Gothabania village	40
International Women's Day	• Under ICAR theme for women's day 2021 "Women Leadership in Agriculture:Entrepreneurship, Equity and Empowerment interaction with Ms. Rashi Verma, founder and president of AgSmartic technologies private limited, New Delhi • Sensitization of staff on Empowerment of women and mainstreaming gender issues	08.03.2021 organized by ICAR-DFMD Bhubaneswar (virtually)	35

12.7 Replacement of existing old website with a new updated website

The existing website was designed decade ago looks outdated and needed replacement to enhance the digital presence of ICAR-DFMD. The overall layout of the website was redesigned with several additional sections like services, payment portal, FMD control, Farmer's corner, NADCP and FMDCP etc. to improve user experience. All the content of the new website were updated to provide useful information for visitors. The new website is user friendly, fast with better navigation bar for finding useful information easily to enhance overall effectiveness of the website.

Home page of old version website

Home page of new version website

13.0 VARIOUS COMMITTEES

13.1 Quinquennial Review Team (QRT, 2014-2019)

Name	Designation	Role
Dr. S. K. Garg	Former Vice-Chancellor, DUVASU, Mathura, Uttar Pradesh	Chairman
Dr.K. Kumanan	Former Director of Research, TANUVAS, Chennai	Member
Dr.M.R. Gajendragad	Former Scientist Emeritus, ICAR-NIVEDI, Bangaluru	Member
Dr. A. Chakraborty	Former Director of Research, AAU, Assam	Member
Dr. Ravindra Sharma	Former Director (Research), LUVAS, Haryana	Member
Dr. R. Somvanshi	Former Scientist Emeritus, ICAR-IVRI, Bareilly	Member
Dr. C. Jana	Pr. Scientist, ICAR-DFMD, Mukteswar	Member Secretary

13.2 Research Advisory Committee (RAC)

Name	Designation	Role
Dr C. Renuka Prasad	Former Vice Chancellor, KVAFSU, Bidar	Chairman
Dr.Lal Krishna	Former ADG (AH), ICAR	Member
Dr. S. K. Das	Former Prof. and Head, Department of Microbiology, College of Veterinary Science, Assam	Member
Dr. S.K. Yadav	Former Prof. and Head, Department of Microbiology, DUVASU, Mathur, UP	Member
Dr V A Srinivasan	Former Advisor, NDDB	Member
Dr.Bhaskar Sharma	Former National Professor, ICAR-IVRI, Bareilly, UP	Member
Dr R P Singh	Director, ICAR-DFMD	Member
Dr. Ashok Kumar	ADG (AH), ICAR, KrishiBhavan, New Delhi-110 001	Member
Dr.Sanjeev Gupta	S/o Sh Nand Kumar Gupta, R/o Van Vihar Colony, Ballupur, Dehradun	Member
Shri Tara Dutt Joshi	S/O Sh. ManoharDutt Joshi, R/OTiwari Nagar, Bindukhatta,Nainital	Member
Dr. Saravanan, S	Sr. Scientist, ICAR-DFMD	Member Secretary

Last meeting of RAC was held on 27th April 2021 through virtual platform

13.3 Institute Technology Management Committee (ITMC)

Name	Designation	Role
Dr. Rabindra Prasad Singh	Director, ICAR-DFMD	Chairman
Dr. Priyabrata Swain	Pr. Scientist, ICAR-CIFA, Bhubaneswar	External Member
Dr. Saravanan S	Sr. Scientist, ICAR-DFMD	Member
Dr. Shyam Singh Dahiya	Scientist, ICAR-DFMD	Member
Dr. Jajati K Mohapatra	Pr. Scientist, ICAR-DFMD	Member Secretary (till September 2021)
Dr. J K Biswal	Scientist (SS), ICAR-DFMD	Member Secretary

13.4 Institutional Animals Ethics Committee (IAEC, Bhubaneswar)

Name	Designation	Role
Dr. Jajati K Mohapatra	Pr. Scientist, ICAR-DFMD	Biological Scientist (Chairperson)
Dr. Prakash Kumar Sahoo,	ICMR-Regional Medical Research Centre, Bhubaneswar	CPCSEA Nominee
Shri Narendra Kumar Parida	The College of Pharmaceutical Sciences, Bhubaneswar	Link Nominee
Dr. S. Parthasarathy	Fisheries & Animal Resources Development Dept, Govt of Odisha, Bhubaneswar	Scientist from outside of the Institute
Shri Amulya Nayak	PFA, Jagatsinghpur	Socially aware Nominee
Dr. A P Sahoo	Sr. Scientist, ICAR-DFMD	Scientist from different biological discipline
Dr. J K Biswal	Scientist (SS), ICAR-DFMD	
Dr. Smrutirekha Mallick	Scientist, ICAR-DFMD	Veterinarian
Dr. Rajeev Ranjan	Scientist (SS), ICAR-DFMD	Scientist In-charge of Animal House Facility (Member Secretary)

Last meeting of IAEC was held on July 7, 2021 using virtual platform.

13.5 Institutional Biosafety Committee (IBSC)

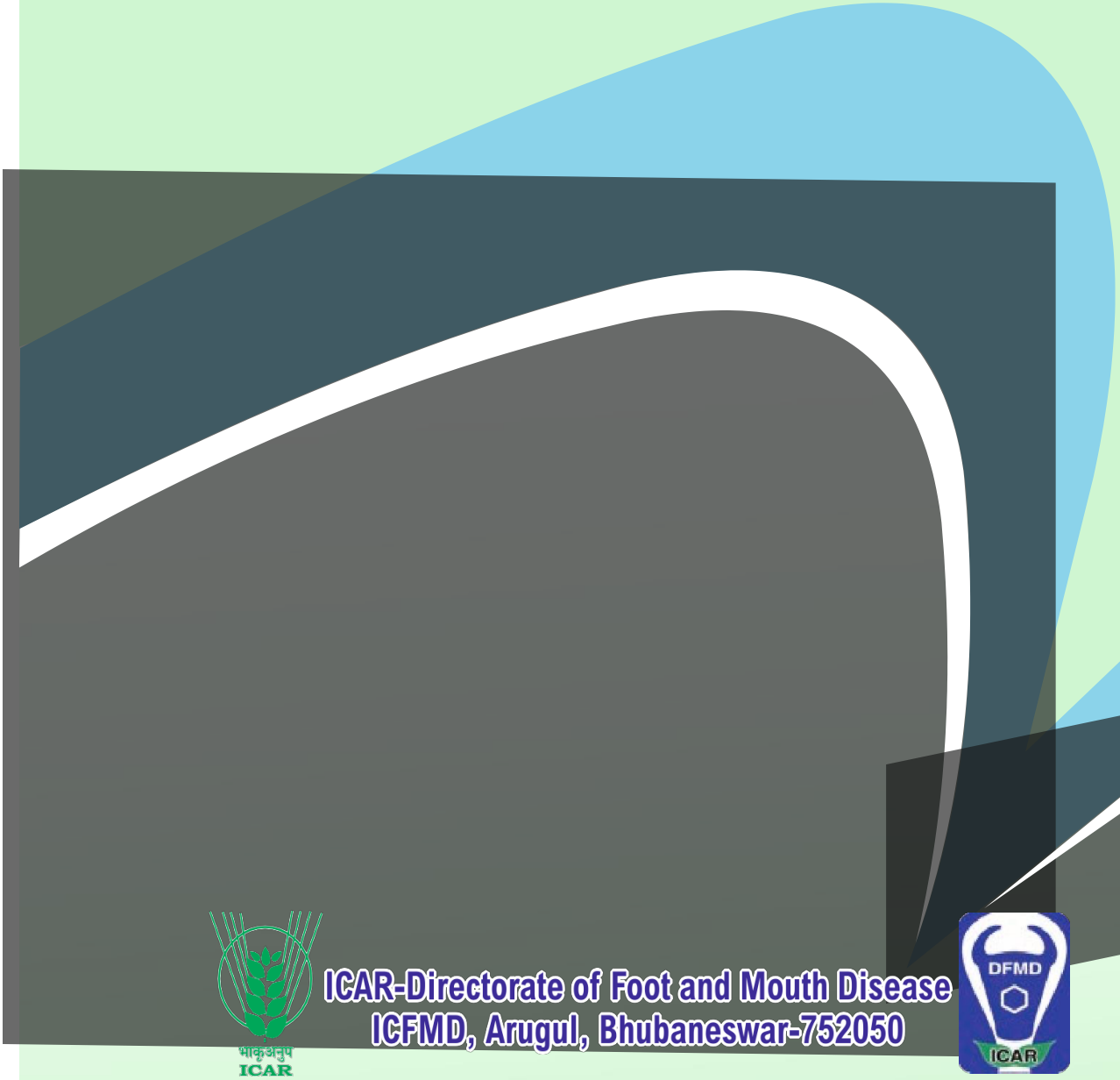
S No	Name		Position
1	Dr. Rabindra Prasad Singh	Director, ICAR-DFMD	Chairman
2	Dr. Biswajit Mishra	Medical consultant, Khurda	Biosafety officer
3	Dr. Sandeep Bhatia		Outside Expert
4	Dr. Sidhartha Giri	Scientific E, ICMR-RMRC, Bhubaneswar	DBT nominee
5	Dr. Jajati K Mohapatra	Pr. Scientist, ICAR-DFMD	Internal Member
6	Dr. Shyam Singh Dahiya	Scientist, ICAR-DFMD	Internal Member
7	Dr. J K Biswal	Scientist (SS), ICAR-DFMD	Internal Member
8	Dr. Rajeev Ranjan	Scientist, ICAR-ICFMD	Internal Member & Member Secretary

Last meeting of IBSC was held on April 16, 2021 through virtual perform.

Staff of ICAR-DFMD

S No	Name	Designation
1	Dr. Rabindra Prasad Singh (Joined on 31-01-2021)	Director (RMP)
Scientific staff		
Veterinary Microbiology		
2	Dr. Jajati K Mohapatra	Principal Scientist
3	Dr. Saravanan Subramaniam	Senior Scientist
4	Dr. Shyam S Dahiya	Scientist (Sr. Scale)
Veterinary Pathology		
5	Dr. Chandrakanta Jana	Principal Scientist
6	Dr. Manoranjan Rout	Senior Scientist
7	Dr. Rajeev Ranjan	Scientist (Sr. Scale)
8	Dr. Monalisa Sahoo (Joined on 27-12-2021)	Scientist (Sr. Scale)
Animal Physiology & Biochemistry		
9	Dr. Jitendra K Biswal	Scientist (Sr. Scale)
10	Dr. Smrutirekha Mallick	Scientist
Animal Genetics & Biotechnology		
11	Dr. Nihar R Sahoo	Senior Scientist
12	Dr. Aditya P Sahoo	Senior Scientist
13	Dr. Khulape S Ashok	Scientist (Sr. Scale)
Technical staff		
14	Sh. Nayan Sanjeev	T-4 (Lab)
15	Sh. S.L.Tamta	T-1 (Lab)
Administrative staff		
16	Sh. Tara Kumar	AAO
17	Sh. R.N.Sahoo	Assistant
18	Sh. Ravi Chaudhary	Junior Stenographer

NOTE



ICAR-Directorate of Foot and Mouth Disease
ICFMD, Arugul, Bhubaneswar-752050