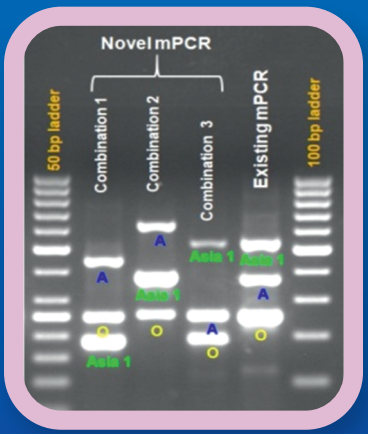
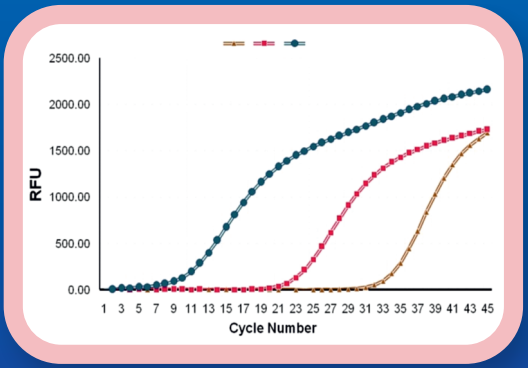
Annual Report

2022





ICAR- National Institute on Foot and Mouth Disease
Arugul, Bhubaneswar-752050, Odisha
Ph. No.: 0674 - 2601104, Web.: www.pdfmd.ernet.in

ICAR-NIFMD

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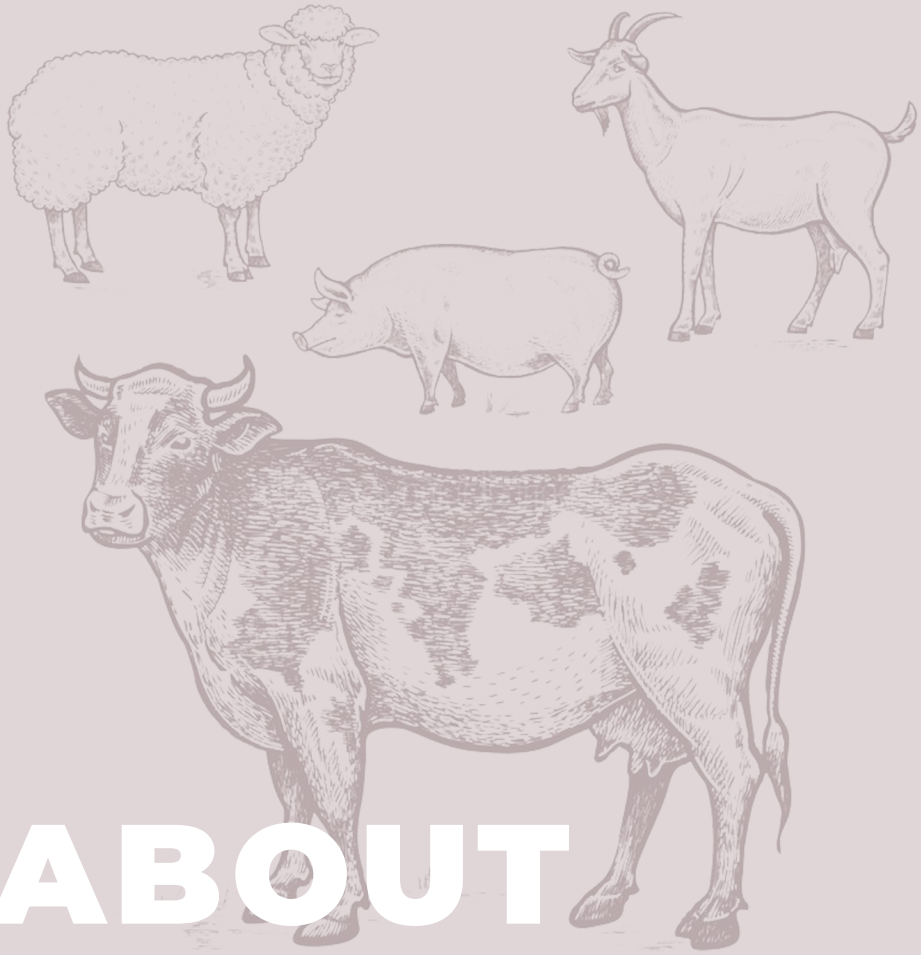
PREFACE

Foot and Mouth Disease (FMD) is a devastating transboundary animal disease endemic in India. FMDV serotypes O, A, and Asia1 are prevalent in India, and the majority of incidences are due to serotype O. India embarks on a vaccination-based control programme to control and eliminate the disease under the LHDCP. ICAR-NIFMD is the premier institute working on FMD and is recognised as the "FAO Reference Centre for FMD'. FMD surveillance in India is carried out by a countrywide network of 32 FMD regional and collaborating centres located in the states, which are supported by the DAHD, GoI, and run under the auspices of the ICAR-NIFMD, Bhubaneswar. Two new FMD collaborating centres at Vijayawada, AP, and Ayodhya, UP, were added in 2022. The institute also uses the state FMD centres to carry out numerous activities of ICAR under the NEH, DAPSC, and DAPST schemes.

ICAR-NIFMD and the network laboratories are involved in serosurveillance and post-vaccination seromonitoring (PVM), in addition to clinical surveillance and outbreak investigation. ICAR-NIFMD continues to develop cutting-edge diagnostic techniques and also works on improving the FMD vaccine. Regular molecular epidemiological studies based on the P1/1D gene sequence and vaccine matching studies of field outbreak viruses with vaccine strains are carried out to monitor antigenic changes, if any, occurring in the field. ICAR-NIFMD also takes part in vaccine quality control (QC) testing. Since 2003–2004, the institute has provided all technical, laboratory, and diagnostic support to the DAHD, the GoI's FMD Control Programme. Several new initiatives were undertaken in 2022, including the development of real-time PCR-based sensitive diagnostics, development of thermostable candidate strain for serotype A, initiation of proficiency testing programme with network laboratories, and initiation of national FMD awareness week celebration. Several awareness programmes on FMD were conducted throughout the country. The institute is also involved in a collaborative research programme on improving vaccine quality testing with the WRL-FMD and The Pirbright Institute.

I express my deep sense of gratitude to Dr. Himanshu Pathak, Hon'ble Secretary, DARE & DG, ICAR; Shri Sanjay Garg, Additional Secretary, DARE & Secretary, ICAR; Ms Alka Nangia Arora, Additional Secretary (DARE) & Financial Advisor (ICAR); Dr. B. N. Tripathi, DDG (AS), ICAR; and Dr. Ashok Kumar, ADG (AH), ICAR, for providing all the necessary support and guidance in steering the Institute. Also, the help and support extended by Dr. Jyoti Misri, Principal Scientist (AH), and Dr. Rajneesh Rana, Principal Scientist, are duly acknowledged. The generous funding support from Secretary, DAHD under NADCP/LHDCP, is gratefully acknowledged, along with the entire team, including Dr. Abhijit Mitra, Animal Husbandry Commissioner; Shri Upamanyu Basu, Joint Secretary (LH); Dr. Sujit Nayak, Joint Commissioner (NADCP); and Dr. Anirban Guha, Assistant Commissioner (LHDCP). The technical support from ICAR-NIVEDI for the formulation of the FMD seromonitoring and surveillance plan and the administrative support from ICAR-IVRI, Mukteswar, and Bengaluru are duly acknowledged. The untiring effort of a small group of young scientists in achieving new milestones at this institute is praiseworthy. I place on record my appreciation for the administration, audit and accounts, technical, and skilled support staff of the ICAR-NIFMD for their excellent assistance in achieving the targets, and objectives of the institute.

(R.P.Singh)
Director, ICAR-NIFMD



ABOUT ICAR-NIFMD

G E N E S I S

ICAR-National Institute on Foot and Mouth Disease (NIFMD), the premier institute for FMD research in the country, was initiated as an All India Coordinated Research Project (AICRP) for FMD in 1968. During about five decades of its existence, the scope of the project expanded progressively, and several milestones were achieved. The AICRP for epidemiological studies on FMD was upgraded to the Project Directorate on FMD in 2001 and then renamed the Directorate of FMD in 2015-16, with 27 regional and collaborative centres covering all the major regions of the country. The institute was further upgraded to National Institute on FMD on 17-02-2023. With the announcement of NADCP in 2019, the AICRP on FMD was concluded with effect from March 31, 2020. Since then, the state FMD laboratories have been operated through funding from DAHD, GoI, NADCP/LHDCP. The centres are also supported under DAPST, DAPSC, and NEH from ICAR and knowledge and technical input from ICAR-NIFMD. The institute has developed scientific expertise in conventional as well as cutting-edge areas in the fields of FMD diagnosis, epidemiology, and vaccine 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 the ultimate goal of eradication. It is also entrusted with the duty of providing technical support and scientific input and information to the planners and strategy-making agencies in planning the control of FMD in the country and the SAARC region. The institute, earlier named DFMD, was redesignated as ICAR-National Institute on FMD (NIFMD) on February 17, 2023.

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	• Member Laboratory of Global FMD Research Alliance (GFRA). • Recombinant nonstructural protein (3AB3) based ELISA test was developed for differentiation of FMD infected from vaccinated animals (DIVA). • 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". • Establishment of state FMD collaborating centre in Shillong, Meghalaya
2022	• Establishment of state FMD collaborating centres in Vijayawada, Andhra Pradesh, and Ayodhya, Uttar Pradesh. • Development of thermotolerant FMD vaccine candidate using modified O IND R2/1975

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

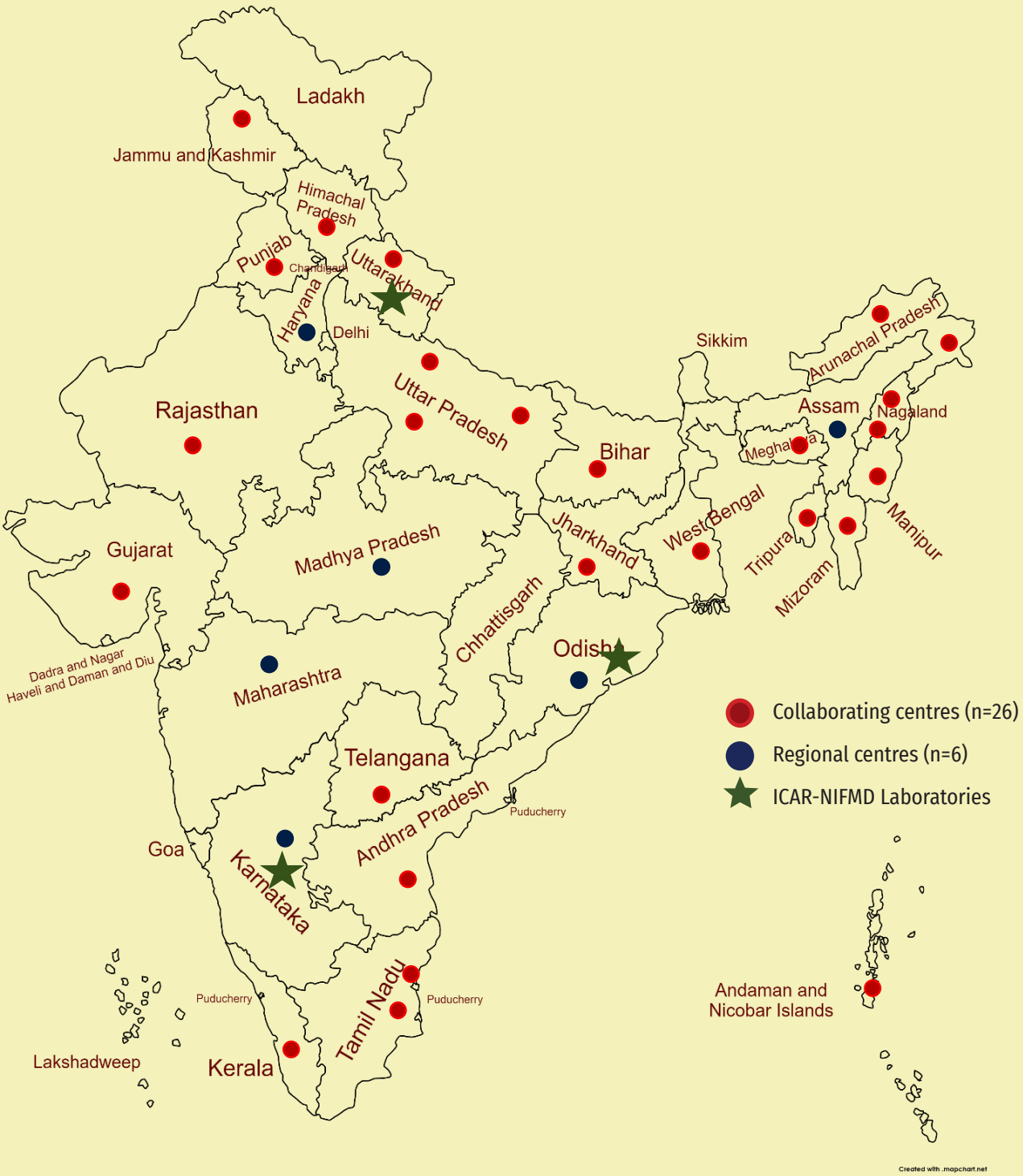
OBJECTIVES

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, and serosurveillance.
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 post-vaccination sero-monitoring and FMD vaccine QC activity.
11.	National FMD Serosurveillance and NSP follow-up investigation.
12.	International collaborations in the areas of interest.

Location of FMD laboratories



1.0 Executive Summary

- Using sandwich ELISA and multiplex PCR, 411 clinical samples were analyzed for serotype identification in 55 FMD outbreaks. During 2022, all three FMD virus serotypes were documented, with serotype O leading the outbreak scenario followed by serotype A. Overall, the disease incidences have decreased many fold compared to the previous year.
- A total of 62 FMD virus isolates (48 serotype O and 14 serotype A) 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 54 FMD viral strains were determined and added to the institute sequence database of Indian FMD viruses (50 serotype O, 2 serotype A and 2 serotype Asia1). In serotype O, dominance of the O/ME-SA/Ind2001e and O/ME-SA/2018 lineages was found, and G-18/2019 lineage in serotype A and Group IX in serotype Asia1 were the exclusive lineage to be detected.
- Vaccine matching analysis of 7 FMDV isolates (4 serotype O and 3 serotype A) were carried. The vaccine strains of serotypes O showed very good antigenic match. In case of serotype A, none of the field isolates had an antigenic match with the currently used vaccine strain A/IND/40/2000. The proposed candidate vaccine stain A/IND/27/2011, on the other hand, demonstrated perfect antigenic match (100%) with the recent serotype A field isolates.
- Under FMD serosurveillance, 72,308 bovine serum samples (69,662 serum samples collected during 2022 and 2646 during 2021) collected across the country were analyzed using the r3AB3 NSP-ELISA (DIVA) to determine the apparent prevalence of NSP-antibody (NSP-Ab) in the bovine population. Overall seropositivity was found in 16.6% of the samples tested, similar to the previous year's seroprevalence of 16.6%. In addition, 2945 serum samples from small ruminants and pigs were also screened.
- During 2022, a total of 92,306 serum samples were examined using Solid Phase Competitive ELISA (SPCE) under NADCP to assess the efficiency of immunization, of which 86406 and 5900 samples were from NADCP-2 and NADCP-3 rounds, respectively. In addition, 10515 serum samples received from various Breeding Bull stations and surrounding villages were also tested to assess the herd immunity.
- For the quality control (QC) testing of FMD vaccines to be utilized for the vaccination under NADCP, ICAR-NIFMD carried out QC testing of five batches of vaccines.
- In 2021, SPCE was correlated with the gold standard method VNT to determine the test cut-off for protective antibody status. Based on the results, the antibody titre cut-off of ≥1.65 $\log_{10}$ (@ 35 PI) was found to be appropriate at herd level. This cut-off was further validated by testing more numbers of serum samples (n=440) and was found 'fit-for-purpose' for assessment of protective antibody titre under NADCP/LHDCP-FMD.
- TaqMan-probe-based one-step multiplex real-time RT-PCR assay for pan-serotype detection of FMDV was developed and the assay was found to be sensitive and specific The diagnostic sensitivity was found to be 100% (95% CI; 99-100), and specificity was 100% (95% CI; 94-100%).
- Novel Reverse Transcription-Multiplex PCR Assay to Differentiate FMD Virus Serotype O, A, and Asia1

was developed. It would be logical to include this newly developed mPCR combinations alongside the existing one as a complementary approach to augment the overall detection sensitivity.

- An efficacious indirect sandwich-ELISA was developed using type O FMDV rabbit polyclonal antibody and anti-FMDV/O monoclonal antibody (Hybridoma clone FMD O-5B6) as capture and detector antibodies respectively. The diagnostic sensitivity and specificity were found to be 100% and 98.89% respectively compared to polyclonal antibody-based sandwich ELISA.
- Thermotolerant properties of FMDV serotype A IND 27/2011 variant selected through heat-resistant method was evaluated. The selected variant was characterized for it's thermotolerant capacity by incubating the virus at different temperature-time combinations. In all the tested conditions, the thermally-selected variant was found to have better stability than the parental counterpart.
- To estimate the state and national level FMDV sero-prevalence rate, one R software package, namely FMDSeroSurv (GPL-3.0 license), has been developed for the users, which is freely available at https://github.com/sam-NIFMD/FMDSeroSurv. This software provides functions to estimate the sero-prevalence rates along with various errors and number of animals having history of infection at the population (i.e., state and national) level using NSP-based serological survey data.
- Under FMD serosurveillance at the wildlife-livestock interface, 1224 serum samples were collected from cattle, buffaloes and goat and it was found that 17.66 %, 2.68 % and 9.83 % of cattle, buffaloes and goat, respectively were recorded positive for anti-3AB3 NSP Antibody of FMD virus by 3AB NSP ELISA.
- The institute provided the state FMD centers with three primary test kits (3AB3 indirect DIVA ELISA for 1,20,481 samples, Solid Phase Competitive ELISA (SPCE) for 1,45,000 samples, and Sandwich ELISA for 1450 samples) for undertaking disease surveillance and seromonitoring.
- Seven laboratory training programs and workshops were organized as part of capacity building for state FMD regional and collaborating centres. Several extension and training programs were organized under SCSP/TSP scheme for FMD stakeholders, including national FMD control awareness week with 11902 partcipants.
- Two new FMD collaborating centers at Vijayawada, Andhra Pradesh, and Ayodhya, Utter Pradesh were established to cater to the need of the respective states in terms of FMD surveillance, diagnosis and PVM
- ICAR-NIFMD as 'FAO Reference Centre for FMD' participated in the FMD Proficiency Testing Scheme, 2021 organized by the FAO World Reference Laboratory (WRL) for FMD, UK with support from EuFMD and DEFRA and achieved highest rank with respect to performance of test and laboratory capability. In addition to it, during 2022, ICAR-NIFMD conducted FMD Proficiency Testing Scheme (PTS) for 3AB3 indirect DIVA ELISA and SPCE for state FMD regional and collaborating laboratories.

कार्यकारी सारांश

- सैंडविच एलिसा और मल्टीप्लेक्स पीसीआर का उपयोग करते हुए 55 एफ.एम.डी. प्रकोपों में एफ.एम.डी. विषाणुसीरोटाइप पहचान के लिए 411 नैदानिक नमूनों का विश्लेषण किया गया। 2022 के दौरान, सभी तीन एफ.एम.डी. विषाणु सीरोटाइप को देखा गया, जिसमें सेरोटाइप O का प्रकोप सबसे ज्यादा, तत्पश्चात सीरोटाइप ए से। पिछले वर्ष की तुलना में एफ.एम.डी.रोग की घटनाओं में कई गुना की कमी आई है।

- बीएचके-21 सेल सिस्टम में पुनर्जीवित कुल 62 एफ.एम.डी. विषाणु आइसोलेट्स (48 सीरोटाइप O और 14 सीरोटाइप A) को एफ.एम.डी. के अंतर्राष्ट्रीय केंद्र, भुवनेश्वर और मुक्तेश्वर प्रयोगशाला में बनाए गए एफ.एम.डी. विषाणु के बढ़ते राष्ट्रीय भंडार में जोड़ा गया।

- 54 एफ.एम.डी. वायरल स्ट्रेन के कैप्सिड कोडिंग क्षेत्र (पी1/वीपी1) अनुक्रम निर्धारित किए गए और भारतीय एफ.एम.डी. विषाणु (50 सीरोटाइप O, 2 सीरोटाइप A और 2 सीरोटाइप Asia 1) के संस्थान अनुक्रम डेटाबेस में जोड़े गए। सीरोटाइप O में, ओ/एम ई-एस ई / इंड2001ई (O/ME-SA/Ind2001e) और ओ/एम ई-एस ए/ 2018 (O/ME-SA/2018) वंशावली का प्रभुत्व पाया गया, और सीरोटाइप A में G-18/2019 वंशावली और एशिया 1 में समूह IX का पता लगाया जाने वाला अनन्य वंश था।

- 7 एफ.एम.डी. विषाणु आइसोलेट्स (4 सीरोटाइप O और 3 सीरोटाइप A) का वैक्सीन मैचिंग विश्लेषण किया गया। सेरोटाइप O के वैक्सीन स्ट्रेन ने बहुत अच्छा एंटीजेनिक मैच दिखाया। सेरोटाइप ए के मामले में, किसी भी फील्ड आइसोलेट्स का वर्तमान में उपयोग किए जा रहे वैक्सीन स्ट्रेन A/IND/40/2000 के साथ एंटीजेनिक मेल नहीं था। दूसरी ओर, प्रस्तावित कैंडिडेट वैक्सीन स्टेन ए/आईएनडी/27/2011 ने हाल के सेरोटाइप ए फील्ड आइसोलेट्स के साथ सटीक एंटीजेनिक मैच (100%) का प्रदर्शन किया।

- एफ.एम.डी. सीरो निगरानी के तहत, एन.एस.पी.-एंटीबॉडी (NSP-Ab) के स्पष्ट प्रसार को निर्धारित करने के लिए r3AB3 NSP-ELISA (DIVA) का उपयोग करके देश भर में एकत्र किए गए 72,308 गोजातीय एवं भैंस सीरम नमूने (2022 के दौरान एकत्र किए गए 69,662 और 2021 के दौरान 2646 सीरम नमूने) का विश्लेषण किया गया। गोजातीय/ भैंस आबादी में परीक्षण किए गए नमूनों में कुल मिलाकर 16.6% में धनात्मकत्ता पाई गई, जो पिछले वर्ष के 16.6% के सेरोप्रेवलेंस के समान थी। इसके अलावा, छोटे जुगाली करने वाले और सूअरों के 2945 सीरम के नमूनों की भी जांच की गई।

- 2022 के दौरान, टीकाकरण की दक्षता का आकलन करने के लिए एनएडीसीपी के तहत सॉलिड फेज कॉम्पिटिटिव एलिसा (एसपीसीई, SPCE) का उपयोग करके कुल 92,306 सीरम नमूनों की जांच की गई, जिनमें से क्रमशः 86406 और 5900 नमूने एनएडीसीपी-2 और एनएडीसीपी-3 दौर से थे। इसके अलावा, झुंड प्रतिरक्षा (herd immunity) का आकलन करने के लिए विभिन्न ब्रीडिंग बुल स्टेशनों और आसपास के गांवों से प्राप्त 10515 सीरम नमूनों का भी परीक्षण किया गया।

- एन.ए.डी.सी.पी.के तहत टीकाकरण के लिए उपयोग किए जाने वाले एफ.एम.डी.टीकों के गुणवत्ता नियंत्रण (QC) परीक्षण के लिए, ICAR-NIFMD ने टीकों के पांच बैचों का QC परीक्षण किया।

- 2021 में, एसपीसीईको सुरक्षात्मक एंटीबॉडी स्थिति के लिए परीक्षण कट-ऑफ निर्धारित करने के लिए स्वर्ण मानक विधि VNT के साथ सहसंबद्ध किया गया था। परिणामों के आधार पर, झुंड स्तर पर ≥1.65 log10 (@ 35 PI) का एंटीबॉडी टाइटर कट-ऑफ उपयुक्त पाया गया। कट-ऑफ को 2022 के दौरान अधिक संख्या में सीरम नमूनों का परीक्षण करके मान्य किया गया था और एन.ए.डी.सी.पी./एल.एच.डी.सी.पी.-एफ.एम.डी.के तहत सुरक्षात्मक एंटीबॉडी टाइटर के मूल्यांकन के लिए उपयुक्त पाया गया था।

- एफ.एम.डी. विषाणुके पैन-सीरोटाइप डिटेक्शन के लिए टैक्मैन-प्रोब-आधारित वन-स्टेप मल्टीप्लेक्स रीयल-टाइम RT-PCR परख विकसित की गई।
- एफ.एम.डी. विषाणु सेरोटाइप O, A और Asia 1 में अंतर करने के लिए नॉवेल रिवर्स ट्रांसक्रिप्शन-मल्टीप्लेक्स पीसीआर जाँच विकसित की गई थी। समग्र पहचान संवेदनशीलता को बढ़ाने के लिए एक पूरक दृष्टिकोण के रूप में मौजूदा एक के साथ इस नए विकसित mPCR संयोजनों को शामिल करना तर्कसंगत है।
- नैदानिक नमूनों में सीरोटाइप O का निदान करने के लिए क्रमशः कैप्चर और डिटेक्टर एंटीबॉडी के रूप में टाइप O एफएमडीवी खरगोश पॉलीक्लोनल एंटीबॉडी और एंटी-एफएमडीवी/ओ मोनोक्लोनल एंटीबॉडी (#5बी6) का उपयोग करके एक संवेदनशील अप्रत्यक्ष सैंडविच-एलिसा विकसित किया गया था।
- वन्यजीव-पशुधन इंटरफेस में एफ.एम.डी. विषाणु सीरोप्रीव्लेंस के तहत, मवेशियों, भैंसों और बकरी से 1224 सीरम नमूने एकत्र किए गए और यह पाया गया कि क्रमशः 17.66%, 2.68% और 9.83% मवेशी, भैंस और बकरी, एंटी-3AB3 NSP FMD वायरस का एंटीबॉडी के लिए 3AB NSP ELISA द्वारा धनात्मक पाए गए।
- गर्मी प्रतिरोधी पद्धति के माध्यम से चुने गए एफएमडीवी सीरोटाइप A आईएनडी 27/2011 के थर्मोटोलरेंट गुणों का मूल्यांकन किया गया। विभिन्न तापमान-समय के संयोजनों पर वायरस को इनक्यूबेट करके चयनित संस्करण को इसकी थर्मोटोलरेंट क्षमता के लिए चित्रित किया गया था। सभी परीक्षण स्थितियों में, थर्मली-चयनित वेरिएंट में पैतृक समकक्ष की तुलना में बेहतर स्थिरता पाई गई।
- राज्य और राष्ट्रीय स्तर के एफ.एम.डी. विषाणु सीरोप्रीव्लेंस दर का अनुमान लगाने के लिए, एक R सॉफ्टवेयर पैकेज, जिसका नाम FMDSeroSurv (GPL-3.0 लाइसेंस) है, उपयोगकर्ताओं के लिए विकसित किया गया है, जो https://github.com/sam-NIFMD/ पर स्वतंत्र रूप से उपलब्ध है। FMDSeroSurv। यह सॉफ्टवेयर एनएसपी-आधारित सीरोलॉजिकल सर्वेक्षण डेटा का उपयोग करके आबादी (यानी, राज्य और राष्ट्रीय) स्तर पर विभिन्न त्रुटियों और संक्रमण के इतिहास वाले जानवरों की संख्या के साथ सीरोप्रीव्लेंस दरों का अनुमान लगाने के लिए कार्य प्रदान करता है।
- रोग निगरानी के लिए संस्थान ने राजकीय एफ.एम.डी. केंद्रों को तीन प्राथमिक परीक्षण किट (1,20,481 नमूनों के लिए 3AB3 अप्रत्यक्ष DIVA ELISA, 1,45,000 नमूनों के लिए ठोस चरण प्रतिस्पर्धी ELISA (SPCE) और 1450 नमूनों के लिए सैंडविच ELISA) प्रदान किए।

2.0 Research Achievements

2.1 Disease Monitoring and Surveillance

2.1.1 Epidemiological Status during 2022

During the year 2022, a total of 55 FMD outbreaks were serotype confirmed in India, which is almost seven fold lower than outbreaks recorded in the year 2021 (Table 1). The disease which was mostly sporadic and mild in nature were recorded in 18 states across all the regions (Fig 1). Majority of incidences were reported from North Eastern region which accounted for 40% of the total FMD outbreaks recorded during 2022. Surprisingly state of Karnataka which is considered to be highly endemic, did not record any FMD outbreaks for the first time in spite of intensive surveillance during 2022. In all the regions, several fold decrease in numbers of FMD outbreaks were observed compared to the last year (Fig 2). FMD vaccination has been resumed in several states under LHDCP after delay in the schedule during 2021, which probably contributed to reduction in disease burden. Similar to earlier estimates, serotype O dominated outbreaks scenario contributing to 92.7% of the total outbreaks. Serotype A and Asia1, on the other hand, were responsible for 3.6 and 1.8% outbreaks respectively (Fig 3). Serotype A outbreaks were reported in the states of Odisha, Assam and Mizoram, and serotype Asia1 was recorded in Jammu & Kashmir. Interestingly, both serotypes O and A were detected from the same animal in one outbreak reported in Assam. A total of 411 clinical materials collected from suspected FMD outbreaks were tested using antigen differentiating sandwich ELISA and multiplex PCR. The test revealed serotype 'O' in 141 samples, 'A' in 4 samples, 'Asia1' in 9 samples (Table 2). In two samples, both serotypes O and A were detected.

More number of outbreaks were recorded during January to March (Fig 4). Generally, in India, higher disease are incidences observed during winter season (October-March) though FMD incidences are reported throughout the year. Large number of FMD outbreaks were recorded in cattle as almost 67.4% of the outbreaks affected only cattle. About 23.9% of the outbreaks were recorded in both cattle and buffalo (Fig 5). No outbreak was reported in sheep and goat. Apart from this, sporadic occurrence was observed in pigs and mithun.

Table 1. FMD outbreaks recorded and diagnosed during 2022 and virus serotype(s) involved

State/UT	Reporting Centre	Number of FMD outbreaks	FMD Serotypes			
			O	A	Asia1	Mixed
Southern Region						
Karnataka	Bengaluru	Nil				
Kerala	Trivendrum	06	06	-	-	-
Tamilnadu	Ranipet	Nil				
Andhra Pradesh	Vijayawada	Nil				
Telangana	Hyderabad	01	01	-	-	-
Pudhucherry	Puducherry	Nil				
Total		07	07	-	-	-
Central Region						
Madhya Pradesh	Bhopal	04	04	-	-	-
Total		04	04	-	-	-

Western Region						
Maharashtra	Pune	07	07	-	-	-
Gujarat	Ahmedabad	01	01	-	-	-
Goa	ICFMD	01	01	-	-	-
Rajasthan	Jaipur	Nil				
Total		08	08	-	-	-
Northern Region						
Uttar Pradesh	Madhura & Meerut	03	03	-	-	-
Uttarakhand	Rishikesh	01	01	-	-	-
Haryana	Hisar	Nil				
Punjab	Jalandhar	Nil				
Himachal Pradesh	Shimla	Nil				
Jammu & Kashmir	ICFMD	01	-	-	01	-
Total		05	04	-	01	-
Eastern Region						
Odisha	Cuttack	02	01	01	-	-
West Bengal	Kolkata	02	02	-	-	-
Bihar	Patna	04	04	-	-	-
Jharkhand	ICFMD	01	01	-	-	-
Total		09	08	01	-	-
North Eastern Region						
Assam	Guwahati	03	02	-	-	01 (O & A)
Arunachal Pradesh	Itanagar	03	03	-	-	-
Meghalaya	Shillong	01	01	-	-	-
Mizoram	Aizawl	03	02	01	-	-
Manipur	Imphal	09	09	-	-	-
Nagaland	Kohima	Nil				
Sikkim	ICFMD	01	01	-	-	-
Tripura	Guwahati	02	02	-	-	-
Total		22	20	01	-	01
Grand Total		**55**	**51**	**02**	**01**	**01**

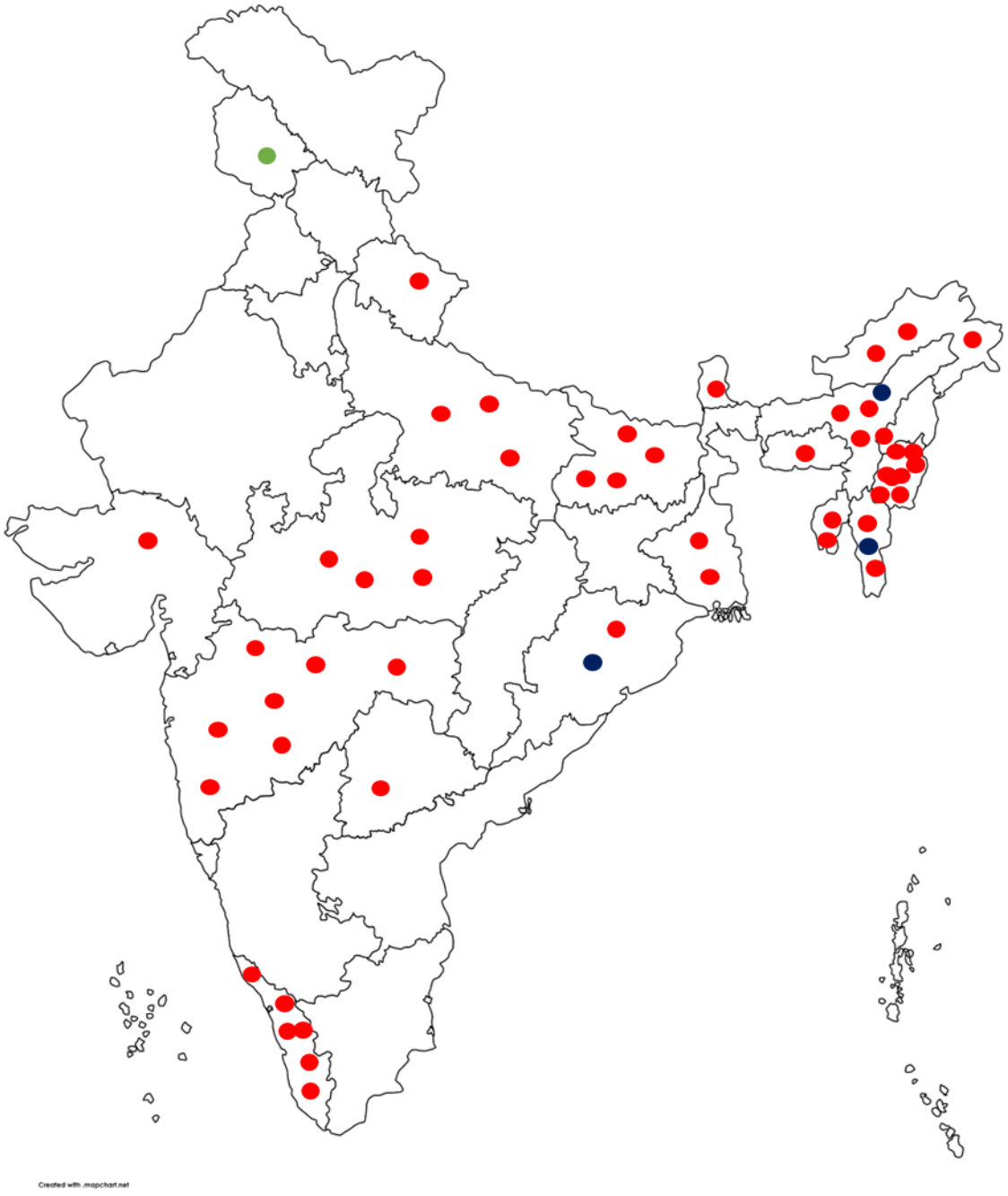


Fig 1: FMDV serotype distribution in different states during 2022. Red dot (●) denotes serotype O, blue (●) represent serotype A and Green (●) indicate serotype Asia1. One dot denotes one outbreak

Table 2. Number of clinical samples tested during 2022 and virus serotype(s) involved

State/UT	Number of Clinical material tested	FMD Serotypes			
		O	A	Asia1	Mixed
Kerala	54	06	-	-	-
Telangana	01	01	-	-	-
Maharashtra	57	15	-	-	-
Gujarat	02	02	-	-	-
Uttar Pradesh	20	10	-	-	-
Uttarakhand	08	02	-	-	-
Punjab	-	-	-	-	-
Jammu & Kashmir	09	-	-	09	-
Madhya Pradesh	23	11	-	-	-
Odisha	17	04	03	-	-
West Bengal	09	02	-	-	-
Bihar	30	07	-	-	-
Goa	6	1	-	-	-
Jharkhand	12	07	-	-	-
Assam	51	27	-		02 (O & A)
Arunachal Pradesh	03	03	-	-	-
Meghalaya	09	01	-	-	-
Chhattisgarh	05	-	-	-	-
Mizoram	05	04	01	-	-
Manipur	33	18	-	-	-
Sikkim	04	04	-	-	-
Tripura	53	16	-	-	-
Total	**411**	**141**	**04**	**09**	**02**

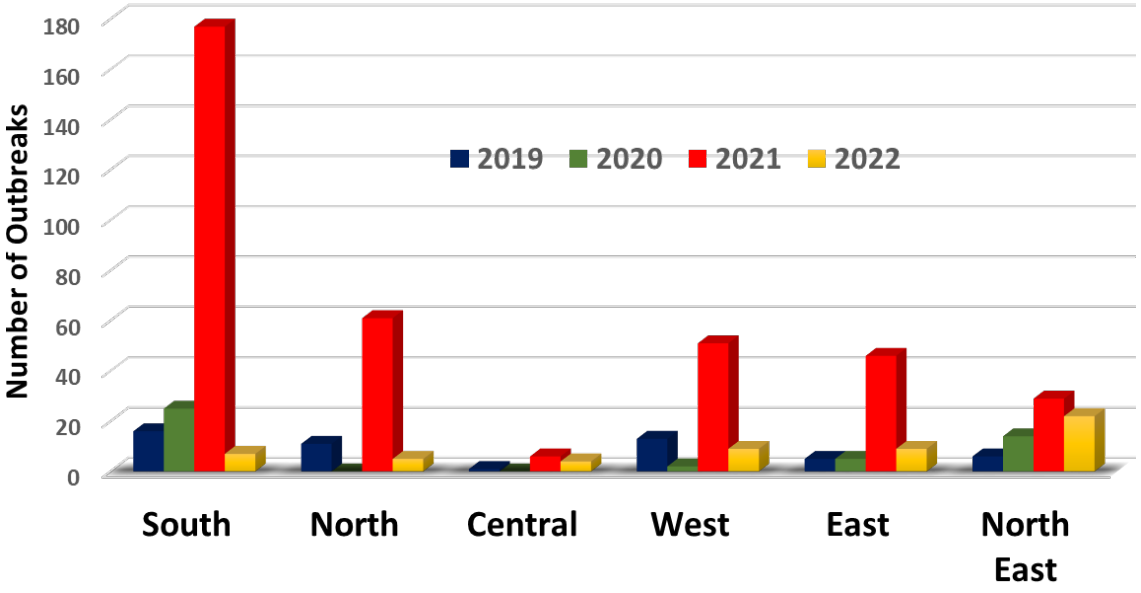


Fig 2: Number of confirmed FMD incidences in different geographical regions during the last four years.

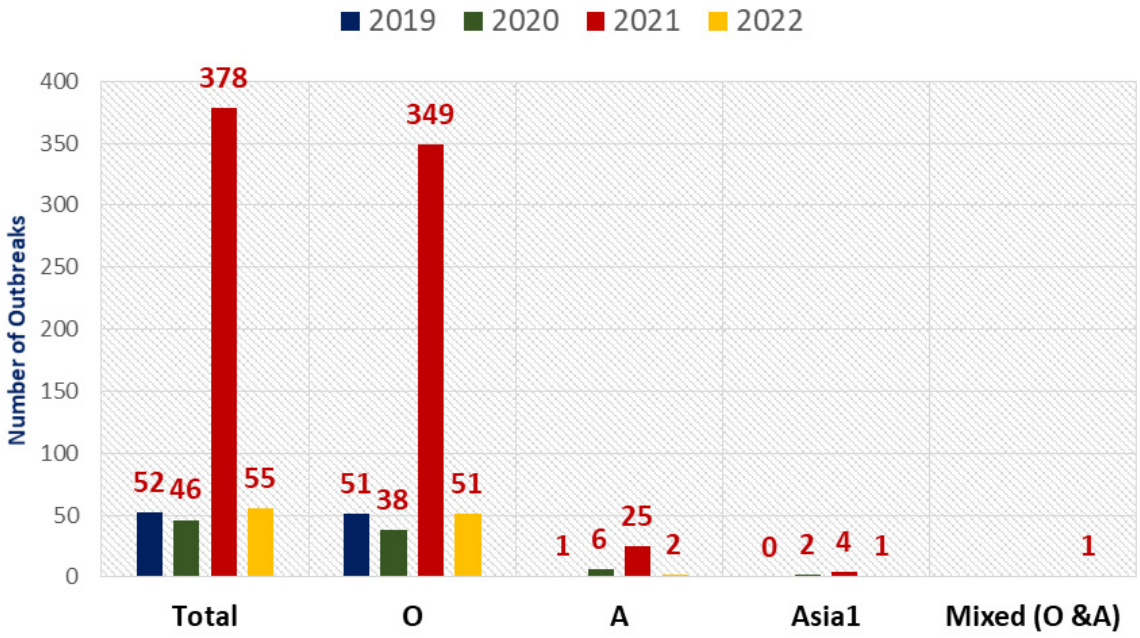


Fig 3: Year wise outbreaks/incidences of FMD and virus serotypes involved during last four years.

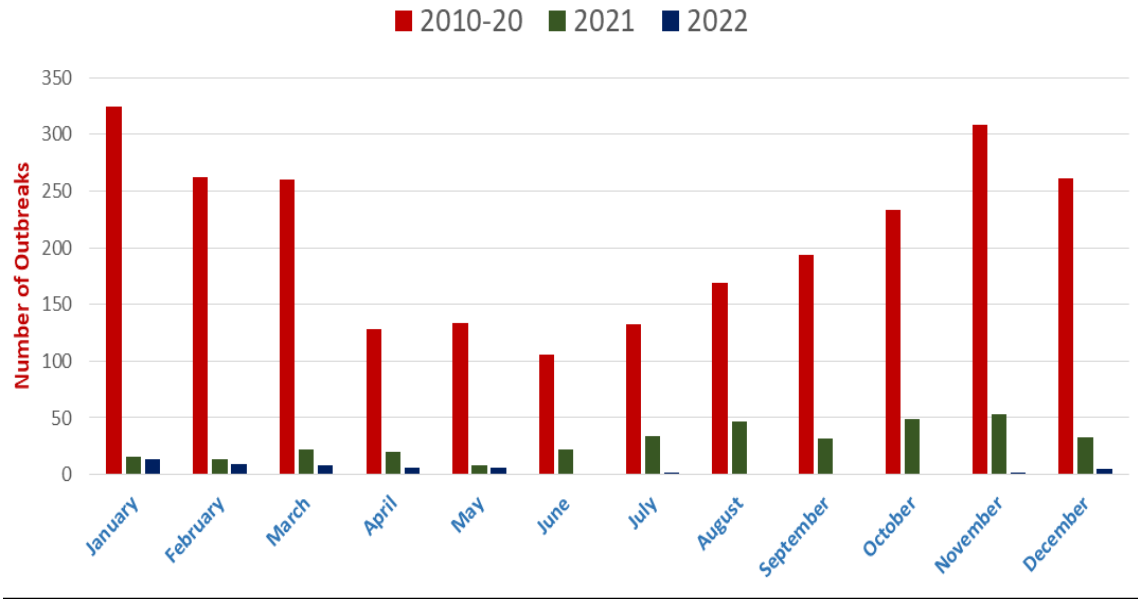


Fig 4: Month-wise FMD incidence during the year 2022 compared to last decade (2010-20)

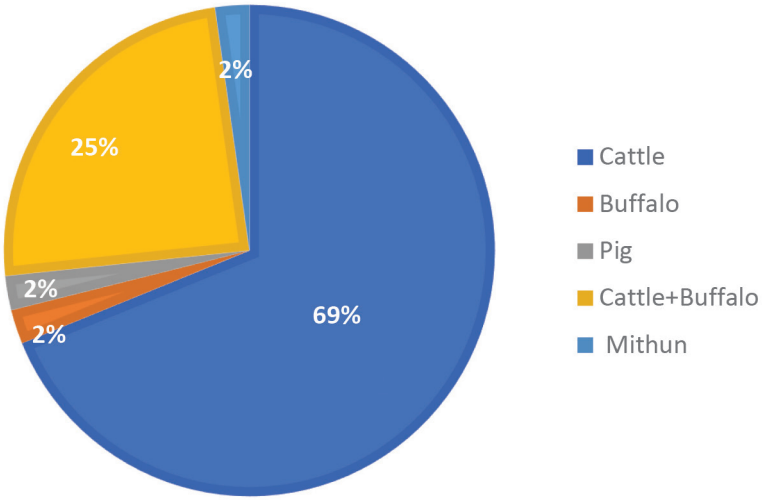


Fig 5: Species involved in FMD outbreaks during 2022

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 land borders and is surrounded by ocean. The state of Karnataka has been identified as an FMD hyper-endemic area. FMDCP has been operating in the southern peninsular region since 2010-11.

Kerala: Six FMD outbreaks were recorded in the state, and all of those were caused by FMDV serotype O. A maximum of four outbreaks were reported in the month of January, followed by one each in May and August. The disease was recorded in the districts of Kollam (n = 4) and Wayanad (n = 2). The disease was recorded only in cattle, with a morbidity rate of 0.06%. No mortality was observed in any of those outbreaks.

Telangana: One FMD outbreak due to serotype O was reported from the state. The outbreak was recorded in the month of March from the district of Sangareddy. The disease was recorded only in cattle with a morbidity rate of 0.22%, and there was no mortality.

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/LHDCP.

Madhya Pradesh: FDMV serotype O caused four outbreaks in the state in the months of January (n=3) and April (n=1). A maximum of three outbreaks were recorded in the district Seoni and one in the district of Betul. The disease was recorded both in cattle and buffalo, with a morbidity rate of 4.7% and there was no mortality.

WESTERN REGION

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

Maharashtra: The state reported a total of seven FMD outbreaks, all of which were caused by serotype O. The district of Ahmednagar had the most outbreaks (n = 5), with Pune and Nashik reporting one each. The outbreaks were reported during the months of December (n = 3), November (n = 2), January (n = 1), and March (n = 1). Six outbreaks were recorded only in cattle, and one involved both cattle and buffalo. The morbidity and mortality rates were low, at 0.76% and 0.19%, respectively.

Gujarat: One FMD outbreak due to serotype O was reported from the state in the month of March. The outbreak was reported in the district of Banaskantha. The morbidity was determined to be 2.2%, and there was no mortality. The disease was recorded only in buffalo.

Goa: One outbreak due to serotype O was recorded in the state

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: Three FMD outbreaks were reported in the state, one each in the districts of Mathura, Moradabad and Kaushambi. The outbreaks were recorded in the months of January, March and April. The outbreaks of Mathura and Moradabad could be serotype confirmed and found to be caused by serotype O. The outbreak reported in Moradabad district in month of March 2022 occured on a larger scale. Several villages of the Block Moradabad and Chajlait namely Agwanpur, Kuda Mirpur, Sandalipur, Pachokara, and Sanjarpur were severely affected. The clinical symptom of disease was evident in cattle and buffaloes. However, goat population in the entire village was unaffected. The disease was mild in most of the affected animals. FMD lesions were mainly observed in foot. Average vaccine coverage of the affected villages was 60-70% only, with last vaccination carried out in the month of January-February 2022.

Uttarakhand: The state recorded one serotype confirmed FMD outbreak, which was caused by serotype O and the disease was recorded in cattle. The outbreak was reported in the month of June in Almora district.

Jammu & Kashmir: The state recorded one FMD outbreak due to serotype Asia1

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, two FMD outbreaks which occurred in the months of February and March were serotype confirmed and found to be caused by serotype A and O, respectively. The outbreaks were reported from the districts of Jaipur and Dhenkanal. The outbreaks caused by serotype A was associated with very high morbidity (85.7%) and serotype O with low morbidity (3.2%) and in both the outbreaks, no mortality was observed.

West Bengal: During the period, one FMD outbreak each were recorded in the districts of Malda and Birbhum. Both the outbreaks were caused by serotype O and recorded in the months of March and May. The disease was recorded in bovine with a morbidity and mortality rate of 0.09% and no mortality was seen.

Bihar: Four FMD outbreaks were serotype confirmed and found to be caused by serotype O. The outbreaks were recorded in the months of January, February, March and June. Two outbreaks were reported from Khagaria followed by one each in Buxar and Muzaffarnagar. The disease was recorded in cattle and buffalo with a morbidity rate of 16.8% and no mortality was observed.

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

NORTH EASTERN REGION

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

Assam: Three outbreaks of FMD were recorded in the state during the period. Serotype O accounted for two outbreaks in the districts of Dibrugarh and Kamrup during the months of January and February. Surprisingly, in two samples collected from an outbreak recorded in Darrang district in the month of April, both serotypes O and A were detected. Two outbreaks were recorded in cattle and one was exclusively reported from pigs. The morbidity rate and mortality rate was observed to be 7.2 % and 1.7 %, respectively.

Arunachal Pradesh: Four FMD outbreaks were recorded in the state in the month of February, April and May (n=2). The outbreaks were due to serotype O. The disease was recorded in the districts of Papumpare (n=2), Kamle, and Lower Siang.

Meghalaya: One incidence of FMD caused by serotype O was recorded in cattle during the period. The outbreak was recorded in the East Garo Hills district in the month of February. The disease was recorded in a single cattle and no mortality was observed.

Manipur: FMD virus serotype O was responsible for the nine FMD outbreaks reported in the state. The outbreaks were reported in the months of January (n = 1), February (n = 2), March (n = 1), April (n = 2), May (n = 1), and December (n = 2). The outbreaks were reported in the districts of Senapati (n = 3), Imphal West (n = 2), Tamemglong (n = 3), and Thoubal (n = 1) in cattle. The morbidity rate and mortality rate were observed to be 5.5% and 0.4%, respectively.

Mizoram: Three outbreaks were reported from the state, of which two were caused by serotype O in Aizawl district in February and one by serotype A in Champhai district in May. The outbreaks in Aizawl were recorded only in cattle, while on the other hand, the disease was reported from cattle, buffalo, and Mithun in Champhai. The morbidity rate was observed to be 18.9%, and no mortality was recorded.

Sikkim: One FMD outbreak due to serotype O was recorded in the state.

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

2.1.2 FMD Serosurveillance under LHDCP

In India, vaccination with inactivated vaccine is the primary mode of FMD control. There is a need to identify the infected animals among the vaccinated population for appropriate implementation of the control programme, and to assess effectiveness of the vaccination campaign. 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, an array of non-structural proteins (NSPs) are produced that elicit anti-NSP antibodies, which is not the case in uninfected 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 having no virus circulation 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-NIFMD. For NSP sero-surveillance, the study design usually focuses on younger animals (**6-18 months age**) since repeated vaccination even with good quality purified vaccine is suspected to generate positive signal in NSP ELISA that may provide false positive NSP reactors.

During the year 2022, a total of **69,662** bovine serum samples (Cattle-43106 and Buffalo-26556) collected at random as per sampling plan from various parts of the country were tested using r3AB3 NSP-ELISA for assessing NSP-antibody (NSP-Ab) prevalence, which is an underlying indicator of FMD virus exposure regardless of vaccination status. The test revealed overall seropositivity (DIVA positive) in 16.6% samples or animals (Table 3). As compared to DIVA reactivity in 2021 (16.6%), the prevalence trend remained the same in 2022. Even though less number of outbreaks reported during 2022, the NSP-Ab induced in the population due to massive outbreaks during 2021 may take time to decline. Species wise comparison revealed cattle has higher seroprevalence rate (22.1%) than buffalo (7.6%). Percent NSP antibody prevalence in different states are depicted in (Fig 6). In general, over the years though there has been a fluctuation in number of outbreaks, but a gradual decline in NSP antibody prevalence was observed in the country (Fig 7).

Table 3. NSP Positivity/ Reactivity during the year 2022 in cattle and buffalo of India

S No	State/UT	Cattle		Buffalo		Total NSP Positive (%)
		No of samples tested	% NSP Positive	No of samples tested	% NSP Positive	
1	A & N Islands	2066	3.1	-	-	3.1
2	Andhra Pradesh	4867	34.7	4962	10.9	22.7
3	Arunachal Pradesh	270	42.2	-	-	42.2
4	Assam	1792	15.5	-	-	15.5
5	Bihar	1461	27.9	724	27.2	27.6
6	Chhattisgarh	1128	29.8	119	8.4	27.7
8	Gujarat	3323	26	3330	2	14
9	Haryana	2095	11.5	4949	2.4	5.1
10	Himachal Pradesh	1667	14	757	4.4	11
11	Jammu & Kashmir	1719	25.9	-	-	25.9
12	Jharkhand	1255	35.8	32	9.4	35.4
13	Karnataka	1261	37.5	402	30.5	36
14	Kerala	1767	18	107	15	17.8
15	Madhya Pradesh	1798	19.6	1030	9.5	15.9
16	Maharashtra	2077	27.1	850	10.6	22.3
17	Manipur	1046	23.1	168	19.6	22.7
18	Meghalaya	630	11.5	-	-	11.5
19	Mizoram	1075	19.2	48	12.5	18.9
20	Nagaland	871	15.3	-	-	15.3
21	Odisha	2144	29.7	196	21.9	29.1
22	Pondicherry	544	31.8	-	-	31.8
23	Punjab	1488	28.8	2331	13	19.2
24	Telangana	3729	9.3	3911	5.5	7.4
25	Uttar Pradesh	1338	13.3	1990	4.1	7.8
26	Uttarakhand	1579	17.0	540	4.8	13.9
28	West Bengal	84	28.6	-	-	28.6
27	Rajasthan	70	17.1	110	3.6	8.9
	Total	**43106**	**22.1**	**26556**	**7.6**	**16.6**

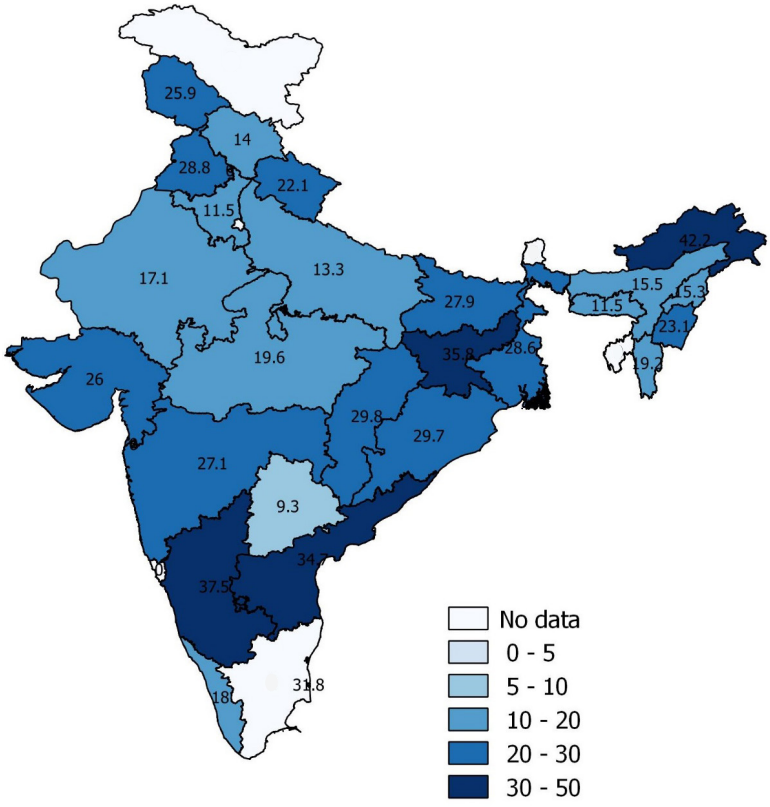


Fig 6a: State-wise **percent** NSP antibody prevalence in cattle during 2022

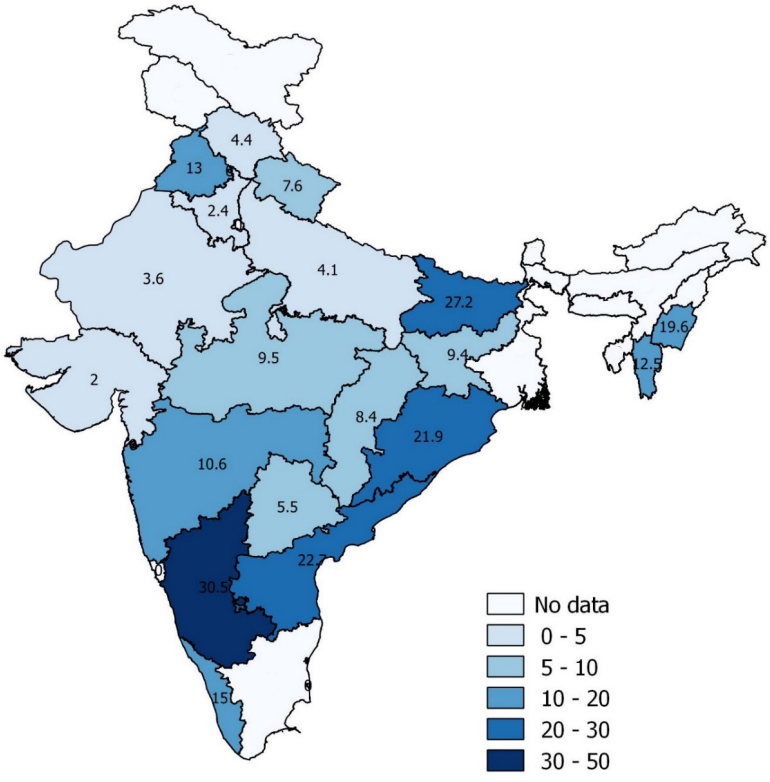


Fig 6b: State-wise **percent** NSP antibody prevalence in buffalo during 2022

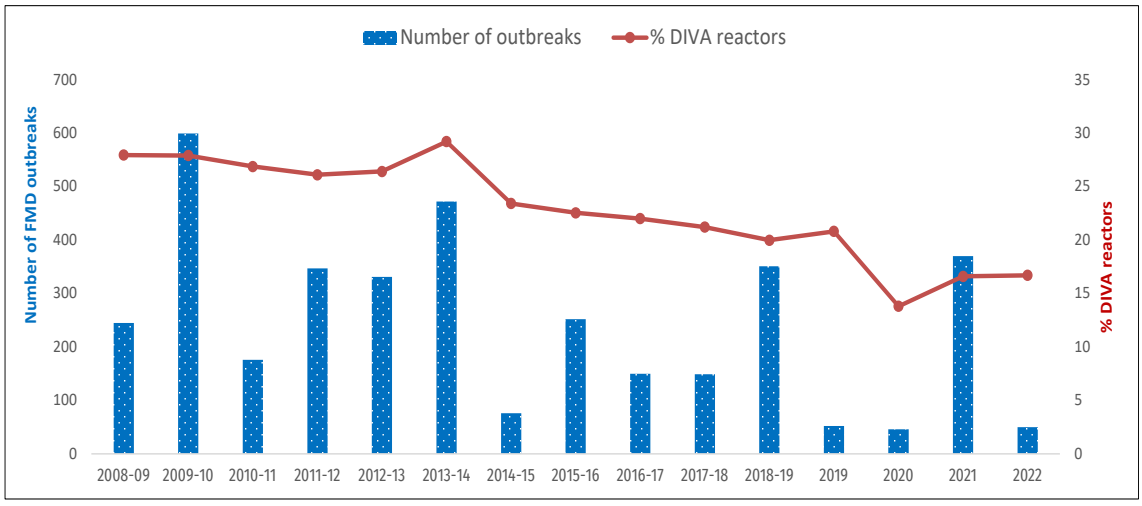


Fig 7. DIVA positivity/reactivity over the years in bovine population of India vis a vis number of FMD outbreaks

Serosurveillance in small ruminants and pigs

FMD surveillance in small ruminants and pigs are critical for understanding their role in FMD epidemiology and for providing inputs 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. (Table 4). Apparently, sheep and goat could be taken as sentinel animals or indicator of virus circulation in 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 or integrated animal husbandry setup, it is by and large 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 (especially in goat) indicates probable spill-over of virus from bovine population, and covert infection. This scenario warrants a more intensive surveillance and follow up in bovine population of the states.

Table 4. NSP positivity/reactivity during the year 2022 in small ruminants and pigs

State/UT	Sheep		Goat		Pig	
	No of samples tested	% NSP Positive	No of samples tested	% NSP Positive	No of samples tested	% NSP Positive
Madhya Pradesh	178	6.7	1486	20.9	118	16.1
Maharashtra	-	-	260	1.5	-	-
Haryana	-	-	903	16.4	-	-
Total	178	6.7	2649	17.4	118	16.1

DIVA positivity in outbreak samples

A total of 325 serum samples collected during FMD outbreaks from different species were tested using DIVA ELISA for retrospective diagnosis. NSP antibody Seroprevalence was found to be higher in cattle (50.9%) followed by Pigs (27.4%) in outbreak scenario as compared to random samples. Screening of serum samples from Yak, Cattle-Yak hybrid from outbreak areas also revealed higher NSP positivity in Yak and Yak hybrid (Table 5).

Table 5. NSP positivity/ reactivity during the year 2022 in outbreak samples

State	Species	Total No. of Samples	Total Positives
Bihar	Cattle	4	4
Chhattisgarh	Cattle	5	5
Delhi	Cattle	1	1
Goa	Cattle	6	3
Gujarat	Cattle	6	0
Kerala	Cattle	6	4
Madhya Pradesh	Cattle	48	28
Maharashtra	Cattle	3	2
Manipur	Cattle	13	3
Odisha	Cattle	26	22
Sikkim	Cattle	26	2
Uttarakhand	Cattle	1	1
Uttar Pradesh	Cattle	10	10
Madhya Pradesh	Buffalo	16	2
Total		**181**	**89 (47.6%)**
Jharkhand	Pig	17	10
Assam	Pig	45	7
Total		**62**	**17 (27.4%)**
Uttarakhand	Goat	4	0
Jharkhand	Goat	57	7
Jammu & Kashmir	Sheep	15	3
Total		**76**	**10 (13.2%)**
Arunachal Pradesh	Yak	**142**	**20**
Arunachal Pradesh	Cattle-Yak Hybrid	**44**	**6**
Total		**186**	**26 (13.9%)**

Status of NSP sero-reactors at Livestock-wildlife interface

In collaboration with Wildlife Conservation Trust (WCT), Mumbai, FMD virus serosurveillance was conducted at the livestock-wildlife interface in the buffer/core zone of Sanjay Tiger Reserve and Bandhavgarh Tiger Reserve, Madhya Pradesh (Fig 8). A total of 1224 serum samples were collected from cattle, buffaloes, and goats, and 3AB3 NSP ELISA revealed that 17.7%, 2.7%, and 9.8% of cattle, buffaloes, and goats, respectively, were positive for 3AB3 NSP antibody, respectively (Fig.9). During active FMD virus surveillance in the buffer/core zone of Sanjay Tiger Reserve and Bandhavgarh Tiger Reserve, 150 oro-pharyngeal samples were also collected, processed, and tested for FMD viral genome using RT-mPCR. FMD viral genomes were found only in cattle and not in buffaloes or goats.

Cluster information:

Clusters	Villages
I	Bijhariya, Damna, Gata, Ghaghaud, Bansa, Ghagadar, Gobratal, Jamunara, Kathali, Lakhumar, Mala, Rakhi, Saramania
II	Badkhera, Devari, Madhau, Majhakheta, Maraikhurd
III	Hiaruali, Malhara, Maraikala, Samarkaini
IV	Dongritola, Mahaman, Parasi
V	Dhaurkoh, Raghopur, Salaiya, Tali
VI	Bamera, Bagdari, Sejwahi, Gangital, Mehendwa, Kaseru, Bagaiha, Kusmaha, Kothiya

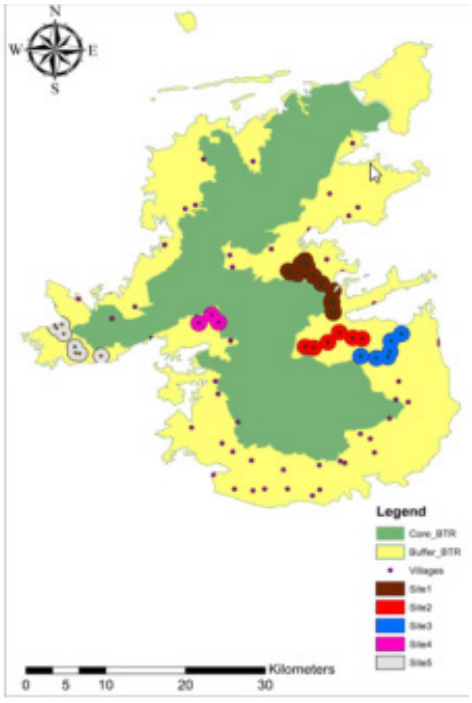


Fig 8: Cluster of villages at the livestock-wildlife interface in the buffer/core zone included in the study

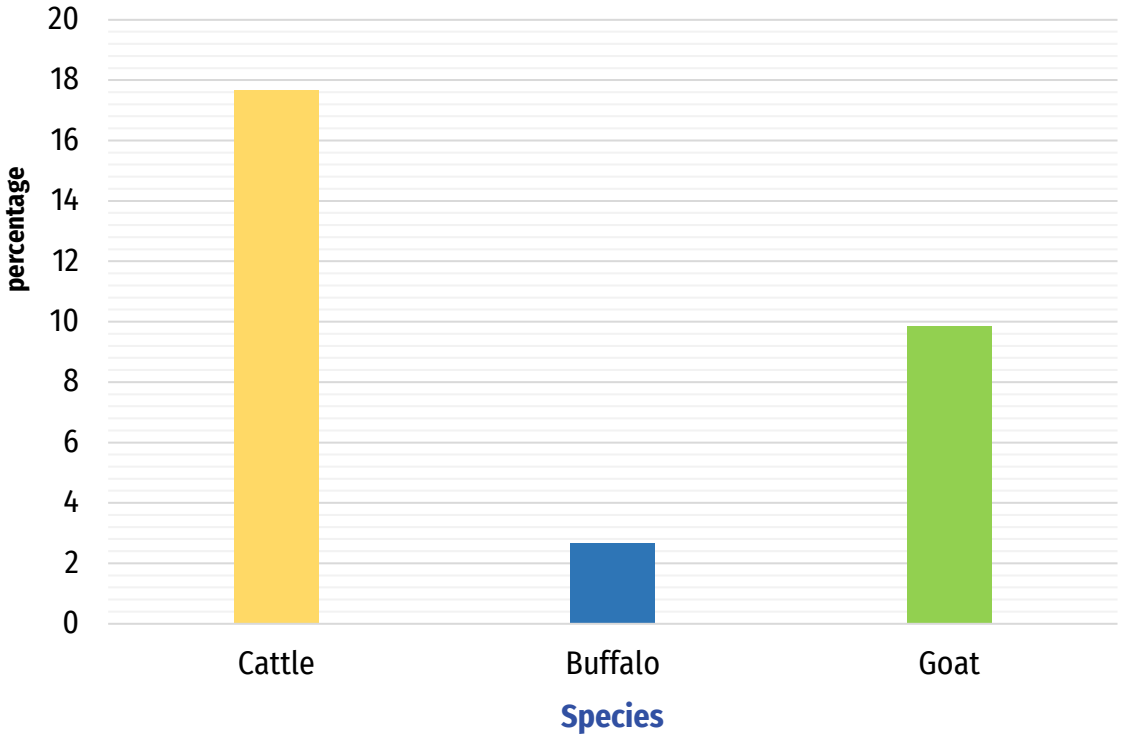


Fig 9: Percentage of NSP Reactors at livestock-wildlife interface.

2.1.3 FMD Seromonitoring under LHDCP

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 eligible cattle and buffaloes. The scheme was expanded progressively 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. Later the scheme was renamed as Livestock Health and animal disease control program (LHDCP). The ambitious target of the NADCP is to control FMD by 2025 with vaccination and its eventual elimination by 2030. This will result in increased domestic production and ultimately in increased export of livestock products. LHDCP for FMD and Brucellosis is a Central Sector Scheme where 100% of funds are provided by the Central Government to the States / UTs.

ICAR-NIVEDI in collaboration with ICAR-NIFMD 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.

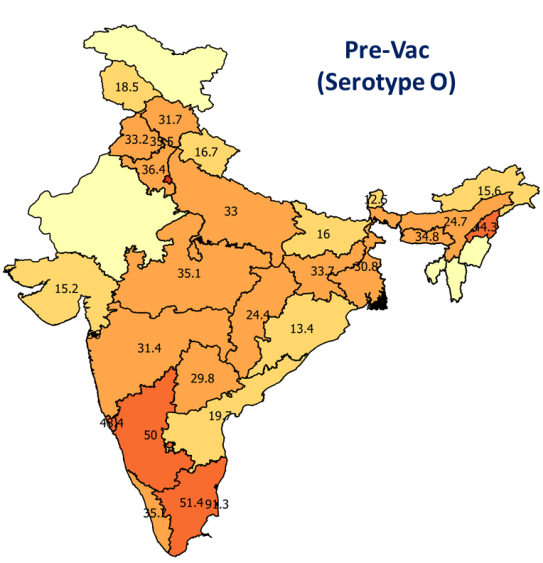
Under FMDCP/LHDCP, serum samples before vaccination and 21 to 30 days post vaccination are collected by the respective state AH departments and tested by ICAR-NIFMD and its state FMD laboratories for estimation of level of serotype specific seroconversion. Globally, there are three tests to screen FMDV 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 and required for bio-containment laboratories. 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. Initially, up to NADCP round 1, protective titre cut-off was fixed at ≥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 cut-off of ≥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.

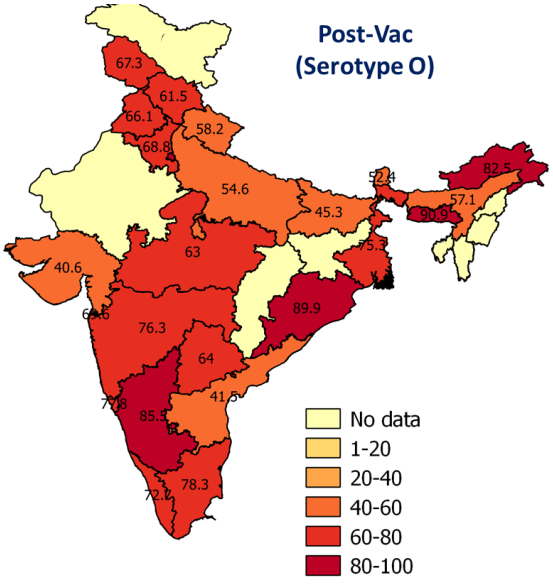
NADCP/LHDCP Round 2

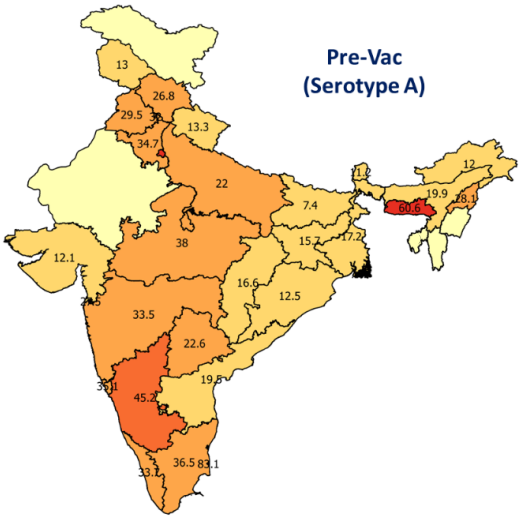
Vaccination under round 2 of NADCP was delayed due to several reasons. During later part of 2021, vaccination in selected states/regions was started and continued in 2022. For Post Vaccination seromonitoring (PVM), the serum samples were collected as per the sampling frame developed jointly by ICAR-NIFMD and ICAR-NIVEDI. In total, 86,406 serum samples (pre-vac: 44860 and post vac: 41546) were tested. From round 2, a total of 17,029 serum samples (pre-vac: 9450 and post vac: 7579) were processed during 2021. Rest of the serum samples were tested during the year 2022. Overall, the protective titre was found in **30.9, 25.9 and 26.7** percent of animals against serotypes O, A and Asia1, respectively in pre vaccination samples, and **66.5, 64.1 and 63.5** percent of animals against serotypes O, A and Asia1, respectively, in post-vaccination samples. The results are presented in the (Table 6).

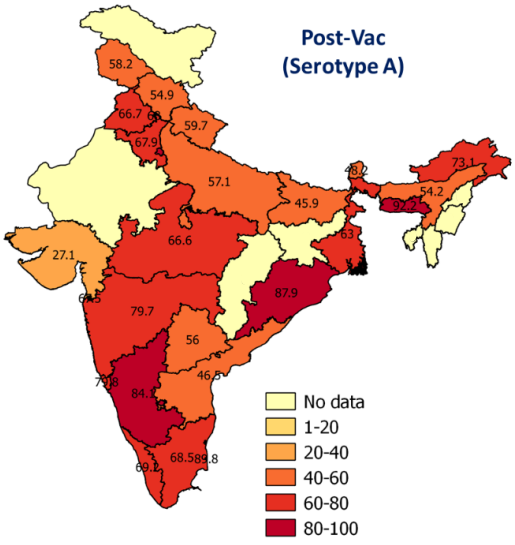
Table 6. State/UT wise percentage of animals showing Pre-vaccinated (Pre) and Post-vaccinated (Post) protective titre against FMD virus serotypes O, A and Asia1 (NADCP-2)

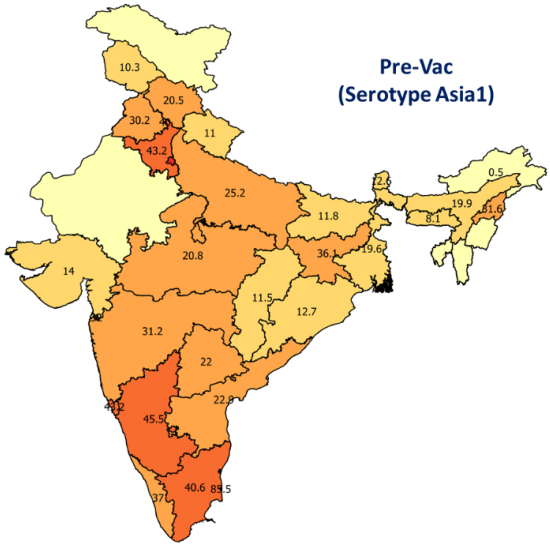
States/UT	Pre (N)	Post (N)	Serotype O (%)		Serotype A (%)		Serotype Asia1 (%)	
			Pre	Post	Pre	Post	Pre	Post
A&N Island	472	472	15.3	79.2	6.8	68.0	16.7	85.8
Andhra Pradesh	2722	2716	19.7	41.5	19.5	46.5	22.9	49.2
Arunachal Pradesh	417	342	15.6	82.5	12.0	73.1	0.5	72.5
Assam	1848	1848	24.7	57.1	19.9	54.2	19.9	55.0
Bihar	2246	2117	16.0	45.3	7.4	45.9	11.8	37.2
Chandigarh	200	200	35.5	75.5	32.0	68.0	40.0	79.0
Chhattisgarh	2209	-	24.4	-	16.6	-	11.5	-
Dadra and Nagar Haveli and Daman and Diu	200	191	56.0	69.6	27.5	67.5	32.0	58.6
Delhi	234	230	73.1	88.7	65.0	86.1	65.0	89.6
Goa	1289	1289	48.4	77.8	35.1	79.8	43.2	84.8
Gujarat	2184	2184	15.2	40.6	12.1	27.1	14.0	34.8
Haryana	2289	2285	36.4	68.8	34.7	67.9	43.2	72.9
Himachal Pradesh	619	1432	31.7	61.5	26.8	54.9	20.5	55.1
Jammu & Kashmir	1073	1048	18.5	67.3	13.0	58.2	10.3	57.4
Jharkhand	83	-	33.7	-	15.7	-	36.1	-
Karnataka	2166	2173	50.0	85.5	45.2	84.1	45.5	83.2
Kerala	2182	2182	35.7	72.7	33.7	69.2	37.0	72.5
Madhya Pradesh	1014	1014	35.1	63.0	38.0	66.6	20.8	51.9
Maharashtra	4420	4420	31.4	76.3	33.5	79.7	31.2	77.8
Meghalaya	198	154	34.8	90.9	60.6	92.2	8.1	66.2
Nagaland	1056	-	44.3	-	28.1	-	31.6	-
Odisha	2262	2262	13.4	89.9	12.5	87.9	12.7	87.0
Pudhucherry	883	883	91.3	95.9	83.1	89.8	85.5	89.1
Punjab	2196	2196	33.2	66.1	29.5	66.7	30.2	68.1
Sikkim	1138	1016	12.5	52.4	11.2	48.2	12.6	45.9
Tamilnadu	2327	2327	51.4	78.3	36.5	68.5	40.6	70.3
Telanagana	2275	2275	29.8	64.0	22.6	56.0	22.0	57.2
Uttar Pradesh	2433	2240	33.0	54.6	22.0	57.1	25.2	45.3
Uttarakhand	1358	1236	16.7	58.2	13.3	59.7	11.0	45.0
West Bengal	803	814	30.8	75.3	17.2	63.0	19.6	63.6
Total	**44860**	**41546**	**30.9**	**66.5**	**25.9**	**64.1**	**26.7**	**63.5**

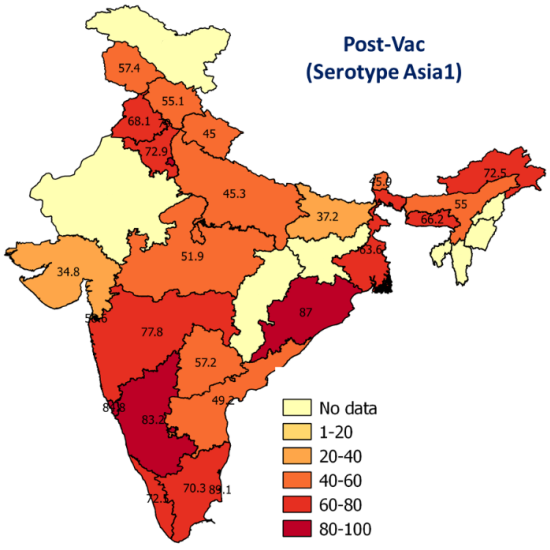

Pre-Vac
(Serotype O)


Post-Vac
(Serotype O)
No data
1-20
20-40
40-60
60-80
80-100


Pre-Vac
(Serotype A)


Post-Vac
(Serotype A)
No data
1-20
20-40
40-60
60-80
80-100


Pre-Vac
(Serotype Asia1)


Post-Vac
(Serotype Asia1)
No data
1-20
20-40
40-60
60-80
80-100

Percent antibody response in different age categories of Bovine

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 (Fig 10)

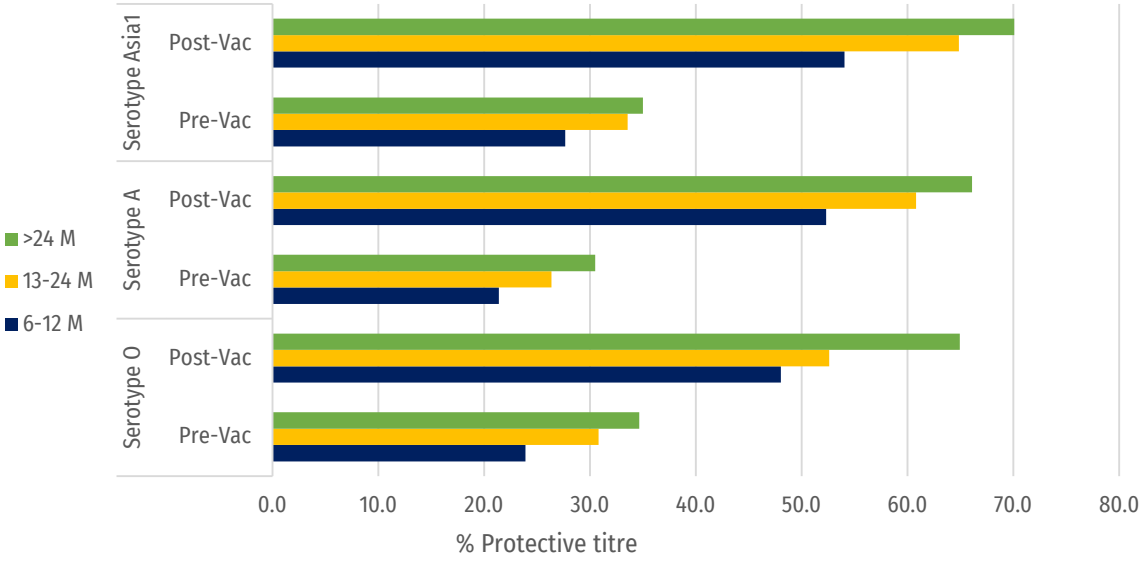


Fig 10: Percent protective antibody titre in different age categories of cattle and buffalo

Percent antibody response in cattle and buffalo

Serum samples were collected from cattle and buffalo

Both the species showed good seroconversion and antibody titre in post vac samples

Cattle in general showed better response compared to buffalo

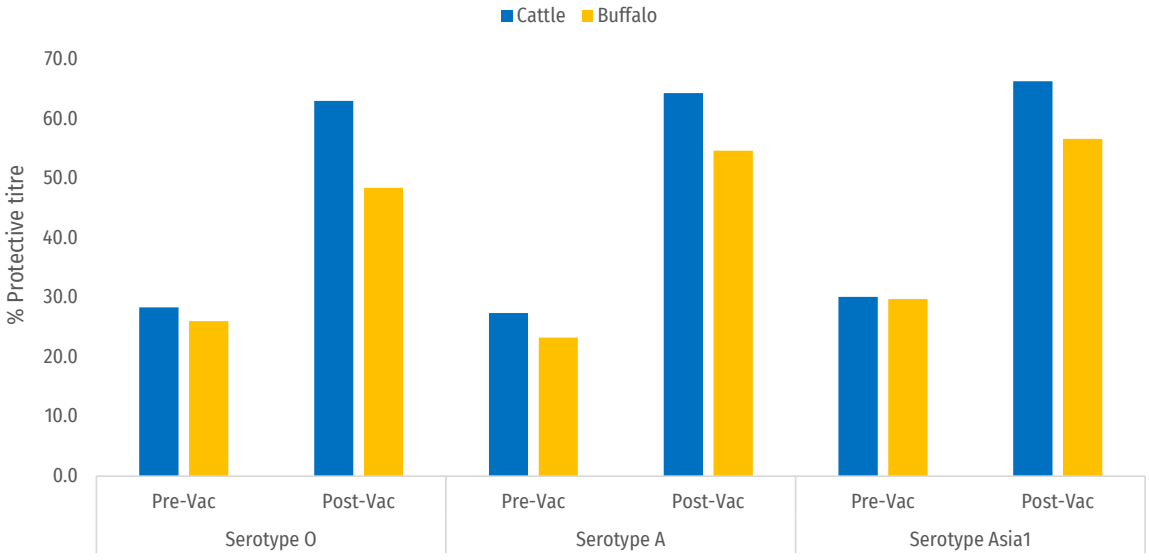


Fig 11: Percent protective antibody titre in cattle and buffalo

NADCP/LHDCP Round 3

Vaccination under round 3 of NADCP was stated in in the 2022. Serum samples from the states of Haryana and Karnataka was assessed. In total, 5900 serum samples (pre-vac: 3757 and post vac: 2143) were tested during 2022. Overall, the protective titre was found in **37.9, 38.7 and 37.5** percent of animals against serotypes O, A and Asia1, respectively in pre vaccination samples, and **74.3, 77.9 and 79.5** percent of animals against serotypes O, A and Asia1, respectively, in post-vaccination samples. The results are presented in the (Table 7).

Table 7. State/UT wise percentage of animals showing Pre-vaccinated (Pre) and Post-vaccinated (Post) protective titre against FMD virus serotypes O, A and Asia1 (NADCP/LHDCP-3)

State/UT	Pre-vac samples (N)	Post-vac samples (N)	Serotype O (%)		Serotype A (%)		Serotype Asia1 (%)	
			Pre	Post	Pre	Post	Pre	Post
Haryana	2145	2143	32.4	74.3	35.9	77.9	34.6	79.5
Karnataka	1612	-	45.3	-	42.3	-	41.4	-
Total	3757	2143	37.9	74.3	38.7	77.9	37.5	79.5

FMD seromonitoring in organized farms

ICAR-NIFMD and its network laboratories undertake the testing of samples from organised government farms. During the year 2022, a total of 10,515 (pre-vac: 5275 and post-vac: 5240) serum samples received from various breeding bull stations and dairy farms were tested to assess the protection level. The antibody titre and post-vaccination seroconversion were found to be excellent (>90%) in most of the farms (Table 8 and Fig 12). In general, regular vaccinations have been practised without fail on organised farms. In order to bring FMD to a zero level with vaccination, similar efforts need to be adapted across the nation.

Table 8. State wise percentage of animals showing Pre-vaccinated (Pre) and Post-vaccinated (Post) protective titre against FMD virus serotypes O, A and Asia1 in organized farms

States	Pre Vac serum (N)	Post Vac serum (N)	Serotype O (%)		Serotype A (%)		Serotype Asia1 (%)	
			Pre-Vac	Post-Vac	Pre-Vac	Post-Vac	Pre-Vac	Post-Vac
Andhra Pradesh	501	326	98.6	97.9	96.2	96.6	98.6	100.0
Kerala	1305	1295	90.9	91.8	88.4	91.7	90.6	92.0
Chhattisgarh	93	68	78.5	100.0	68.8	100.0	74.2	100.0
Uttar Pradesh	570	339	84.2	90.3	91.9	90.0	93.0	97.9
Himachal Pradesh	103	144	96.1	95.8	97.1	97.2	96.1	96.5
Madhya Pradesh	401	398	92.5	99.5	90.8	97.7	92.5	97.5
Tamilnadu	547	500	97.6	98.8	92.7	97.6	97.4	98.8
Haryana	644	868	93.6	98.5	93.3	98.7	93.0	98.8
Odisha	21	21	28.6	90.5	23.8	90.5	19.0	85.7
Telangana	14	96	14.3	99.0	0.0	95.8	0.0	99.0
Maharashtra	283	240	92.2	100.0	91.9	100.0	91.5	100.0
Gujarat	379	562	100.0	100.0	98.7	94.3	93.1	95.0
Uttarakhand	44	44	93.2	95.5	93.2	95.5	100.0	100.0
Karnataka	370	339	94.1	99.4	94.9	99.4	94.3	99.4
Total	5275	5240	92.5	96.6	91.5	95.6	92.6	96.7

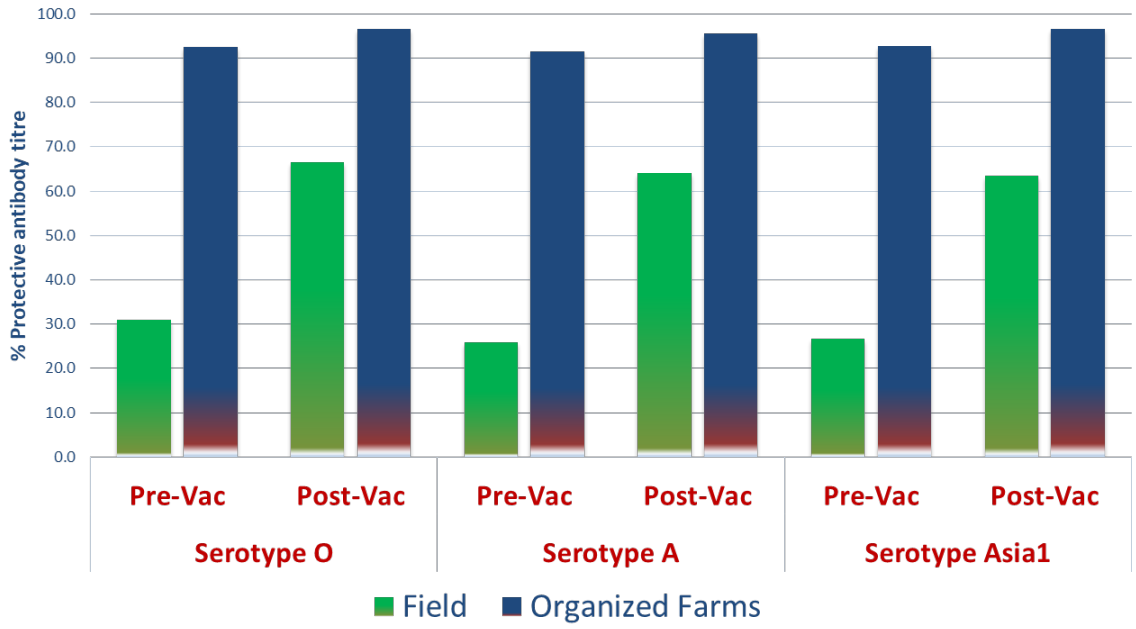


Fig 12: Comparison of present protective titer in organized farms and field

2.1.4 FMD vaccine quality control testing under NADCP/LHDCP

Since the year 2020, ICAR-NIFMD has been participating in the quality control testing of FMD vaccines to be used for vaccination under the LHDCP. During the year 2022, five batches of FMD vaccines (Table 9) have been tested at different farms across the country, and reports have been communicated. In each batch, the safety, sterility, purity, and potency tests were conducted as per the standard operating procedure laid down by DAHD.

Table 9: Batches of FMD vaccine tested by ICAR-NIFMD and location of farms

Sl No.	Batch	Date of start of test	Place
1.	129-213-JJ29U-26	04-12-2021	CBF, Imlikheda
2.	012-215-LL02U-22	04-12-2021	CBF, Imlikheda
3.	001-255-GG10V-22	23-08-2022	SSDAG Trust Gaushala, Chandwa
4.	015-264-II15V-22	24-09-2022	Shree Jharia Gaushala, Dhanbad
5.	110-285-JJ10V-22	19-10-2022	Shri Gopal Gaushala, Giridih

2.1.5 Investigation of NSP seroreactors

The ICAR-NIFMD, state FMD regional and collaborating centres, and state AH departments collaborated on a systematic follow-up investigation of FMD NSP seroreactors using oropharyngeal fluid collection and testing (OPF). Based on laboratory test results, ICAR-NIFMD identified three states and territories with 10% FMD NSP seroreactors: (1) Haryana, (2) Telangana, and (3) Andaman and Nicobar, which were targeted for OPF collection. ICAR-NIFMD has requested animal identification numbers for NSP seroreactors from the identified state. The animal IDs of individual NSP seroreactors were provided by all three identified states and UT. A total of 65 oropharyngeal fluids (OPF) from NSP-positive animals from the states of Haryana and Telangana were tested for FMD viral genome detection. RT-mPCR testing revealed that none of the 65 OPF tested positive for the FMD virus.

2.2 Development and Improvement of Diagnostics

The development of sensitive diagnostics and the refinement of existing diagnostic tests are important mandates of the institute. During the reported period, the comparative efficacy of solid-phase competitive ELISA (SPCE) with that of the virus neutralisation test (VNT) for post-vaccination protective antibody assessment was done on more number of samples. A TaqMan-probe-based one-step multiplex real-time RT-PCR assay for pan-serotype detection of FMDV and a novel reverse transcription-multiplex PCR assay to differentiate FMD virus serotypes O, A, and Asia1 were developed.

2.2.1 Comparative performance evaluation of SPCE with VNT

Solid Phase Competitive ELISA (SPCE) developed at this institute is being applied in all the testing laboratories involved in FMD post-vaccination seromonitoring activity under NADCP/LHDCP-FMD since 2017. The test provides a semi-quantitative structural antibody titre estimate in the serum sample against Indian vaccine strains for three serotypes such as O, A, and Asia 1 and categorises the serum antibody titres in a dichotomous manner as 'protective' titre and 'un-protective' titre. Initially, a set of 198 samples (119 judged protective and 79 un-protective in VNT) were tested both in VNT and SPCE to revise the cut-off of interpretation in SPCE so as to achieve a reasonably high relative diagnostic sensitivity (DSn) and specificity (DSp). VNT, considered to be the gold standard alternative *in vitro* test, was used to categorise the samples as having protective and un-protective levels of antibody titre (log10 titre cut-offs of 1.8, 1.65, and 1.65 for serotypes O, A, and Asia 1, respectively). Final interpretation criteria were revised from 50% inhibition of OD_{max} values and a cut-off $\log_{10}$ titre of 1.8 to 35% inhibition and $\log_{10}$ titre of 1.65. Without losing much of its diagnostic specificity, the diagnostic sensitivity could be significantly improved with the revised interpretation criteria as compared to the earlier criteria of 50% inhibition and $\log_{10}$ titre cut-off of 1.8.

To further validate the revised interpretation criteria, a set of 242 serum samples (119 judged protective and 123 un-protective in VNT) were tested during 2022 and analysed including the earlier available data. In addition, 24 monovalent bovine vaccinal sera were also tested to determine the extent of heteroserotypic cross-reaction. At the revised criteria of interpretation, although the relative DSn did not show any significant change except for a substantial increase in the case of serotype Asia 1 (DSn of 90%, 84%, and 78% for O, A, and Asia 1, respectively, changed to 92%, 85%, and 87%), the DSp values dropped to some extent (DSp of 94%, 95%, and 93% for O, A, and Asia 1, respectively, changed to 88%, 86%, and 84%). The drop in DSp could be attributed mostly to the heteroserotypic cross reaction observed while testing the high-titer monovalent vaccine. Nevertheless, the revised criteria of interpretation adopted for SPCELISA (35% inhibition and titre cut-off 3 $\log_{10}$ 1.65) exhibited reasonably higher DSn and DSp balance over a range of varied cut-offs tested (Table 10) and therefore are found 'fit-for-purpose' for assessment of protective antibody titre under NADCP/LHDCP-FMD.

However, more serum samples need to be tested, particularly those collected from vaccine potency challenge studies. Also, the uniform cut-off criteria suggested for all three serotypes for now may be refined on a serotype-to-serotype basis for better accuracy once more relevant data is available for analysis in the time to come.

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

FMD Serotype O

SPCE log10 titre cut off / % Inhibition	Log 1.5		Log 1.65		Log 1.8	
	DSn %	DSp %	DSn %	DSp %	DSn %	DSp%
30%	96	75	96	81	93	85
35%	92	82	92	88	78	92
40%	84	92	83	92	69	96
50%	79	95	78	98	56	98

FMD Serotype A

SPCE log10 titre cut off / % Inhibition	Log 1.5		Log 1.65		Log 1.8	
	DSn %	DSp %	DSn %	DSp %	DSn %	DSp %
30%	92	79	90	81	85	84
35%	86	82	85	86	74	89
40%	81	91	79	91	67	97
50%	64	99	61	100	52	100

FMD Serotype Asia1

SPCE log10 titre cut off / % Inhibition	Log 1.5		Log 1.65		Log 1.8	
	DSn %	DSp %	DSn %	DSp %	DSn %	DSp%
30%	94	74	92	76	78	81
35%	91	80	87	84	76	88
40%	82	83	81	86	68	93
50%	72	95	68	99	58	99

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

2.2.2 TaqMan-probe-based one-step multiplex rRT-PCR assay for pan-serotype detection of FMDV

The World Organisation for Animal Health (WOAH) recommended 5' UTR and 3D polymerase gene-based RT-qPCR have been extensively used as reference molecular diagnostic methods for the detection of FMDV in a pan-serotype manner. Due to the high level of nucleotide mutations generated during the replication of FMDV, nucleotide substitutions either in the primer or probe binding regions may result in a negative signal in one RT-qPCR assay, while the other RT-qPCR assay could still give a positive result. However, an RT-qPCR assay simultaneously targeting multiple genetic regions could enhance the overall sensitivity of nucleic acid detection for the diagnosis of FMDV. Therefore, a multiplex TaqMan probe-based one-step RT-qPCR assay simultaneously targeting the 5'UTR and 3Dpol regions and the endogenous 18S rRNA gene as an internal control (IC) was developed at ICAR-NIFMD. The newly developed multiplex RT-qPCR assay was also evaluated for the detection of FMDV serotypes O, A, and Asia1 strains circulating in India in a variety of clinical sample matrices from FMDV-affected animals.

In order to evaluate the performance of the one-step multiplex RT-qPCR assay on the field samples, RNA extracted from a variety of clinical samples was tested. Out of 740 tongue and foot epithelial (TE and FE) samples collected from the FMD-suspected animals, 704 samples were detected as positive in the multiplex RT-qPCR. Amongst these epithelial samples, FMDV RNA was detected in 172/172, 298/310, and 234/258 samples collected from infected animals at 1–5 days, 5–10 days, and 10-15 days, respectively, post-manifestation of clinical symptoms. Similarly, out of 210 OPF samples, viral RNA was detected in 26/35, 52/98, and 32/77 samples collected at 1-3 months, 3-6 months, and 6-9 months, respectively, post-FMD outbreaks. Likewise, FMDV RNA was detected in 8/20, 40/40, and 9/15 oral and nasal swab samples collected before, during, and after the onset of the clinical symptoms of FMD. Milk samples collected sequentially from 10 FMDV naturally infected cows were also analysed by multiplex RT-qPCR, and it was determined that 10/10, 7/10, 5/9, and 3/9 cattle were found positive for viral RNA in the milk samples collected at 2 days post manifestation of infection (DPI), 7 DPI, 14 DPI, 21 DPI, and 28 DPI, respectively (Fig 13). Furthermore, in all the field samples tested, both the 3Dpol and 5'UTR targets were amplified with comparable efficacy.

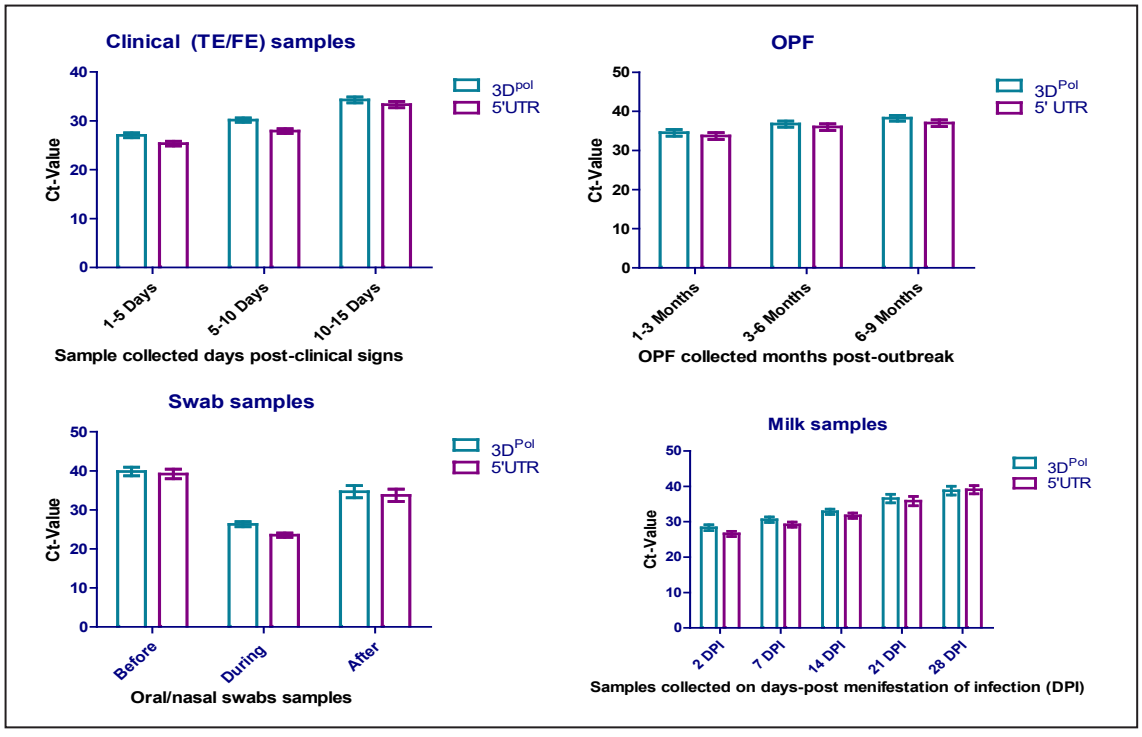


Fig 13: Detection of FMDV RNA in various FMD-suspected field samples, (A) tongue/feet epithelium, (B) oro-pharyngeal fluids (OPF) (C) oral/nasal swabs, and (D) milk, by one-step multiplex RT-qPCR assay.

2.2.3 Novel multiplex RT-PCR assay to differentiate FMDV Serotypes

Reverse transcription-multiplex PCR (RT-mPCR), developed during 2005 at this institute, is being used as the second line of testing after antigen detection sandwich ELISA to detect and differentiate between FMD virus serotypes O, A, and Asia1 genomes in FMD-suspected samples referred to NIFMD. RT-mPCR is known to have the advantages of higher diagnostic sensitivity over serotype-differentiating ELISA and adaptability to test a variety of samples. FMD virus, being an RNA virus, is known for its genetic heterogeneity, more so at its structural protein coding region, which is the target region for the primers designed in mPCR assays. Generally, mPCR primers are tailored to detect the pool of genetic variants circulating in a particular region. Therefore, a single test system is not necessarily efficient enough to detect all global variants within a serotype. Such sensitivity-compromising factors associated with PCR-based diagnostic systems, particularly when developed for highly mutable RNA viruses, become more complicated in the context of the perceived threat of inter-pool virus movement and cross-border incursion of novel virus lineages into the country. Therefore, there is a constant need to monitor the genetic variation in the field strains at primer binding sites and to update the primers and assays as and when required. Also, in order to circumvent such issues, many laboratories advocate running more than one mPCR assay in parallel to enhance the overall diagnostic performance.

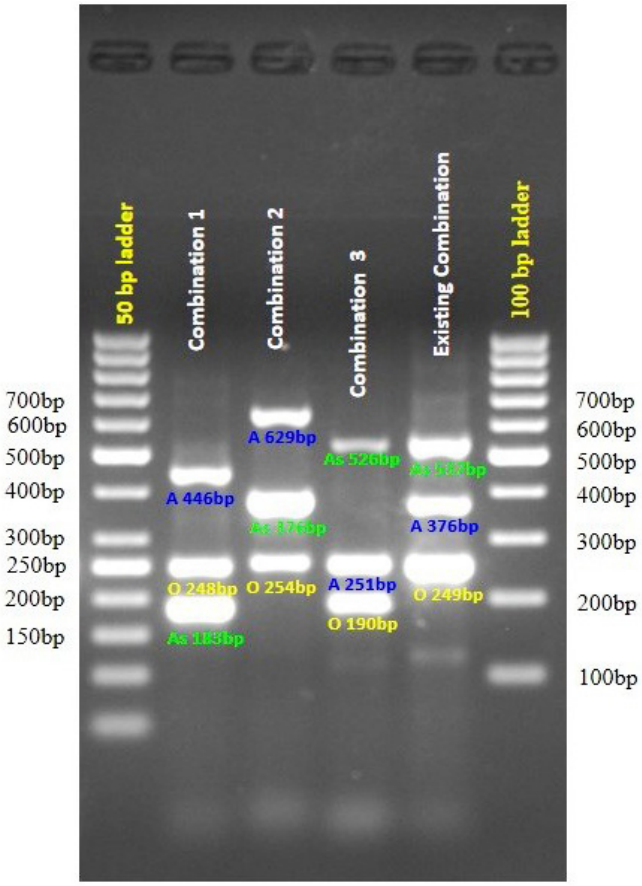


Fig 14: Approximate size (kb) of the serotype specific PCR amplicons on 1.5% agarose gel for the novel and existing assays

Keeping in view the above rationale, screening and comparison of genetic targets within the capsid coding region after including the updated available sequence information in the analysis was carried out to devise novel RT-mPCR assays to differentiate serotypes O, A, and Asia 1. Three primer combinations having distinct PCR amplicon size distributions (Fig. 14) were shortlisted based on their relative diagnostic sensitivity with respect to the existing mPCR assay. The assays were validated on 72 cell culture virus isolates and 76 suspected clinical materials. Heteroserotypic cross-amplification and diagnostic specificity of all the combinations were checked using uninfected cells, tissues, and other viruses. Analytical sensitivity was also assessed over a range of serial 10-fold dilutions of RNA and pre-titrated cell-adapted viruses. Their efficiency in detecting co-infection with multiple serotypes was checked both on natural samples and spiked ones. Various materials such as tongue and foot vesicular epithelium, saliva, nasal swabs, OPF, and hides have so far been tested. While combination 3 was found to have lower analytical and relative diagnostic sensitivity as compared to the existing mPCR, combination 2 and 1 were found to have a comparable level of sensitivity to that of the in-use mPCR.

With the gradual reduction in disease burden in the country as observed over the past years, coinciding with the launch of an extensive vaccination-based control programme, it is envisaged to equip the state FMD centres with a more sensitive RT-PCR diagnostic system. In that scenario, it would be logical to include one of the newly developed mPCR combinations alongside the existing one as a complementary approach to augment the overall detection sensitivity. It also remains to be elucidated how the different mPCR primer combinations behave over a wider range of strains that are not native to the country.

2.2.4 Negative staining methods for detection of FMDV by Electron Microscopy

Negative staining methods for the detection of foot-and-mouth virus through electron microscopy in cell suspension have been developed and optimized. FMD virus cell suspension was used to improve FMD virus detection by the negative staining technique using 1% phosphotungstic acid (PTA) as the negative stain. The cell suspension was centrifuged at 12000 rpm for 5 minutes, and the supernatant was used for negative staining. Negative staining of samples on Transmission Electron Microscope (TEM) grids was accomplished using single droplet touch methods or direct application of a single drop to the TEM grid. The image was captured after screening a negatively stained TEM grid with a Jeol 1400 Plus TEM at 120 kV and X15000 magnification. The positive cell suspension was found to be positive for FMD virus, with viral capsids appearing as icosahedral shapes, whereas the negative cell suspension samples TEM grid contained no FMD virus particles (Fig 15).

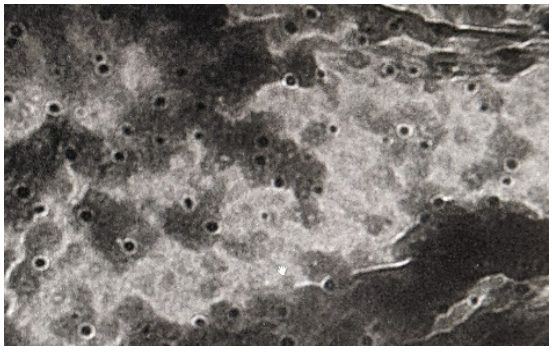


Fig 15: TEM showing FMD virus particle by negative staining technique

2.2.5 Application of monoclonal antibodies for virus antigen detection

A sensitive indirect sandwich-ELISA was developed using type O FMDV rabbit polyclonal antibody and anti-FMDV/O monoclonal antibody **(FMD O** 5B6**)** as capture and detector antibodies, respectively. The performance of the Mab-based sandwich ELISA was evaluated by testing 649 clinical samples of field origin, and the results were compared with the available polyclonal antibody-based sandwich ELISA for the same set of samples on parallel testing. In both ELISAs, OD values of 0.1 or more were judged as positive. The mab-based ELISA showed 100% relative diagnostic sensitivity (198/198) and 98.89% relative diagnostic specificity (446/451) compared to polyclonal ELISA (Fig 16). Further, the new assay showed higher (p 0.001) sensitivity (approximately twofold higher OD values) than that of conventional polyclonal ELISA for each of the samples tested. The correlation between the test results (OD values) of mab-based ELISA and polyclonal antibody-based ELISA was found to be significantly high (p 0.0001; r = 0.95). The new assay had comparatively lower backgrounds (OD of 0.04) than the polyclonal ELISA (OD of 0.05) in the FMD-negative samples.

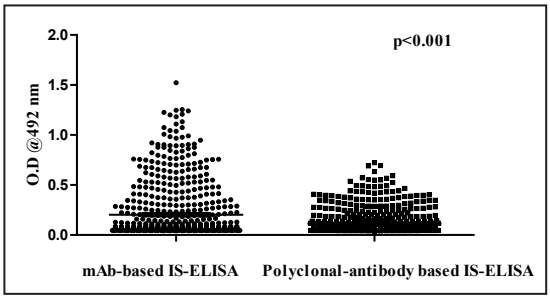


Fig 16: Comparative efficacy (OD values) of Mab-based sandwich (IS)-ELISA vs. polyclonal antibody-based IS-ELISA for FMDV serotype O antigen detection in clinical materials (n=649)

2.2.6 Lineage independent detection of serotype O

The VP1 gene sequence analysis of FMDV is critical to understand viral evolution and disease epidemiology. Standard set of primers are being used for detection and sequence analysis of VP1 gene of FMDV directly from suspected clinical samples with limited success. The VP1 specific degenerate primers-based RT-PCR were validated for qualitative detection and sequencing of serotype O FMDV lineages currently circulating in India. The novel degenerate primer-based RT-PCR for amplification of VP1 gene can elude genetic heterogeneity observed in virus after cell culture adaptation and ease up precise viral gene sequence analysis from clinical samples.(Fig 17)

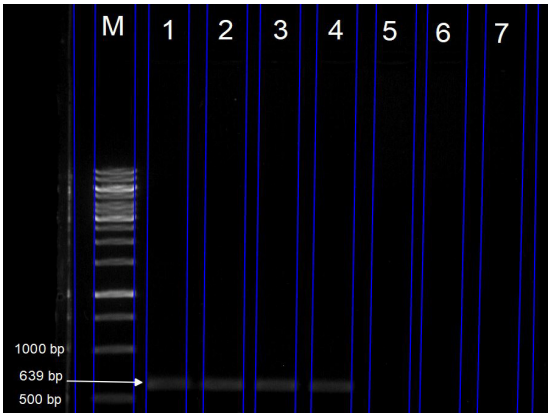


Fig 17: Lineage independent specific amplification of complete VP1 gene [639 bp] for serotype O FMDV

2.3 Development and Improvement of Vaccines

2.3.1 Thermotolerant properties of FMDV serotype A IND 27/2011

Studies by various investigators suggested that the protective immunity offered by the FMD vaccine is mainly dependent on the intact virion particles (either 146S or 75S), while the dissociated 12S pentameric particles contribute little to the vaccine-induced disease protection Therefore, the dissociation of FMDV antigen in the vaccine preparation due to high environmental temperatures could lead to poor vaccine efficacy and a short duration of immunity. An earlier genetically defined thermotolerant FMDV serotype O IND R2/1975 vaccine virus was developed at ICAR-NIFMD. In this study, a heat-resistant FMDV serotype A IND 27/2011 (an alternative vaccine strain to A IND 40/2000) was selected through serial passage under heat stress. The selected variant was characterised for its thermotolerant capacity by incubating the virus at different temperature and time combinations. In all the tested conditions, the thermally selected variant performed better than its parental counterpart (Fig.18).

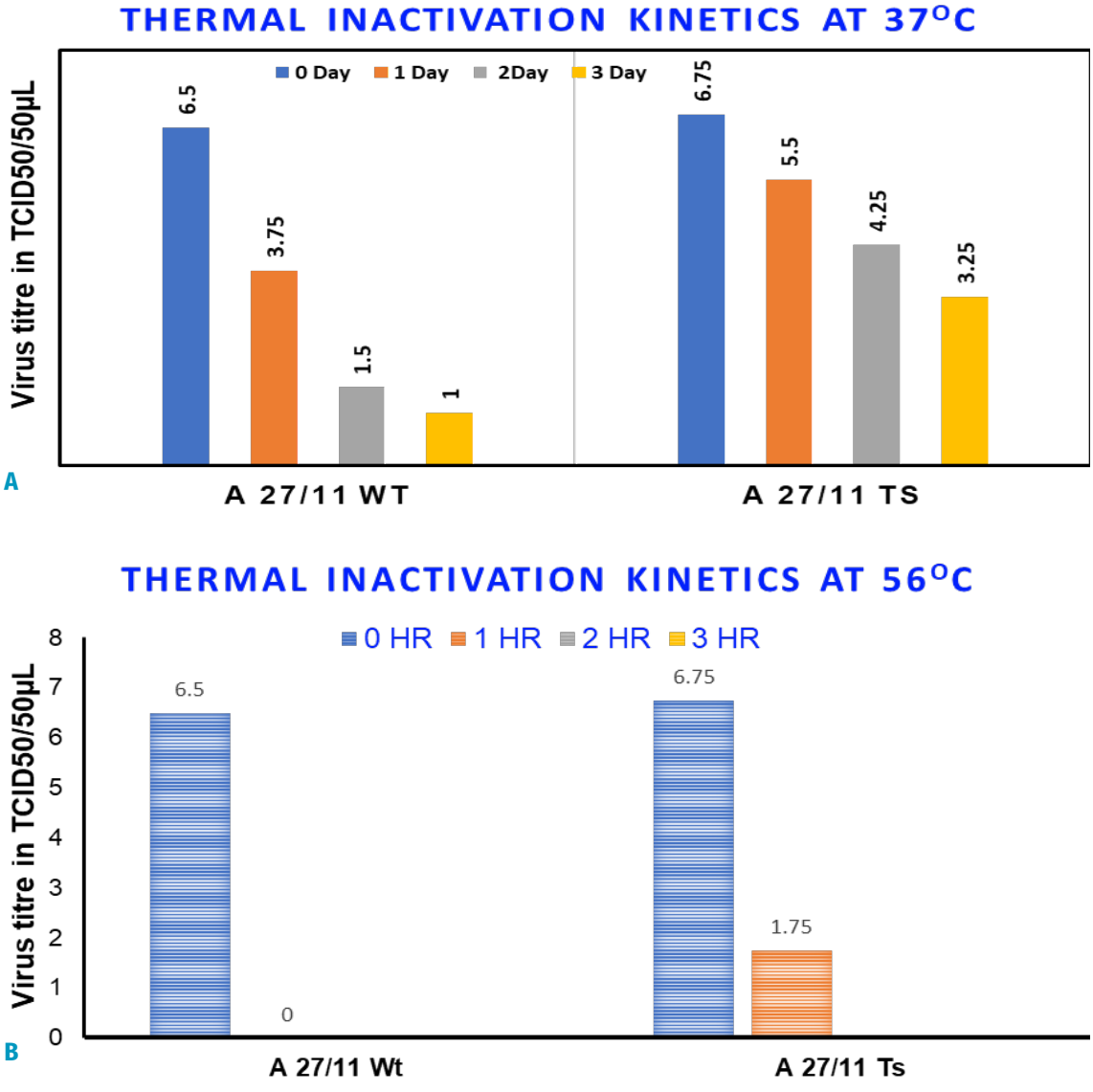


Fig 18: Thermal inactivation kinetics of parental (A 27/11 WT) and thermotolerant (A 27/2011 Ts) viruses after incubating at 37°C for 3-days (A), 50°C for 3 hours (B), and 56°C for 3-hours (C)

2.4 Other Research and Development

2.4.1 Evaluation of efficacy of disinfectants and cleaners against FMDV

The virucidal efficacy of low-cost chemicals (sodium carbonate, alum, lactic acid, and a mixture of citric acid and sodium chloride) was assessed against FMD virus *in vitro* on simulated non-porous environmental surfaces. It was performed as per the guidelines of WOAH with a few modifications in the BHK 21 cell line against FMD virus serotype O (stock virus titre = 7.8 log10 $TCID_{50}$/ml). The assay was conducted in duplicate using an interfering substance (BSA 0.3%) on different environmental surfaces, namely, plastic, stainless steel, and rubber. The mixture of citric acid (2% W/V) and sodium chloride (10% W/V) showed a significantly higher reduction of FMDV serotype O virus titre (more than 5.0 log10 $TCID_{50}$/ml) in 5 minutes of exposure time on plastic and stainless steel surfaces *in vitro*. The mixture could be explored for the disinfection of FMDV-contaminated plastic and steel surfaces in a livestock farm setting. The same mixture was also found to be effective on virus-spiked milk and urine samples after a minimum of 10 minutes of contact time. Further, the mixture of citric acid (2% W/V) and sodium chloride (10% W/V) was safe, as revealed by the skin irritation test, and very cheap. The sodium carbonate (4%) was also capable of reducing the infectivity of the FMD virus serotype O [> 4.0 log10 $TCID_{50}$ reduction] with an extended contact time of 15 minutes (Fig. 19). The lactic acid was also found to be effective in reducing viral infectivity at a concentration of 4% v/v within 5 minutes [> 4.0 log10 $TCID_{50}$ reduction], but it is not easily available at the local market. The alum solution (0.5%) efficiently reduced virus infectivity within 2 minutes of contact time on a simulated rubber surface.

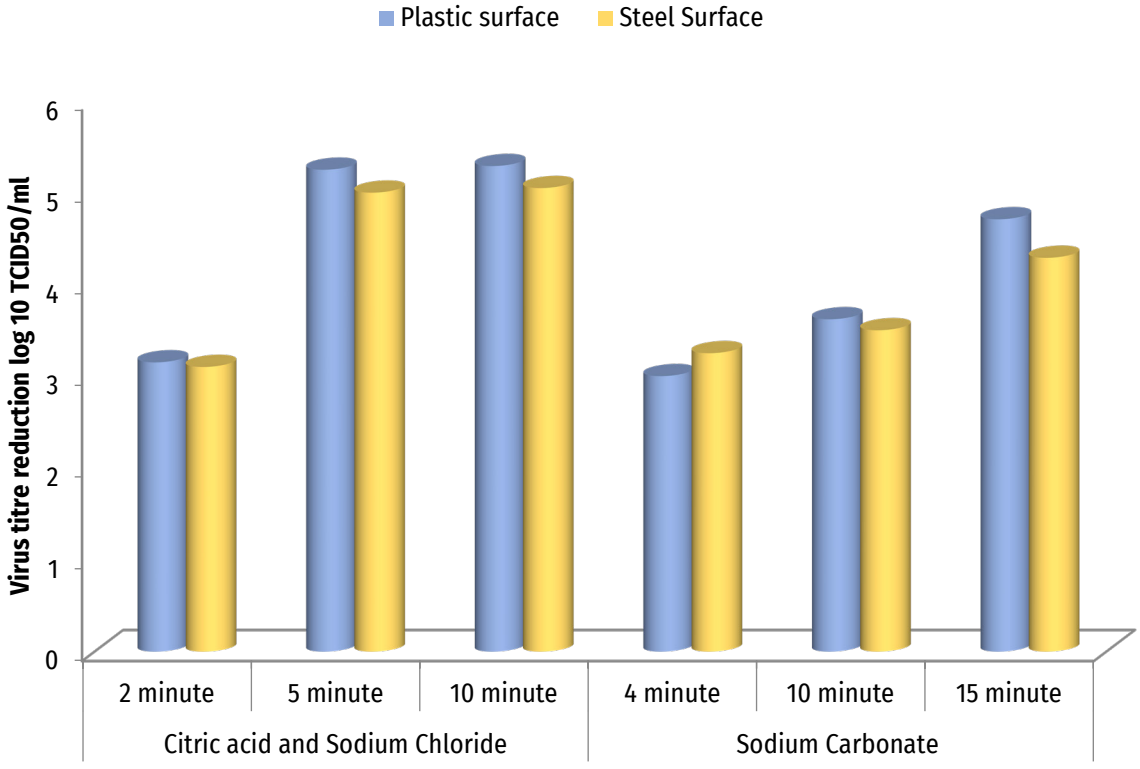


Fig 19: Bar Chart indicating virucidal effect of disinfectants against FMDV on simulated Steel and plastic surface

2.4.2 Role of cytokines and chemokines in the pathogenesis of FMD

A total of 15 tissue samples were collected from cattle naturally infected with FMDV, showing the gross lesions of blisters on the buccal mucosa and hoof and myocarditis. Grossly, multiple small to big coalescing blisters were observed on the tongue, lips, and buccal mucosa. The mucosal epithelium of the lips and tongue showed ballooning degeneration, intercellular edoema, numerous micro-vesicles and a few bullae formation, and necrotizing inflammation in the stratum spinosum and stratum basal layers. The sub-epithelial tissues were edematous and congested and revealed infiltration by mononuclear cells. In five cases, neutrophilic exudates were found to cover the entire tongue epithelium. The most conspicuous pathological findings in the affected hearts were marked edoema, congestion, haemorrhages, interstitial lymphohistiocytic inflammatory infiltrates with a varying degree of neutrophilic infiltration, and hyaline degeneration and necrosis of cardiomyocytes. Myocardial degeneration and necrosis vary from patchy and multifocal to confluent in all cases. The degenerated myocardial fibres were swollen, displaying eosinophilic and amorphous cytoplasm. Elongated nuclei had clumped chromatin and pyknosis in the foci of myocarditis and in adjacent sites. Pericarditis was characterised by edema and the infiltration of mononuclear cells surrounding the pericardium. In four cases, endocarditis was characterised by the infiltration of mononuclear cells surrounding the Purkinje fibres. For molecular detection and serotyping, RNA followed by cDNA were synthesised from these affected tissues. Positive RT-PCR results consisting of the amplification of a 328-bp genome fragment were observed in 15 cases, and the serotype was found to be type O in multiplex PCR. The primers for 12 different types of cytokines and chemokines were designed for the gene expression studies. Out of which, five cytokine genes were standardised in uniplex PCR. The immunohistochemistry of paraffin-embedded tissue sections of the tongue and heart showed intense cytoplasmic immunoreactivity of viral antigens in the degenerated stratified squamous epithelium and inflammatory cells in the heart, as indicated by dark brown-coloured signals (Fig 20).

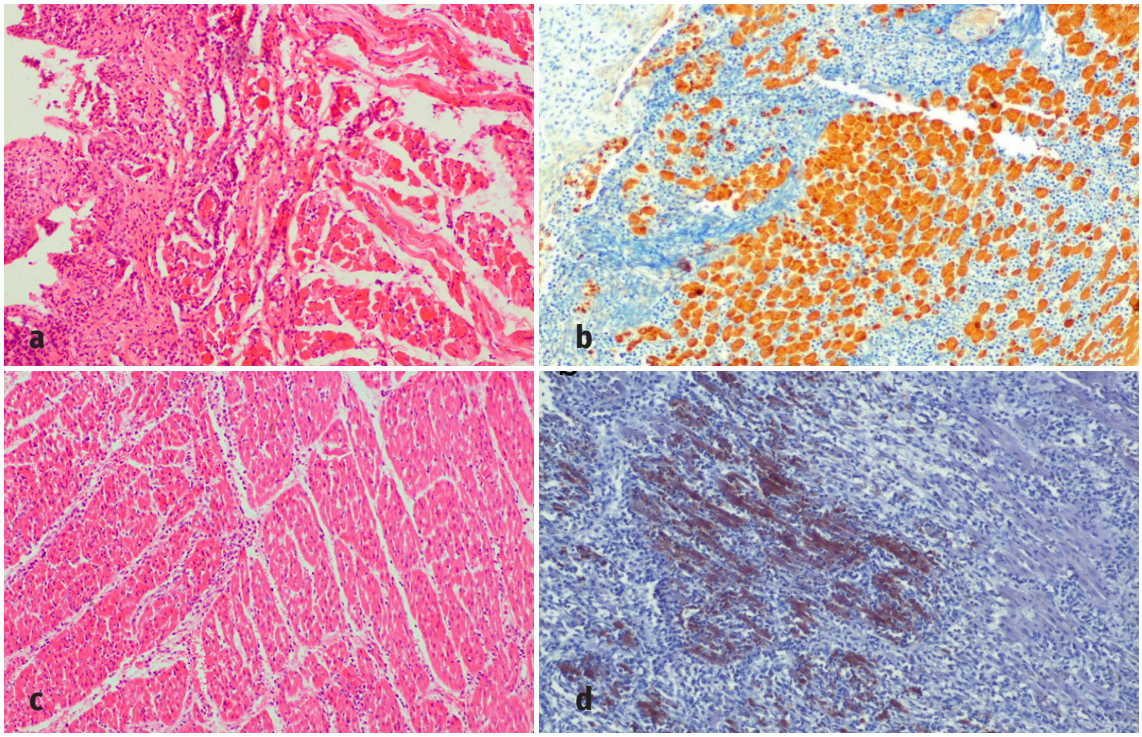


Fig 20: Histopathological and immunolocalization of FMDV in affected tissues of cattle showing a) Extensive infiltration of inflammatory cells in the tongue, H&E, X100, b) Strong cytoplasmic immunoreactivity of FMD antigen in tongue at the lesions, IHC, X200, c) interstitial myocarditis showing infiltration of mononuclear cells in the cardiac myocytes, H&E X100, d) intense cytoplasmic immunoreactivity of viral antigen in the cardiac myofibres, IHC X100.

2.4.4 FMDSeroSurv for the estimation of seroprevalence

To estimate the state and national level FMDV sero-prevalence rate, one R software package, namely FMDSeroSurv (GPL-3.0 license), has been developed for the users, which is freely available at https://github.com/sam-NIFMD/FMDSeroSurv. This software provides functions to estimate the sero-prevalence rates along with various errors and number animals having history of infection at the population (i.e., state and national) level using NSP-based serological survey data. FMDSeroSurv R software Package, developed at ICAR-NIFMD, was used to estimate the state and national level FMDV sero-prevalence rate during the year 2008-21 using the previous NSP-based serological survey data. It was observed that the overall trend in the distribution of estimated NSP sero-prevalence rates has been gradually declining over the years and has achieved its lowest value (with minimal error) for the year 2021. This finding is well supported by the declining trends of the temporal FMD outbreaks reported in India. The role of sustained efforts of the Government (*e.g.*, ASCAD, FMDCP, NADCP, and LHDCP) and the use of better diagnostics supported by precautionary and public awareness measures taken by ICAR-NIFMD and state FMD centres to achieve this feat cannot be ruled out. Further, the relationship among the national-level estimates of sero-prevalence rate and FMD field outbreaks during 2008-21was established through structural equation approach. For this purpose, various structural equation models were developed. The results indicated that the NSP-ELISA results are significantly associated with field outbreaks with one- and two-year lags. Besides, a downward trend in sero-prevalence and FMD outbreaks in India over the years was observed. This indicates the effectiveness of various measures implemented under the FMD control programmes by the Government of India. The developed methodology and the findings of the study will help FMD researchers and policymakers to identify potential disease-free zones in India through vaccination.

2.5 Characterization of Pathogens and Epidemiology

2.5.1 National FMD virus repository

The National FMD Virus Repository, maintained by ICAR-NIMFD, has the world's largest collection of FMD viruses. The repository is updated yearly with samples of novel, well-characterised FMD viruses collected in India. During 2022, a total of **62** FMD virus isolates (**serotype O-48 and serotype A-14**) revived in the BHK-21 cell system were added to the National Repository of FMD Virus maintained at the International Centre for FMD, Bhubaneswar (Table 11). At present, the National FMD Virus Repository holds a total of **2453** isolates (**O-1724, A-347, C-15, and Asia-1-367**). The repository serves purposes such as retrospective analysis, the selection of vaccine strains, diagnostic development, etc. FMDV serotype C isolates are being kept only at the bio-containment laboratory of the ICFMD, Bhubaneswar. Box-wise digitalization of details of FMDV serotypes available in the repository was done for easy identification. Individual details of the viruses have been hyperlinked in the electronic file

Table 11. Year-wise details of the virus isolates added to National FMD Virus Repository during last five years.

Year	O	A	Asia1	Total
2018 (Apr-Dec)	76	-	-	76
2019	15	-	-	15
2020	-	-	-	-
2021	102	10	1	113
2022	48	14	-	62

2.5.2 Molecular Epidemiology FMDV Serotype O

Eleven geographically restricted topotypes have been identified globally, namely Europe-South America (EURO-SA), the 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 and sub-lineages) of the ME-SA topotype virus have been found, each with more than a 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 has branched into at least five sub-lineages (Ind2001a, b, c, d, and e). The appearance of sub-lineage O/ME-SA/Ind2001e during the year 2015 in India was identified by phylogenetic studies. During the years 2015–2017, the sub-lineage O/ME-SA/Ind2001e was responsible for sporadic cases before causing epidemic outbreaks in 2018. Since its discovery 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 decreased since the emergence of lineage O/ME-SA/Ind2001e. During the years 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 O/ME-SA/Cluster-201, was previously recorded. This lineage showed considerable genetic divergence from both the O/ME-SA/Ind2001 and O/ME-SA/PanAsia lineages.

During the year 2022, a total of 50 FMD virus serotype O field isolates were sequence determined and subjected to phylogenetic analysis. Out of the 50 isolates sequenced, 47 were actually collected during 2021, and the rest of the three were collected in 2022. Maximum of 34 isolates grouped within O/ME-SA/Cluster-2018, followed by 14 isolates within lineage O/ME-SA/Ind2001e and 2 isolates within lineage O/ME-SA/PanAsia-2 ANT^{10}. All three isolates collected during 2022 from the states of Sikkim, Bihar, and Jharkhand were grouped within O/ME-SA/Cluster-2018.

The analysis revealed four important epidemiological events (Fig 21 and 22).

1. 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 and also found to cause FMD in 2022.
2. The dominance of O/ME-SA/Ind2001e was maintained in 2021 and its status during 2022 is not known.
3. The lineage O/ME-SA/PanAsia-2 ANT^{10} could not be detected anywhere in the country except for the two sporadic incidences in Jammu & Kashmir in 2021
4. The O/ME-SA/Ind2001e and O/ME-SA/Cluster-2018 were responsible for 60 and 40% of the FMD outbreaks recorded during 2021 and 2022

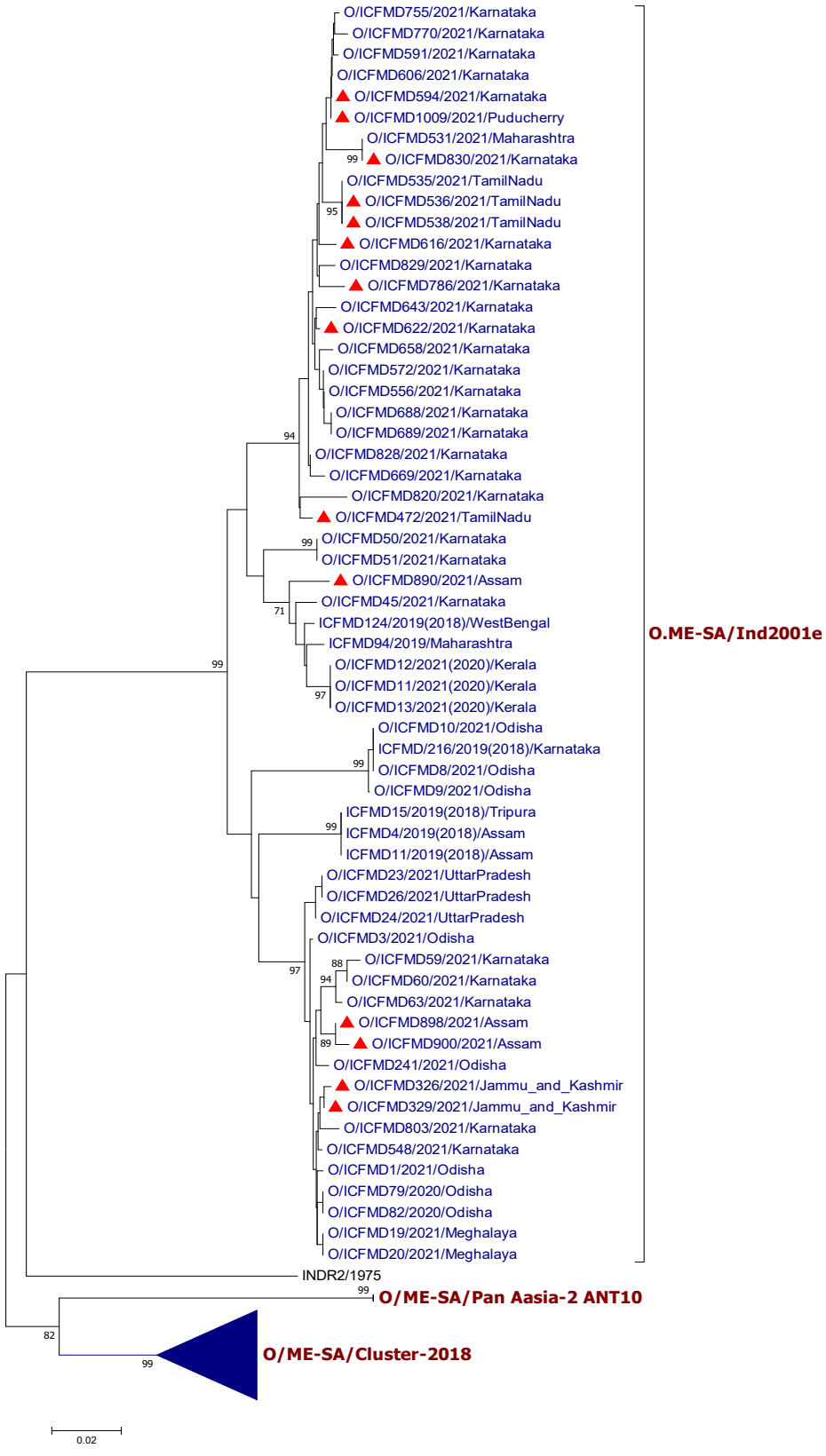


Fig 21: Maximum Likelihood phylogenetic tree at VP1 coding region of Indian serotype O FMD virus isolates during 2022. Isolates (n=50) sequenced during 2022 are indicated by red triangle.

Fig 22: Maximum Likelihood phylogenetic tree at VP1 coding region of Indian serotype O FMD virus isolates during 2022. Isolates (n=50) sequenced during 2022 are indicated by red triangle.

2.5.3 Molecular Epidemiology FMDV Serotype A

The serotype A virus population is the most genetically and antigenically diverse of the three serotypes found in India. Molecular phylogeny has established the circulation of four genotypes (2, 10, 16, and 18), with more than 15% nucleotide (nt) divergence among them in the 1D region of serotype A so far in India. Since 2001, genotype 18 has been exclusively responsible for all field outbreaks and has outcompeted all other genotypes. Within the currently circulating genotype 18, a divergent and unique lineage emerged in the late part of 2002 that showed an amino acid (AA) deletion at the 59th position of VP3 ($VP3^{59}$-deletion group) and dominated the field outbreak scenario in 2002–03. Recently, the emergence of a novel genetic lineage was demonstrated in 2019 in the state of Maharashtra. The lineage clustered distinctly within genotype 18 and was designated as the G-18/non-deletion/2019 lineage. During the year 2022, the sequences of a total of two isolates sampled from Odisha were determined. Phylogenetic analysis based on the maximum likelihood method revealed clustering of all the isolates within the G-18/non-deletion/2019 lineage (Fig. 23). The analysis confirms that the lineage has been established strongly in India.

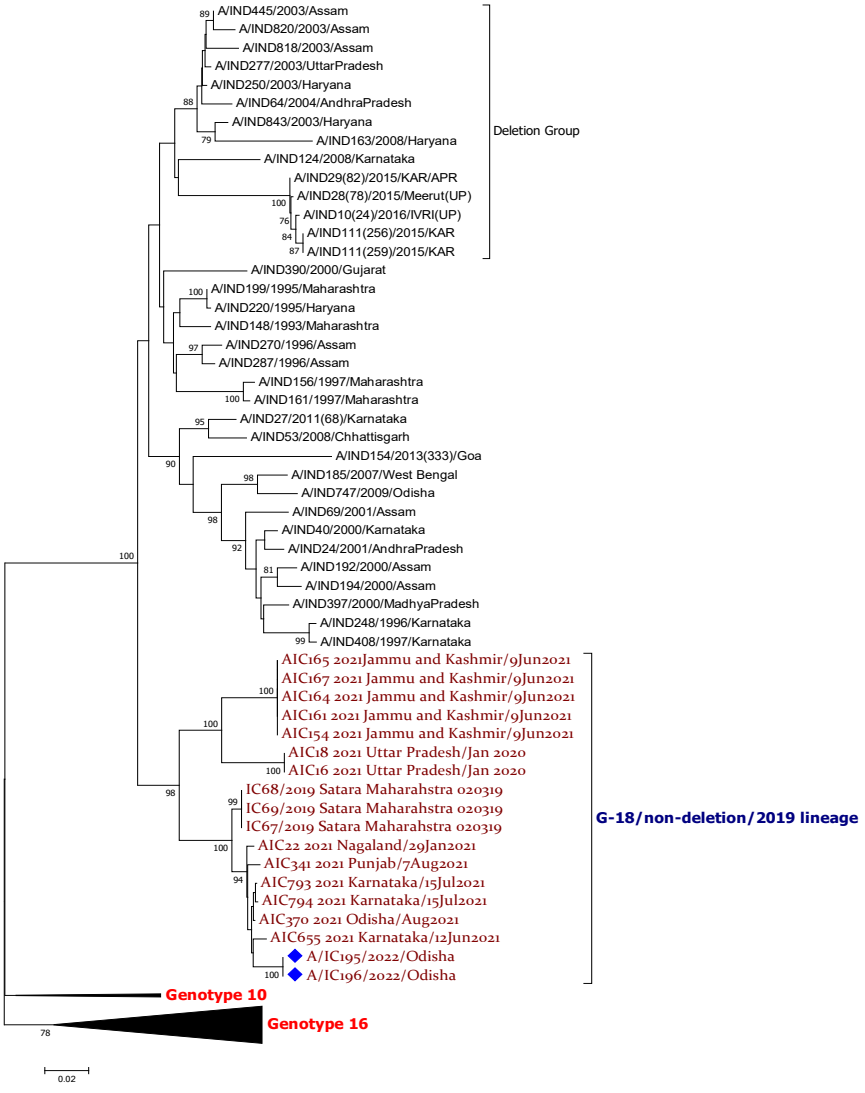


Fig 23: Maximum Likelihood phylogenetic tree at VP1 coding region of Indian serotype A FMD virus isolates during 2022. The analysis showed circulation of G-18/non-deletion/2019 lineage. Isolates (n=2) sequenced during 2022 are indicated by blue rhombus.

2.5.4 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 Asia 1 field outbreaks between 1998 and 2002, although it disappeared between 2001 and 2004 and re-emerged as the dominant lineage from 2005 onwards (sub-lineage CII). FMD virus serotype Asia1, collected since 2004, is classified into nine different genetic groups (G I–IX) globally. On a global scale, isolates collected from India during 2001–2004 (referred to earlier as lineage D) clustered within Group III. Isolates collected in India after 2005 (dubbed earlier sub-lineage CII) clustered with those in Group VIII. Two FMDV serotype Asia1 isolates collected in 2022 from the state of Jammu and Kashmir clustered within Group-IX (BD-18), whose emergence was recently described in Bangladesh in January 2018 and in Tamil Nadu in January 2020 (Fig. 24). The analysis indicates the extended circulation of Group-IX in India.

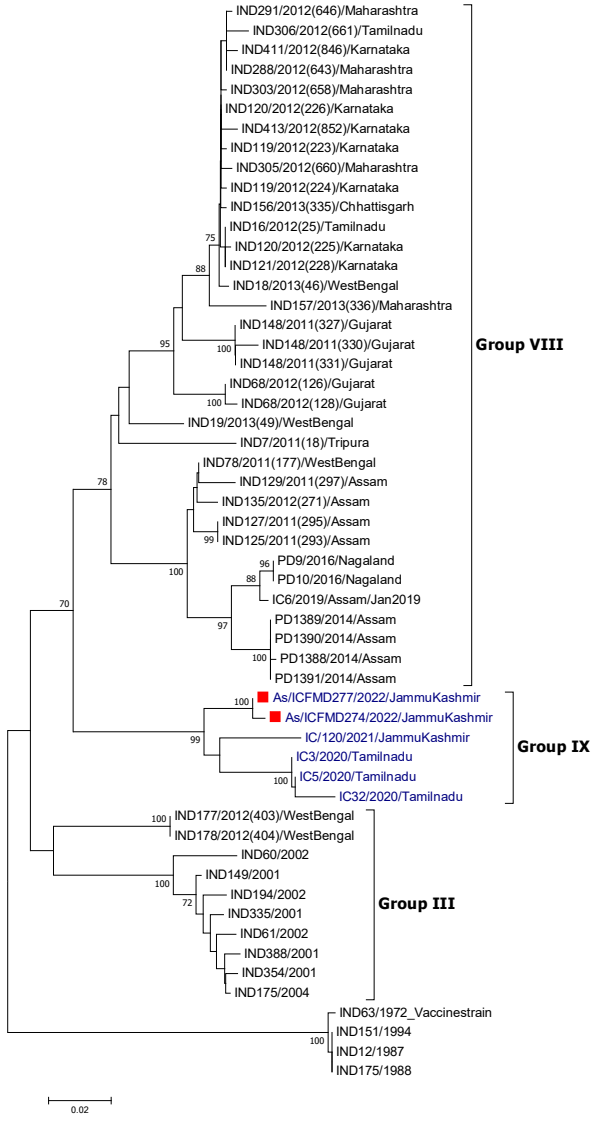


Fig 24: Maximum Likelihood phylogenetic tree at VP1 coding region of Indian serotype Asia1 FMD virus isolates during 2022. Isolates (n=2) sequenced during 2022 are indicated by red square.

2.5.5 Vaccine matching studies of FMDV field isolates

A vaccine matching analysis employing bovine vaccine serum (BVS) against the respective vaccine strain with field isolates was carried out to assess the appropriateness of the in-use vaccine strain. The antibody titre was determined as the reciprocal of the last dilution of serum that neutralised 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 strains. Conversely, an r-value of 0.3 is suggestive of antigenic deviation. The test was repeated three times, and the log_{10} titres were averaged for the calculation of the r-value.

Serotype O

A total of 4 serotype O FMDV field isolates collected during the year 2022 were subjected to vaccine matching using BVS against in-use serotype O vaccine strain O INDR2/1975. The isolates were collected from the states of Sikkim, Bihar, Jharkhand, and Karnataka. From the analysis, it was found that all the isolates showed an r-value of >0.3 with the vaccine strain O INDR2/1975, showing an exceptional antigenic match (Fig. 25). Three of the four isolates were also characterised phylogenetically and found to belong to O/ME-SA/Cluster-2018. The current serotype O vaccine strain can be used in Indian vaccine formulations since it continues to provide the best antigenic coverage even 40 years after virus isolation.

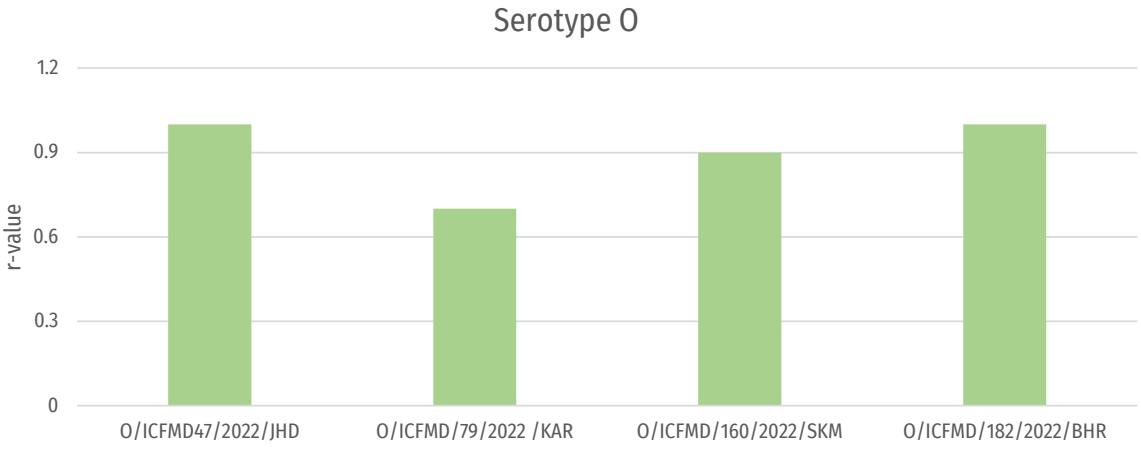


Fig 25: The antigenic relationship value of 4 FMDV serotype O field isolates collected during the year 2022.

Serotype A

Serotype A FMD 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 the selection of a new candidate vaccine strain that can cover this diversity in the antigenic spectrum. Taking into account the studies carried out by ICAR-NIFMD regarding the selection of suitable (alternate) FMDV serotype A vaccine strains, A/IND27/2011 emerged as the candidate strain of choice out of a panel of 8 strains initially selected based on its widest antigenic relatedness with the circulating field strains. The candidate strain A/IND 27/2011 showed all the vaccine-worthy attributes as evaluated by IVRI, Bengaluru. During the year 2022, a total of 3 serotype A isolates were subjected to vaccine matching with A/IND/40/2000 and the new candidate vaccine strain A/IND/27/2011. All three isolates belonged to the A/G-18/non-deletion/2019 lineage. None of the isolates had an antigenic match (r value > 0.3) with the currently used vaccine strain A/IND/40/2000, indicating a weak antigenic match with the serotype A field isolates. The new candidate vaccine stain A/IND/27/2011, on the other hand, demonstrated a great antigenic match (100%) with the recent serotype A field isolates. A/IND/27/2011 would be a preferable alternative for inclusion in the Indian vaccine formulation under the current situation (Fig. 26). A transition plan for this has already been submitted to ICAR-NIFMD.

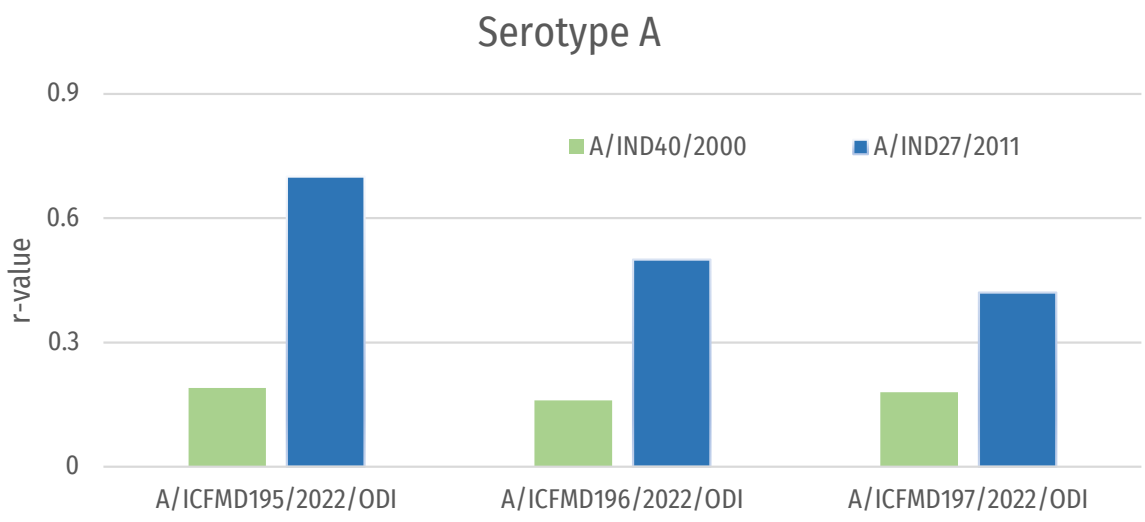


Fig 26: The antigenic relationship value of 3 FMDV serotype A field isolates collected during the year 2022

2.6 Production and Standardization of Biologicals

2.6.1 Panel FMDV serotype O monoclonal antibodies

A panel of mouse monoclonal antibodies (FMDV-O-5B6, FMDV-O-4C8, FMDV-O-4D6, FMDV-O-4G10, FMDV-O-3B9, FMDV-O-3H5, FMDV-O-2F9, and FMDV-O-2G10) were developed against Indian FMDV serotype O vaccine strain (IND/R2/75) via hybridoma systems (Fig. 27). The Mabs generated were FMDV/O specific without cross-reactivity against FMDV type A and Asia 1. All the Mabs were identified as IgG1/kappa type. Out of those, the mAb FMD O-5B6 was applied in developing indirect sandwich-ELISA as explained in section 2.2.25

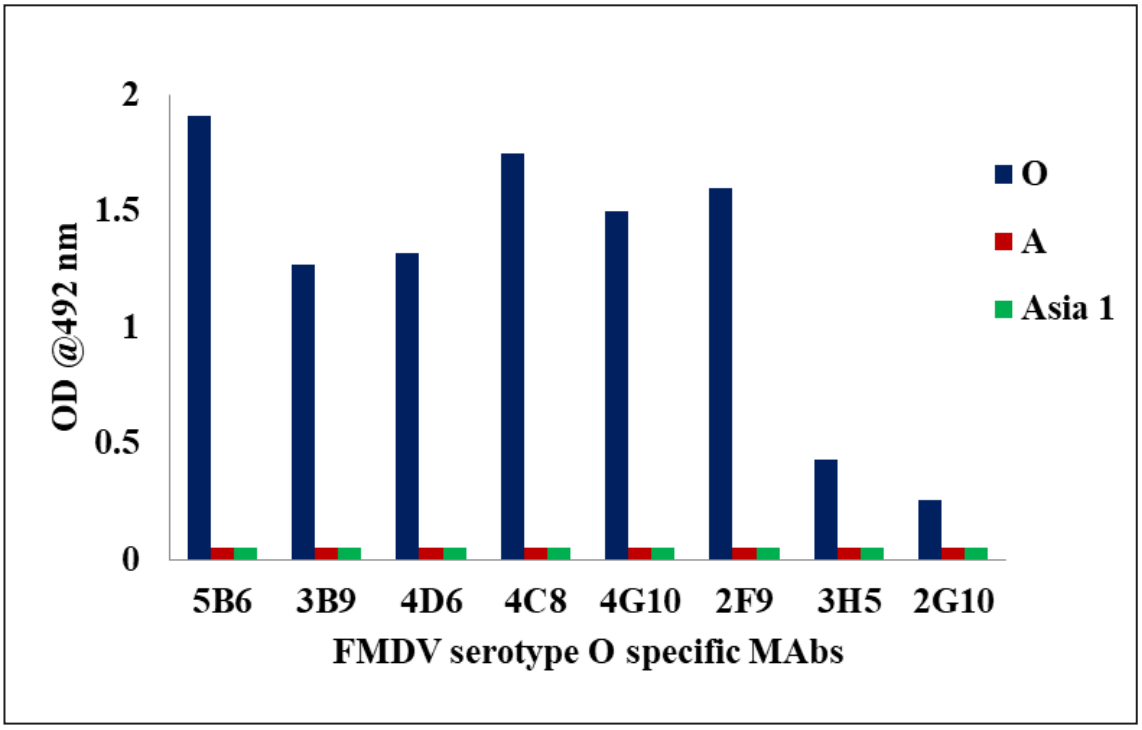


Fig 27: Reactivity of FMD serotype O specific mAbs

2.6.2 Panel of FMDV monoclonal antibodies

A panel of FMDV serotype independent mouse monoclonal antibodies (FMDV-2A4, FMDV-3C7, FMDV O-3B8, FMDV O-5E11, FMDV O-5G8, FMDV O-7E2, FMDV O-8D5, FMDV O-8H9, FMDV O-10E9) were developed via hybridoma systems. All the Mabs recognized three FMDV serotypes (O, A and Asia1) in indirect sandwich (IS) ELISA, suggesting that the binding epitopes of the Mabs are conserved between serotypes (Fig 28). These Mabs are suitable for type-independent diagnosis of FMDV.

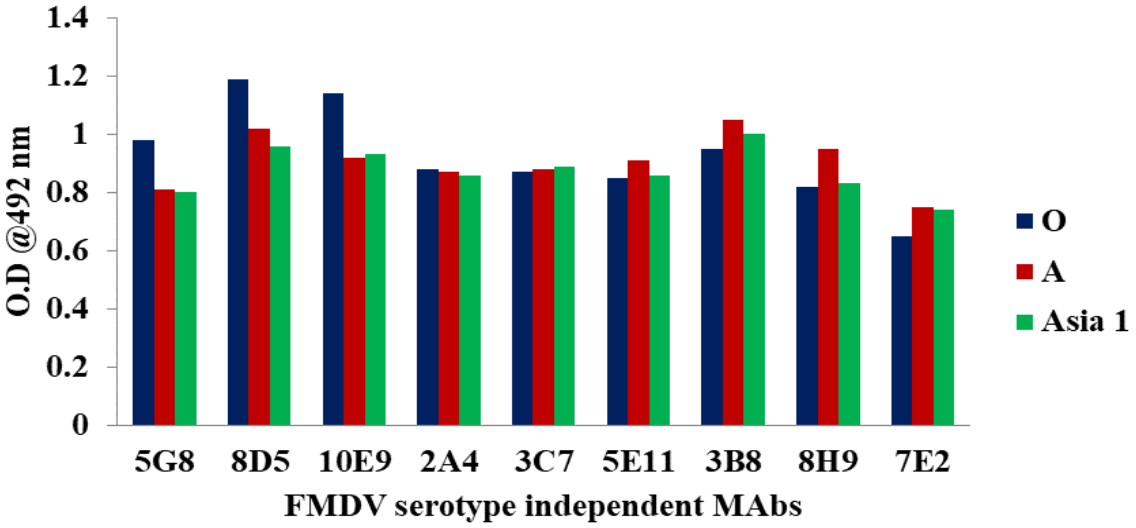


Fig 28: Reactivity of FMDV specific mAbs

2.6.3 Monoclonal antibodies against rP1 of FMDV serotype O

Four mouse monoclonal antibodies (FMDV-O-rPI-2B7, FMDV-O-rPI-3C2, FMDV-O-rPI-3A1, FMDV-O-rPI-3A4) were developed against capsid precursor polyprotein rP1 of FMDV serotype O. The Mabs showed positive reactivity against type "O" recombinant P1 protein in indirect ELISA. The antibody isotype of 2B7 was IgG2a where as 3C2, 3A1, 3A4 were determined as IgG1 type. These Mabs may have application to detect antibodies to the structural proteins of FMDV/O (Fig 29).

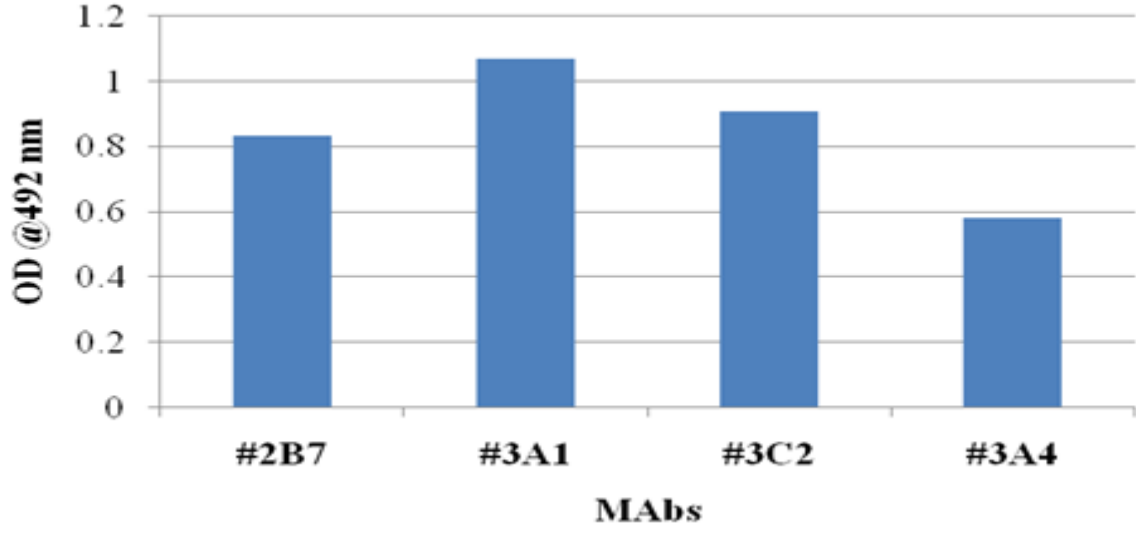


Fig 29: Reactivity of mAbs against rP1 of FMDV serotype O

2.6.4 Production, Standardization and supply of diagnostic kits

ICAR-NIFMD produced, optimized and supplied critical regents for 3AB3 indirect DIVA ELISA and Solid Phase Competitive ELISA (SPCE) kits to carry out FMD serosurveillance and seromonitoring, and Sandwich ELISA kit for serotyping of FMD viruses to the state FMD centres. The details of supplies made are given below. Besides supply, the diagnostic kits were also used at ICAR-NIFMD laboratories at Bhubaneswar, Bengaluru and Mukteswar for seromonitoring and serosurveillance under LHDCP (Table 12).

Table 12. Diagnostic kits supplied and used at NIFMD during 2022

Institute/ Organization	3AB3 indirect DIVA ELISA kit (Number of samples)	Solid Phase Competitive ELISA kit (Number of samples)	Sandwich ELISA kit (Number of samples)
FMD centre, Ahmedabad	7000	8500	-
FMD centre, Aizawl	1500	4000	-
FMD centre, Bengaluru	4750	10000	-
FMD centre, Bhopal	6000	10000	-
FMD centre, Cuttack	7450	6500	-
FMD centre, Guwahati	2500	5000	-
FMD centre, Hisar	10000	11500	-
FMD centre, Hyderabad	8500	4500	-
FMD centre, Imphal	5336	4500	-
FMD centre, Itanagar	-	2500	-
FMD centre, Jallandhar	13000	8000	150
FMD centre, Jammu	2500	-	-
FMD centre, Kohima	-	2000	-
FMD centre, Kolkata	-	2000	-
FMD centre, Mathura	8800	2000	-
FMD centre, Puducherry	500	3000	-
FMD centre, Pune	5000	2000	200
FMD centre, Patna	4560	8000	100
FMD centre, Port Blair	1500	6000	-
FMD centre, Ranchi	900	-	-
FMD centre, Ranipet	3360	8500	100
FMD centre, Rishikesh	2650	5500	-
FMD centre, Shimla	2600	7000	-
FMD centre, Shillong	1200	4000	200
FMD centre, Trivendrum	3875	-	300
FMD centre, Vijayawada	12000	-	-
ICAR-NIFMD	5000	20000	400
Total	120481	145000	1450

2.7 Extension activities and outreach program organized

The state FMD centres organized several FMD awareness programs, health and treatment camp throughout the country under the guidance of ICAR-NIFMD. Many programs were organized online or though TV. In such scenario, details of exact number of participants could not be estimated. Over all, more number of stake holders than mentioned in the table below might have benefited through the awareness activities of FMD centres

2.7.1 Activities under LHDCP

Under the NADCP for FMD, state collaborating units carried out various extension activities for stakeholders in different states of the country. FMD Centres organized 34 trainings for veterinary officers, students on various aspects of FMD prevention and control in which 1324 professionals' have participated. In total, 204 awareness programme/animal health camps on the thematic area of FMD control were organized and a total of 27983 farmers got beneficiated from such programme. A total of 5 digital outreach programme has also been organized in different languages for prompt popularization of the NADCP/LHDCP project (Tables 13, 14 and 15).

Table 13. Details of FMD Awareness camp/ Kisan Gosthi/ Technology Exhibition for Farmers

Description/Type of programme	Organizer	Venue and date/ Month	No of Participants/ Beneficiaries
FMD awareness Programme (n=4)	FMD Regional Centre, Bhopal	SAHTI, Bhopal September and December 2022	134
FMD Awareness Programme (n=32)	FMD Collaborating Centre, Jammu	Different villages of Jammu. Throughout the year	1688
FMD Awareness Program (n=2)	FMD Collaborating Centre, Mathura	Mathura, September 2022	186
FMD awareness cum vaccination programme for high altitude animals (n=5)	FMD Collaborating Centre, NRC Yak	Different Villages of Arunachal Pradesh March, May, December, 2022	150
Prevention and control of foot and mouth disease in livestock (1)	FMD Collaborating Centre, Port Blair	Sippighat Vllage, South Andaman 16.09.2022	36
Community awareness programme (n=11)	FMD Collaborating Centre, Shillong	Different villages of Meghalaya	256
FMD vaccination and awareness camp (n=2)	FMD Collaborating Centre, Kohima	FMD unit, Kohima October 2022	~90

Awareness regarding FMD vaccination (n=10)	FMD Collaborating Centre, Ranipet	Melapulam, Ranipet 20.01.2022	40
Kisan Mela (Kharif) for farmers from Haryana and surrounding states (n=2)	FMD Collaborating Centre, Hisar	Hisar 15-16 March, 2022	~10000
Awareness on FMD towards Eradication, Treatment, Control & Eradication under the NADCP (n=11)	FMD Collaborating Centre, Aizawl	Different Villages of Mizoram	920
Farmers Awareness Camp (n=5)	FMD Collaborating Centre, Shimla	Different Villages of Himachal Pradesh March 2022	470
ASCAD to create farmer's awareness about various livestock diseases including FMD (n=1)	FMD Collaborating Centre, Shimla	All districts of HP February 2022	1050
Field awareness program on FMD (n=1)	FMD Collaborating Centre, Trivendrum	Online	20
Farmers Awareness Program (n=3)	FMD Collaborating Centre, Ranchi	Different Villages of Jharkhand 14.09.2022 16.09.2022 14.12.2022	157
Awareness camp for FMD control (n=3)	FMD Regional Centre, Pune	Sangli (Dt) 12-09-2022 14-09-2022 16-09-2022	260
Awareness Programme on FMD Vaccination and control (n=94)	FMD Collaborating Centre, Kolkata	Through out the year Different Villages of West Bengal	11785
FMD Control Awareness (n=1)	FMD Collaborating Centre, Patna	SGIDT, Patna 23-09-2022	45
Awareness programme on FMD control programme (n=15)	FMD Regional Centre, Guwahati	Through out the year Different Villages of Assam	476
Animal health camp and Awareness Program (n=1)	FMD Collaborating Centre, Meerut	Feb, Apr, May and June Different Villages of Assam	220

FMD Awareness activity in Arunachal Pradesh

Table 14. Details of FMD Training/ Workshop for Field veterinarian, Internee, students and para-veterinary staff

Description/Type of programme	Organizer	Venue and date/ Month	No of Participants
Control of FMD, Seromonitoring and Serosurvillance under LHDCP (n=5)	FMD Regional Centre, Bhopal	Bhopal FMD Centre. April, May, August, December, 2022	93
Capacity building training for Veterinary Officers on Serosurveillance and seromonitoring streategy for FMD control in India	FMD Collaborating Centre, Mathura	Lucknow 12.03.2022	60
Awareness lecture for students of Institute of Para veterinary Sciences	FMD Collaborating Centre, Mathura	Mathura, 14.09.2022	220
Scientific goat farming for enhancing productivity and income generation	FMD Collaborating Centre, Port Blair	Maymyo village, South Andaman, August 2022	30
Lecture on FMD: causes, symptoms and preventive measures" during the Vocational Training on Dairy Farming	FMD Collaborating Centre, Hisar	Hisar 14-20 October, 2022.	23
Clinical Material collection and dispatch during outbreak, Clinical and Laboratory Diagnosis, Prevention and Control, NADCP-FMD vaccination	FMD Collaborating Centre, Hyderabad	TSVBRI, Hyderabad 28/12/2022	19
FMD awareness programme, seromonitoring and surveillance (n=4)	FMD Collaborating Centre, Trivendrum	SIAD, Trivandrum 12/04/2022 17/09/2022 15/11/2022 21/12/2022	130
Capacity building program for collection of nasal swab, sublingual swab and tissue samples from goat and cattle	ICAR-NIFMD and FMD Centre, Ranchi	RVC 23,24.06.22	25
Lecture on "Persistence of FMD virus in cattle and buffalo"	ICAR-NIFMD and FMD Centre, Ranchi	RVC 24.06.2022	50
Virtual meeting with Officers of State AH Department, Lecture on FMD	ICAR-NIFMD and FMD Centre, Ranchi	RVC 15.09.2022	55
Lecture on Collection,Packing and Transportation of clinical samples and Postmartum material for Laboratory Diagnosis with special reference to FMD (n=6)	FMD Regional Centre, Pune	Online Feb and March	180

Control of Foot and Mouth Disease, importance of vaccination, disease control and prevention	FMD Regional Centre, Pune	Sangli 12-09-2022	55
Biosecurity measures for livestock diseases. SHGs	FMD collaborating Centre, Shillong	Vocational Training Centre Kyrdemkulai, Ri-Bhoi District 06-04-2022	56
Economically Important diseases. SHGs	FMD collaborating Centre, Shillong	Vocational Training Centre Shillong, East Khasi Hills 14-09-2022	52
FMD vaccination and vaccination failure	FMD Regional Centre, Bengaluru	Ramanagara January 2022	20
FMD control through vaccination (n=5)	FMD collaborating Centre, Patna	Online and BVC, Patna	156
Awareness cum training programme on FMD CP with special reference to integrated farming system for budding veterinarians	FMD Regional Centre, Guwahati	RRC, Guwahati March 21/03/22 till 23/03/22.	100

Table 15. Details of Digital outreach programme (n=10) organized by FMD centres.

Name of programme	Organizers /Hosted by	Media	Remarks/ Language
TV Live programme on FMD	Assistant Director, ADDL, TSVBRI Line, Hyderabad	TSAT channel	Broadcasted in Telugu in June 2022
T.V. talk on "Effect of FMD on Livestock" telecasted on 28.10.2022 Sahyadri	FMD Regional Centre, Pune	Door Darshan Mumbai and on Youtube	English/Marathi
Economic Importance of FMD in December 2022	FMD Regional Centre, Pune	Door Darshan	English/ Marathi
Red FM Radio jingle on FMD and brucellosis on 01-04-2022	FMD Collaborating Centre, Shillong	Directorate, Shillong	English
TV telecast programme on FMD (n=6)	FMD Collaborating Centre, Patna	"Krishi Darshan", DD Bihar channel	Hindi

2.7.2 Activities under DAPST

The institute has implemented Developmental Action Plan for Scheduled Tribes (DAPST) scheme, a major flagship program launched by Government of India for welfare and development of ST. Various technical interventions were carried out in total of four states (Assam, Gujarat, Uttarakhand, Jharkhand) and union territory of Jammu & Kashmir as per demographic status and available resources. The state FMD centers participated in the institute DAPST are namely, FMD Regional centre, Department of Microbiology, CVSc, AAU, Assam; State FMD Collaborative Unit, Gujarat, Department of Animal Husbandry, Govt. of Gujarat; State FMD Collaborative Unit, Rishikesh, Department of Animal Husbandry, Govt. of Uttarakhand and State FMD collaborative unit, J&K, Department of Animal Husbandry, UT J&K. The activities for DAPST were planned in-sync with the mandate of the institute and are primarily focused on improvement of livelihood and nutritional security of the target population. The objective of the program is to improve livelihood and nutritional security of scheduled tribes. The programme 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 **3056** tribal farmers and farm women benefited through various interventions. Details of these are given in (Table. 16, 17, 18, 19, 20 and 21)

Table 16. Trainings and skill development programme under DAPST (n=12, participant=453)

Title of the programme	Venue	Date and Duration	Participants	Organized by
Scientific management of pig	Medhikuchi	10.01.22	25	FMD Regional Centre, CVSc, AAU, Assam
Scientific management of Goats	Goriaghuli, Assam	11.01.22	28	
Economically important diseases of livestock and their control strategies	Kahikuchi, Assam	14.02.22	32	
Scientific management of pig	Naojam, Assam	20.03.22	35	
Micro management strategies to tap the full genetic potential of hybrid poultry	Moirakuchi, Assam	28.03.22	31	
Training on scientific management of pig	Hatimuria, Tamulpur, Assam	05.06.22	55	
Training on goat value chain	Kaundha Khera, Sitarganj block, Uttarakhand	13.05.22	15	ICAR-NIFMD Mukteswar campus
Training on Goat housing and management	Sunkhari Kala village, Sitarganj block, Uttarakhand	02.12.22	37	
Goat farming an profitable entrepreneurship	Bannakherasani, Bazpur, US Nagar, Uttarakhand	16.03.22	50	State FMD Collaborative Unit, Rishikesh, Department of Animal Husbandry, Govt. Of UK
Importance of mineral supplementation before FMD vaccination	Bhagchuri, Khatima, US Nagar, Uttarakhand	26.03.22	50	
Importance of mineral supplementation before FMD vaccination	Nausar, Khatima, US Nagar, Uttarakhand	28.03.22	65	
Training and demonstration on FMD	Khanpur, Jammu	28.09.22	30	State FMD Collaborative Unit, Jammu, J&K (UT)

Table 17. Technology demonstration under DAPST (n=8, participant=278)

Theme area	Venue	Date	Participants	Organized by
Mineral mixture supplementation for cattle	Goriaghuli, Kamrup, Assam	03.02.22	41	FMD Regional Centre, CVSc, AAU, Assam
Application of Acaricidal drug	Goriaghuli, Kamrup, Assam	03.02.22	30	
Deworming of livestock before vaccination	Goriaghuli, Kamrup, Assam	03.02.22	41	

Procedure of oral medicine administration	Tamulpur, Baksa, Assam	15.02.22	32	
Creep ration for weaned piglet	Andherighat, Darang, Asssam	18.02.22	34	
Use of disinfectants	Barama, Nalbari, Assam	27.03.22	35	
Cattle feeding practice	Akalpur village, Jammu, J&K	26.03.22	52	State FMD Collaborative Unit, Jammu
Method demonstration on MM supplementation to dairy animals	Kaundha Khera, Sitarganj, U.K	13.05.22	13	ICAR NIFMD Mukteswar

Table 18. FMD Awareness camps and *kisan gosthi* at different locations under DAPST (n=29, participant=1741)

Village	Block	District	State / UT	Date	No. of Beneficiaries	Organizer
Kedarwala	Kalsi	Dehradun	Uttarakhand	01.01.2022	52	State FMD Collaborating unit, Rishikesh
Thaina	Kalsi	Dehradun	Uttarakhand	16.03.2022	60	
Goriaghuli	Sonapur	Kamrup	Assam	03.02.2022	30	FMD Regional Centre, CVSc, AAU, Assam
Khanapara	Dispur	Kamrup	Assam	21.03.2022-23.03.2022	100	
Moirakuchi	Dispur	Kamrup	Assam	28.03.2022	21	
Taroti	Khour	Jammu	Jammu & Kashmir	15.01.2022	69	State FMD Collaborative Unit, Jammu, J&K (UT)
Nikki Tawi	Raipur Satwari	Jammu	Jammu & Kashmir	12.02.2022	77	
Ladore	Marh	Jammu	Jammu & Kashmir	23.02.2022	55	
Salehar	R.S. Pura	Jammu	Jammu & Kashmir	24.02.2022	45	
Mattoo and Nai Basti	Khour	Jammu	Jammu & Kashmir	26.02.2022	87	
Chaloge	Bani	Kathua	Jammu & Kashmir	21.02.2022	49	
Rehan and Gatti	Basholi	Kathua	Jammu & Kashmir	22.02.2022	97	
Ransoo	Pouni	Reasi	Jammu & Kashmir	26.02.2022	63	
Kothia	Pouni	Reasi	Jammu & Kashmir	04.03.2022	53	
Raipur Kamila	Qila Darhal	Rajouri	Jammu & Kashmir	04.03.2022	63	
Hathal	Sunderbani	Rajouri	Jammu & Kashmir	22.03.2022	26	

LAM and Jhanger	Nowshera	Rajouri	Jammu & Kashmir	23.03.2022-24.03.2022	76	
Kamila	Kote Quiladar-hal	Rajouri	Jammu & Kashmir	29.03.2022	38	
Rakh Barotia	Vijaypur	Samba	Jammu & Kashmir	15.02.2022	61	
Dhaki	Sumb	Samba	Jammu & Kashmir	19.03.2022	68	
Bali	Narsoo	Udhampur	Jammu & Kashmir	10.02.2022	49	
Darsoo and Jar Krimchi	Udhampur	Udhampur	Jammu & Kashmir	11.03.2022	98	
Treen Mayasi	Panthal	Reasi	Jammu & Kashmir	18.10.22	35	
Muttal	Tikri	Udhampur	Jammu & Kashmir	18.10.22	38	
Chnni B Rajori	Subderbani	Rajori	Jammu & Kashmir	24.11.22	72	
Rakharotia	Vijayput	Samba	Jammu & Kashmir	29.11.22	70	
Rakh Jarogh	Batote	Ramban	Jammu & Kashmir	19.12.22	72	
Jeora Farm	R.S. Pura	Jammu	Jammu & Kashmir	20.12.22	92	
Ranchi	-	Ranchi	Jharkhand	Baseline survey and sensitization programme	25	State FMD Collaborative Unit, Ranchi

Table 19. Animal health camp and AI programme using sex sorted semen under DAPST

Theme area	Venue	Date	Participants	No of animal covered	Organized by
Animal health camp	Dimoria, Tepesia, Assam	03.02.22	30	Total 100 cattle and goats	FMD Regional Centre, CVSc, AAU, Assam
Vaccination camp	Tamulpur, Baksa, Assam	15.02.22	32	Total 277 animals (82 Cattle, 149 goats and 46 pigs)	
AI programme using sex sorted semen	Different tribal villages of Gujrat			Total 664 animals (Heifer and cow)	State FMD Collaborative Unit, Gujurat

Interventions	Implementing organization	Number of Programme/ quantity	Number of beneficiaries
Inputs distribution for livestock production and health care Goat Mineral mixture Feed Calcium supplements Piglet Utility carte	All units	**68 goats** (Improved buck-8, goats of 3-6 month old-60)	28
		Pregnancy feed (10750 kg)	43
		Pig ration (15 qt)	33
		Mineral mixture 323 kg	175
		Piglet (40 nos)	33
		Calcium supplements	30
		Utility crate	147
		Booklet	33
			522

Animal Health camps at Dimoria and Tamulpur villages, Assam

Table 20. Activities under Tribal Sub-Plan in collaboration with State FMD Units

Description of activity	Organizer	Venue	Beneficiaries (No)
Inputs distribution	FMD Collaborating Centre, Jammu	Different villages of Jammu	1760
Inputs distribution	FMD Collaborating Centre, Port Blair	Port Blair	25
Inputs distribution	FMD Collaborating Centre, Hisar	Different villages of Haryana	160
Method Demonstration on Cattle Feeding Practice	FMD Collaborating Centre, Jammu	Vil.Akalpur Jammu	52
Awareness programme on scientific livestock farming and input distribution	FMD Collaborating Centre, Port Blair	ICAR-CIARI, Port Blair 01.12.2022	25

Table 21. Trainings organized under DAPST

Title of training	Date and duration	Venue	Participant numbers
Goat value chain development for rural women	13.05.2022 One Day	Kaundha-Khera village, U.S.Nagar, Uttarakhand	15
Scientific goat farming practices	23-03-2022 One day	Village Barakuda, Jamukoli GP, Jatani Tehsil	20

Input Distribution under TSP by FMD Centre, Port Blair

2.7.3 Activities under DAPSC

Development Action Plan for Scheduled Castes (DAPSC) programme of ICAR-NIFMD was implemented for the livelihood support of farming community of different geographical locations. This institute has undertaken various steps at four states in collaboration with State FMD units for better outreach of activities for the upliftment of livelihood of SC community through providing critical inputs and preventive healthcare measures for their livestock. The operational area included in scheduled caste dominated villages of Haryana, Odisha, Uttar Pradesh and Uttarakhand. It was implemented by conducting baseline survey cum sensitization programme, animal health camp, skill development and training programme, capacity building programme, Gosthi and awareness camps on FMD (Table 22 and 23). In addition, the need based critical inputs for livestock health management were distributed among the scheduled caste families. During the period a total of 1,839 scheduled caste families were included through various interventions to channelize the flow of benefits for the development of Scheduled Castes community in physical and financial terms. Moreover, creation of goat value chain was also focussed under which the interested SC beneficiaries were provided with goats of different breeds and other inputs towards improvement of their financial status and earning livelihood. They were also provided with anthelmintics, feeds, mineral mixtures and other supplements, preventive healthcare knowledge towards capacity building with simultaneous vaccination of their goats against PPR.

Table 22. Activities under Development Action Plan for Scheduled Caste by ICAR-NIFMD

Programme/Activities	Number of activities	Venue	Beneficiaries (Numbers)
Goat distribution under DAPSC programme	06	Barakuda, Arugul & Kansapada villages of Odisha	78
Capacity building programme organized	07	Barakuda village of Odisha	22
Input distribution programmes		Barakuda, Arugul, Kansapada, Tirimal, Taraboi, Benapanjari, Panchupalli, Motari, Harirajpur, Kushamati, Rengal, Padanpur, Kantia, Janla, Jharpada villages of Odisha, Odlohar village, Bageswar district of Uttarakhad	
Cattle feed	17		259
Mineral mixture & other necessary inputs	18		286
Milking can	01		50
FMD Awareness programme & distribution of technical literatures	09	Barakuda, Arugul, Kansapada, Taraboi, Benapanjari, Harirajpur, Barasahi. Rengal, Janla villages of Odisha	268
Baseline survey & tour for goat value chain	02	Barakuda, Odisha	22
Organization of PPR vaccination camps	10	Podapada, Kansapara, Patrapada, Barakuda, Taraboi, Benapanjari, Panchupalli, Harirajpur, Kushamati, Bhimpur, Padanpur, Kantia, Niranjanpur villages of Odisha	142
Organization of health camps	09	Barakuda, Arugul Kansapada, Taraboi, Benapanjari, Harirajpur, Rengal villages of Odisha Khadgujar, Dist- Amroha, Sikheda, Dist- Baghpat, Uttar Pradesh	154

Table 23. Activities under Development Action Plan for Scheduled Caste in collaboration with State FMD Units

Description of activity	Number of Activity	Organizer	Venue	Beneficiaries (Numbers)
Training Programme organized		State FMD collaborating Centre, College of Biotechnology, SVPUAT, Meerut, Uttar Pradesh	College of Biotechnology, SVPUAT, Meerut, Uttar Pradesh	265
One day vaccinator training programme	02			
One-week training programme on goat farming	01			
One-week training programme on pig farming	01			
Organization of Pashupalak Gosthi	01	State FMD collaborating Centre, College of Biotechnology, SVPUAT, Meerut, Uttar Pradesh	College of Biotechnology, SVPUAT, Meerut, Uttar Pradesh	100

Organization of Health camp	02	State FMD collaborating Centre, College of Biotechnology, SVPUAT, Meerut, Uttar Pradesh	Khadgujar, Dist-Amroha Sikheda, Dist-Baghpat	33
Skill development in animal health for scheduled caste livestock farmers	02	Regional Research Centre on FMD, Lala Lajpat Rai University of Veterinary and Animal Science	Ramrai, Kirmara, Gangwa & Agroha villages of Haryana	160


Animal Health Camps organized under DAPSC

PPR Vaccination Camps organized under DAPSC


FMD Awareness Camps organized under DAPSC





Input distribution programmes organized under DAPSC

Capacity building programme on scientiific Goat farming at Barakuda village, Odisha under DAPSC

Vaccinator training programme at SVPUAT, Meerut under DAPSC

Training Programme on Pig Farming at SVPUAT, Meerut under DAPSC

Pashupalak Gosthi conducted at SVPUAT, Meerut under DAPSC

Training Programme on Goat Farming at SVPUAT, Meerut under DAPSC

Skill development in animal health for scheduled caste livestock farmers of Haryana under DAPSC

2.7.4 Activities under NEH scheme

NEH programme of ICAR-NIFMD was initiated with the aim to support surveillance activities & 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 2022, there were 7 participating centres such as NRC on Yak (ICAR institute), Regional Research Centre at C.V.Sc., A.A.U., Khanapara, Guwahati (SAU) as well as State FMD collaborating centres at Imphal, Aizawl, Kohima, Itanagar, Agartala under Animal Husbandry Departments of respective Governments (**Table 24**). The collaborating centres conducted various activities such as FMD awareness camps, training & workshops, capacity building, animal health camps & FMD vaccination in collaboration with ICAR-NIFMD as a part of the programme.

Table 24. List of activities performed by the NEH FMD Regional & Collaborating Centres

State	Date	Name of Programme	No. of farmers/ stakeholders participated		
			Total	Male	Female
Arunachal Pradesh	09-04-2022	Animal Health Camp	70	49	21
Manipur	23-04-2022	Animal Health Camp and vaccination programme	239	126	113
Mizoram	29-04-2022	Organization of State Level workshops on FMD	70	32	38
Tripura	29-04-2022	Training of rural youth for intensive animal husbandry	25	9	16
Assam	29-04-2022	Awareness cum training programme on FMD CP with special reference to disease prevention & disease control	30	0	30
Tripura	30-04-2022	Animal health camp	30	18	12
Manipur	08-05-2022	State level workshop on FMD organized by ICAR-NIFMD & AICRP-FMD-Manipur centre	70	40	30
Assam	10-05-2022	Awareness cum training programme on FMD CP with special reference to disease prevention & disease control	32	17	15
Tripura	16-05-2022	Training on FMD Awareness	35	0	35
Mizoram	23-05-2022	Animal health camp	30	19	11
Mizoram	27-05-2022	Animal health camp	56	23	33
Arunachal Pradesh	28 &29-05-2022	FMD awareness cum vaccination programme for high altitude animals	26	15	11
Mizoram	02,23 & 24-06-2022	Awareness Campaign cum Distribution of Technical Literatures and Mineral Mixture	42	20	21
Manipur	20-06-2022	State level workshop on FMD organized by ICAR-NIFMD & AICRP-FMD-Manipur centre	121	30	91
Tripura	20-06-2022	Training on FMD Awareness	20	15	5
Manipur	04-07-2022	The second round of FMD vaccination organized by Directorate of Veterinary	262	87	175
Manipur	21-08-2022	Animal Health Camp and vaccination programme	276	191	85

The work plan of the programme has been re oriented to provide maximum benefit to the stakeholder as guided by ICAR from time to time. As per the revised guidelines communicated to identify least performing KPIs of the aspirational districts, a new work plan was prepared in consultation with the centres to conduct outreach activities at NEH region. The centres have identified KPIs and planned programmes in order to generate success stories from the interventions. Four NEH centres viz. RRC Guwahati & collaborating centres of Imphal, Agartala & Kohima were selected for farmers livelihood support in area of advanced pig farming at 1st phase and supported accordingly. The FMD centres in the NEH region conducted initial baseline survey, Awareness on FMD & other important diseases, distribution of piglets/ other critical inputs (medicines, vitamins & feed supplements), training/ capacity building programme to the farmers, periodic screening of important diseases and constant monitoring & supervision to generate success stories.

Animal Health Camp at Kangkarnalla. Naharlagun organised by FMD Collaborating Centre, Itanagar

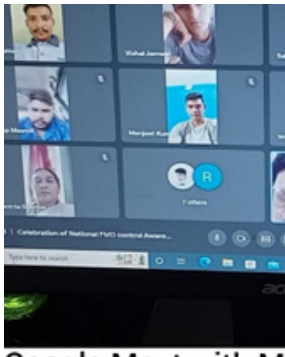
Awareness Campaign cum Distribution of Technical Literatures on FMD and Mineral Mixture atLunglei, Mizoram organised by FMD Collaborating Centre, Aizawl.

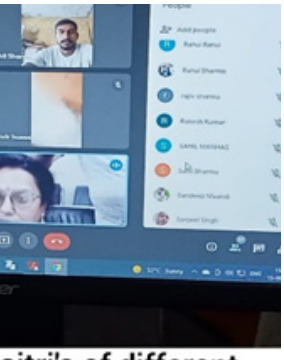
Training programme on Scientific pig farming at KarbiAnglong district, Assam by Regional FMD Research Centre, Guwahati

2.7.5 Celebration of National FMD control awareness week (12-17 September, 2022)

As per the recommendation of QRT, National FMD control awareness week was observed from 12th to 17th September,2022. The awareness week was celebrated throughout the country to celebrate the launch of the nationwide National Animal Disease Control Programme (NADCP) on foot and mouth disease (FMD) in livestock on 11th September, 2019 by Hon'ble Prime Minister of India. All the state FMD Regional and Collaborating centres along with all the 3 campuses of ICAR-NIFMD tookpart in awareness campaign against FMD by means ofvarious kinds of activities such as oral presentation in both online or offline mode, awareness & health camps, input distribution, vaccination of livestock, training, poster competitions among students, live radio sessions, mela/exhibitions etc..The centres' participations were monitored in terms of the google form responses submitted by the centres after the event. Along with the weeklong celebration of ICAR-NIFMD institute in different villages, a total of 135 responses of different events were submitted by the centres with a total number of 11902 participants (farmers-8358, veterinarians-613, students-2119, academicians-111, paravets-291, other stakeholders-410). Although celebrated for the first time, a good number of stake holders have been involved in the programmes organized by the FMD units throughout the week.

GLIMPSE OF DIFFERENT FMD AWARENESS ACTIVITIES ORGANISED BY VARIOUS STATE FMD REGIONAL AND COLLABORATING CENTRES DURING THE WEEK





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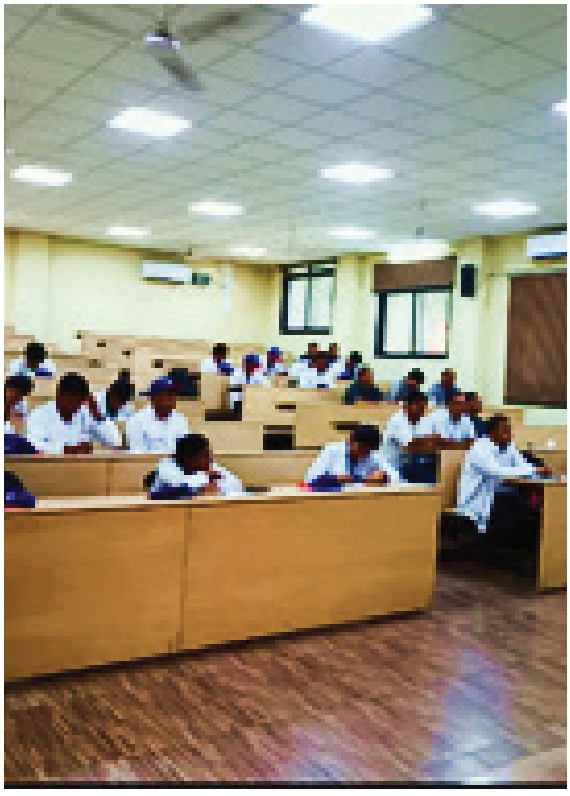

Various FMD awareness activities organised by ICAR-NIFMD at different villages in Odisha on the occasion of National FMD Control Awareness Week (12-17 September, 2022)

3.0 Awards and Recognitions

3.1 National/International Awards

Dr R. P. Singh, Director was selected as Member of Partnering & Financing Panel (PFP) of Global Framework –Trans boundary Animal Diseases (GF-TADS) by FAO-WOAH/OIE on 26th April 2022

Dr Ranjan R received Pashudhan Samriddhi "India Award 2022" under award category "Research area: Understanding of FMD virus ecology" dated on 15.08.2022. Certificate No.: PSIA41/22 Date:15.08.2022

3.2 Editor/Associate Editor of Research Journals

Dr Samrendra Das was recognized as guest editor for the journal 'Entropy (MDPI)' for editing special issue on "Biostatistics, Bioinformatics, and Data Analysis".

Dr Samrendra Das was recognized as guest editor for the journal 'Genes (MDPI)' along for editing a special issue.

Dr. Saravanan S recognized as Review Editor in Viral Disease Investigation for the journal "Frontiers in Virology"

4.0 List of Publications

a) Research articles

Biswal JK, Sreenivasa BP, Mohapatra JK, Subramaniam S, Jumanal V, Basagoudanavar SH, Dhanesh VV, Hosamani M, Tamil Selvan RP, Krishnaswamy N, Ranjan R, Pattnaik B, Singh RK, Mishra BP, Sanyal A (2022). A single amino acid substitution in the VP2 protein of Indian foot-and-mouth disease virus serotype O vaccine strain confers thermostability and protective immunity in cattle. *Transbound Emerg Dis*. doi: 10.1111/tbed.14735. (IF-4.521; NAAS Score: 11.01)

Biswal JK, Jena BR, Ali SZ, Ranjan R, Mohapatra JK, Singh RP (2022). One-step SYBR green-based real-time RT-PCR assay for detection of foot-and-mouth disease virus circulating in India. *Virus Genes*. 58(2):113-121. doi: 10.1007/s11262-021-01884-3 (IF-2.198; NAAS Score: 8.33)

Gunasekera U, Biswal JK, Machado G, Ranjan R, Subramaniam S, Rout M, Mohapatra JK, Pattnaik B, Singh RP, Arzt J, Perez A, VanderWaal K (2022). Impact of mass vaccination on the spatiotemporal dynamics of FMD outbreaks in India, 2008-2016. *Transbound Emerg Dis*. 69(5):e1936-e1950. doi: 10.1111/tbed.14528 (IF-4.521; NAAS Score: 11.01)

Sahoo M, Kondabattula G, Thakor JC, Dinesh M, Kumar P, Singh R, Singh K and Saminathan M (2022). Novel pathological findings and immunohistochemical detection of FMDV antigens in the brain of calves naturally infected with foot-and-mouth disease. *Microb. Pathog*. 169, p.105650. (IF-3.848; NAAS Score: 9.8)

Subramaniam S, Mohapatra JK, Sahoo NR, Sahoo AP, Dahiya SS, Rout M, Biswal JK, Ashok KS, Mallick S, Ranjan R, Jana C, Singh RP (2022). Foot-and-mouth disease status in India during the second decade of the twenty-first century (2011-2020). Vet Res Commun. 46(4):1011-1022. (IF-2.816; NAAS Score: 8.82)

Ranjan R, Biswal JK, Mohapatra JK, Dahiya SS, Mallick S and Sahoo NR (2022). Biosafety Measures for the Laboratories Engaged in the Diagnosis/ Research of SARS-CoV-2. Acta Sci Vet Sci 4 (8): 190-204. (IF-1.008)

c) Technical papers/full invited papers in conferences/trainings, etc

R. P. Singh (2022) Lead Paper presentation on" **Vaccine and vaccination for Prevention and control of Antimicrobial Resistance**" in the International seminar on Interventions for control of AMR: Harnessing one health knowledge. a parallel event of Gander In Aquaculture & Fisheries (GAF8) held during 21-22 November at ICAR- Central Institute of Fisheries, Kochi, Kerala.

Ranjan R., Biswal J.B., Kumar K. and Kumar S. (2022). **Understanding of emerging and re-emerging infectious diseases**. 1st National conference on "Fostering one health for food safety and security through sustainable animal husbandry & aquaculture practices organized by Society for promotion of farm and companion animals & Bihar Animal Sciences University, Patna, Bihar during 10-11 November, 2022. Pp.- 42-46.

d) Abstracts/ papers presented in conferences/ symposia

Ranjan R, Biswal JK, Mohapatra JK and Singh RP (2022). **Cannibalism in foot-and-mouth disease virus inoculated experimental BALB/c Mice**. International Veterinary Pathology Congress--2022 on "Global Challenges in Rapid Diagnosis and Management of Animal and Poultry Disease for Improved Health and Productivity" at College of Veterinary Science, Rajendranagar, PVNRTVU, Hyderabad,17-19 November 2022. Pp-153-154.

Ranjan R, Biswal JK, and Singh RP (2022). **Detection of foot-and-mouth disease virus by negative staining method**. International Veterinary Pathology Congress-2022 on "Global Challenges in Rapid Diagnosis and Management of Animal and Poultry Disease for Improved Health and Productivity" at College of Veterinary Science, Rajendranagar, PVNRTVU, Hyderabad, 17-19 Nov. 2022. Pp-167

Sahoo M, Singh R, Singh KP, P Kumar P, Mariappan AK, Saminathan M, Dhama K, Das T, Kashyap G, Sahoo NR (2022). **Novel pathologic findings and viral antigen distributions in the organs of calves naturally infected with Foot and Mouth Disease.** International Veterinary Pathology Congress--2022 on "Global Challenges in Rapid Diagnosis and Management of Animal and Poultry Disease for Improved Health and Productivity" at College of Veterinary Science, Rajendranagar, PVNRTVU, Hyderabad,17-19 November 2022. Pp-173.

Kakker NK, Swati Dahiya, SS. Juneja, Suman, Rajiv Nagar, Mohapatra JK and Subramaniam S (2022). **Studies on post-vaccinal humoral immune response in FMD+HS combined vaccinated buffaloes in an government organized farm, Haryana**. XXXIVth Annual Convention of Indian Association of Veterinary Microbiologists, Immunologists and Specialists in Infectious Diseases. National Current Trends in Immunodiagnostics & Vaccinology for Health of Livestock & Poultry. LUVASU, Hisar, Haryana, 27-28 May, 2022.

Dahiya S, Kakker NK, Juneja SS, Dhaka SS, Patil CS, Mohapatra JK and Subramaniam S. (2022). **Studies on post-vaccinal humoral immune response in FMD+HS combined vaccinated cattle in an organized Farm, Haryana**. XXXIVth Annual Convention of Indian Association of Veterinary Microbiologists, Immunologists and Specialists in Infectious Diseases. National Current Trends in Immunodiagnostics & Vaccinology for Health of Livestock & Poultry. LUVASU, Hisar, Haryana, 27-28 May, 2022.

Shrinivas JW, Jana C, Sagar A. Khulape and Subramaniam S (2022). **An investigation of Foot and Mouth Disease outbreak and pathological study in farm ruminants.** International Veterinary Pathology Congress-2022. Global Challenges in Rapid Diagnosis and Management of Animal and Poultry Diseases for improved Health and Productivity College of Veterinary Science, Rajendranagar, Hyderabad. 17-20 November, 2022

Mallick S and Mohapatra JK (2022). **Effect of FMD vaccination on immune response, production and reproductive performance of crossbreed cows in a small-scale dairy herd**. International Veterinary Pathology Congress-2022. Global Challenges in Rapid Diagnosis and Management of Animal and Poultry Diseases for improved Health and Productivity College of Veterinary Science, Rajendranagar, Hyderabad. 17-20 November, 2022. page no. 160

e) Foreign Visit

Dr R P Singh visited the Wageningen Bioveterinary Research Institute, Lelystad, the Netherlands to participate in the 17th Annual Meeting of the OIE/ FAO FMD Reference Laboratory Network OIE/FAO representative, laboratory leaders, SAARC. 29th, 30th November, and 1st December 2022.

f) Popular articles

राजीव रंजन एवं जितेन्द्र कुमार बिस्वाल (२०२२). थनैला रोग: कारण, लक्षण, निदान, उपचार एवं रोकथाम. कृषिओमिका, भा.कृ.अनु.प.-भारतीय कृषि जैव प्रौद्योगिकी संस्थान, गढ़खटंगा, राँची- ८३४००३, झारखंड (भारत), अंक-01 पेज- ७९- ८२-

Jana C and Khulape SA (2022). Role of animal raisers in prevention of Foot and Mouth Disease (*in Bengali*); *Bardhaman Joyti*

g) Technical documents

Technical Report on North Eastern Hill (NEH) region Activities 2021-22 (2022). ICAR-Directorate of FMD, Arugul, Bhubaneswar, Odisha. Editors: Sahoo NR, Jana C, Mohapatra JK, Subramaniam S and Singh RP. ICAR-NIFMD, Bhubaneswar.

Development of Action Plan for Scheduled Tribe (DAPST) 2021-22. ICAR-Directorate of FMD, Arugul, Bhubaneswar, Odisha. Editors: Jana C, Mohapatra JK and Kulaphe SA

Suresh KP, Heamdri D, Patil SS, Subramaniam S, Mohapatra JK and Singh R P (2022) Sampling Plan for Seromonitoring of FMD in India under National Animal Disease Control Programme Round III. ICAR-NIVEDI, Bengaluru and ICAR-NIFMD, Bhubaneswar.

Suresh KP, Heamdri D, Patil SS, Subramaniam S, Mohapatra JK and Singh R P (2022) Sampling Plan for Serosurveillance of FMD in India under National Animal Disease Control Programme: 2022. ICAR-NIVEDI, Bengaluru and ICAR-NIFMD, Bhubaneswar.

h) Book/Book chapters

BN Tripathi, RP Singh, AK Tiwari, G Saikumar, GVPPS Ravi Kumar, Yash Pal, BR Gulati, BR Shome, VP Singh, Jyoti Misri, Triveni Dutt and Ashok Kumar (2022). Achievements in Animal Health Management in Independent India. Editors Pathak H, Mishra JP and Mohapatra T (2022) Indian Agriculture after Independence. Indian Council of Agricultural Research, New Delhi 110 001, pp 426. ISBN: 978-81-7164-256-4

Sahoo AP and Deb R (2022). Lateral Flow Assay for Diagnosis of Pig Viral Diseases. In Protocols for the Diagnosis of Pig Viral Diseases (pp. 195-204). Humana, New York, NY.

Sahoo NR, Sahoo M, and Patel SK (2022). A Beginner's guide to Pig production. Published by Jaya publishing House, ISBN: 978-93-5651-166-8

i) Extension leaflet

N R Sahoo, M. Rout, JK Mohapatra, SS Dahiya, JK Biswal, S Mallick, R Ranjan, M Sahoo, R P Singh.2022. National Animal Disease Control Programme (NADCP) on FMD.

M. Rout, JK Mohapatra, S Mallick, NR Sahoo, SS Dahiya, JK Biswal, R Ranjan, M Sahoo, R P Singh 2022. Uttama Chheli Palan Sambandhiya Keteka Janiba Katha (In Odia)

N R Sahoo, M. Rout, JK Mohapatra, SS Dahiya, JK Biswal, S Mallick, R Ranjan, M Sahoo, R P Singh.2022. Jatiya Prani Roga (Phatua) Niyantrana Karyakrama (In Odia)

5.0 Intellectual Property Management

5.1 Patent applications filed

Biswal JK, Mohaparta JK, Subramaniam S, Ranjan R and Singh RP. "Live-attenuated FMDV serotype O IND R2/1975 negative-marker vaccine strain". Application no. 202211067069; Dated 22nd November 2022

5.2 Revenue generated

During 2022, the institute has provided testing services for FMD seromonitoring using SPCE, serosurveillance using DIVA ELISA, and serotype identification using mRT-PCR to private bull and dairy farms and exporters, as well as DIVA kits. The details of revenue generated is depicted in the Table 25.

Table 25. Details of revenue generation during last four years

Year	Testing of serum sample using SPCE	Testing Service using DIVA	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
2022	30,99,944	38,906	79,441	14,077	-	32,32,368

6.0 List of Research Projects

6.1 List of institutional funded research projects

S. No.	Title	PI and Co-PI	Duration
1	Generation of monoclonal antibodies against recombinant FMDV polyprotein 3AB and their application in immunodiagnosis	Mallick SR (PI) Mohapatra JK, Biswal JK, Dahiya SS	Mar 2019-Mar 2023 (extended for one year)
2	Host genetic factors affecting FMD vaccine response in calves	Sahoo NR (PI) Mohapatra JK, Biswal JK, Rout M	May 2020-May 2023 (extended for one year)
3	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 (PI) Khulape SA	Aug 2021-July 2023
4	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 (PI) Rout M, Saravanan S, Dahiya SS	Aug 2021-March 2023
5	Production and characterization of monoclonal antibodies against recombinant capsid polyprotein (rP1) of FMD virus serotype O	Mallick SR (PI) Biswal JK, Khulape SA	Aug 2021-July 2023
6	Epidemiology of Foot and Mouth Disease in Small Ruminants and Pigs in India	Rout M (PI) Mohapatra JK, Saravanan S	July 2021-July 2024
7	Sero-clinical Surveillance of FMD-like Vesicular Diseases in Susceptible Animals in India	Rout M (PI) Mohapatra JK, Saravanan S, Dahiya SS	July 2021-July 2023
8	Genetic and antigenic characterization of Foot and Mouth Disease virus serotype Asia1	Rout M (PI) Dahiya SS, Mohapatra JK, Saravanan S	July 2021-July 2024
9	Comprehensive analyses of codon usage bias of Foot and Mouth Disease virus vis-à-vis adaptation to the hosts	Sahoo AP (PI) Saravanan S, Sahoo NR Das S	Aug 2021-July 2023 (extended for one year)
10	Elucidating the role of cytokines and chemokines in the pathogenesis of Foot-and-Mouth Disease	Sahoo M (PI) Rout M, Biswal JK, Ranjan R	Sep 2022-Dec 2024
11	Development of a medium throughput NA based diagnostics for FMD	Sahoo NR (PI) Sahoo M, Rout M	Aug 2022-July 2024
12	Development of combination reverse transcription-PCR (RT-PCR) strategy to enhance sensitivity and confidence of FMD virus serotype diagnosis	Mohapatra JK (PI) Sahoo NR, Rout M, Saravanan S, Dahiya SS, Biswal JK	Aug 2022-Mar 2024
13	Development and evaluation of lateral flow immunoassay for Foot-and-Mouth Disease virus detection and serotyping using monoclonal antibodies	Mallick SR (PI) Mohapatra JK, Biswal JK, Rout M	Aug 2022-Mar 2025

14	Antigenic and Genetic characterization of Indian foot and mouth disease virus serotype A strains during 2022-27	Mohapatra JK (PI) Rout M, Saravanan S	Aug 2022-March 2027
15	Evolutionary and antigenic analysis of foot and mouth disease virus serotype O strains from India during 2022-27	Dahiya SS (PI) Mohapatra JK, Saravanan S	Aug 2022-March 2027
16	Understanding FMD virus ecology in livestock wild life interface in buffer zone of Sanjay Tiger Reserve/Bandhavgarh Tiger Reserve	Ranjan R (PI) Khulape SA, Mohapatra JK, Biswal JK, Prashant Deshmukh (WCT), Vinay Pandey (WCT), Himanshu Joshi(WCT)	July 2021-July 2023
17	Kinetics of FMD virus serotype specific protective antibody response induced in pigs vaccinated with commercial FMD vaccine intended for use in cattle	Singh RP (PI) Mohapatra JK, Jana C, Sahoo NR, Rout M, Sahoo AP, Ranjan R, Khulape SA	Aug 2021-Mar2024

6.2 List of externally funded research projects

S. No.	Title	PI	Duration	Funding
1	Generation and analyses of mRNA vaccine against foot-and-mouth disease	Biswal JK (PI) Ranjan R	Feb 2022-Feb 2025	DST-SERB; Budgetary outlay: 47.54 lakhs
2	Statistical Approaches of Differential Gene Network Analysis for High-throughput Single-cell RNA-sequencing Studies	Das S (PI) Sahoo NR	July 2022-July 2025	DST-SERB, Budgetary outlay: 21.17 lakhs
3	Understanding FMD viral ecology and landscape epidemiology towards control and eradication	Ranjan R (PI) Mohapatra JK, Biswal JK, Saravanan S, Rout M, Khulape SA	2014-18 (Extended)	PIADC, USA Budgetary outlay: 66 lakhs
4	FMD Vaccine Quality Testing and Enhancing India's Animal Vaccine Testing Capabilities (Budgetary outlay:	Mohapatra JK(PI) Singh RP, Biswal JK, Khulape SA, Dahiya SS, Sahoo AP, Saravanan S Ranjan R, Rout M	Dec 2021-Dec 2023	DAHD Budgetary outlay: 258 lakhs
5	Progarmmes to support LHDCP/NADCP			DAHD
5A	Seromonitoring of pre and post vaccinal immunity against Foot and Mouth Disease under LHDCP/NADCP during 2021-2024	Saravanan S (PI) Sahoo AP, Mohapatra JK	April 2021-March 24	
5B	Serosurveillance in bovines under LHDCP/ NADCP during 2021-2024	Mohapatra JK (PI) Saravanan S, Rout M, Sahoo AP, Ranjan R Mallick SR	April 2021-March 24	

5C	Investigation of NSP seroreactors for the presence of FMD virus by oropharyngeal fluid testing	Ranjan R (PI) Jana C, Rout M Biswal JK, Khulape SA, Mohapatra JK Saravanan S	April 2021-March 25	
5D	FMD vaccine quality control under LHDCP/ NADCP	Sahoo NR (PI) Mohapatra JK Saravanan S, Sahoo AP, Rout M, Dahiya SS	April 2021-March 25	
6	Institute Technology Management Unit	Biswal JK	April 2022-March 23	

6.3 List of service projects

S. No.	Title	Nodal Officer/PI	Associates
1	FMD virus isolation and maintenance of virus repository	Dahiya SS	Rout M Mohapatra JK
2	FMD virus diagnostic service and serotype identification	Mohapatra JK	Biswal JK Dahiya SS Rout M
3	Revenue generation by offering testing service using SPCE	Saravanan S	Sahoo AP
4	Revenue generation by offering testing service using DIVA and multiplex PCR	Mohapatra JK	Rout M
5	Surveillance of FMD and vaccine effectiveness study within 5 km radius of ICFMD, Arugul, Bhubaneswar	Rout M	Mohapatra JK Sahoo NR Saravanan S
6	Transmission Electron Microscopy as a tool in diagnostic pathology and research for Foot-and-mouth disease virus	Ranjan R	Sahoo M Rout M
7	Production, standardization and supply of diagnostic reagents for FMD virus diagnosis and surveillance	Mohapatra JK	Sahoo AP Dahiya SS Biswal JK Saravanan S Rout M Sahoo M Mallick SR
8	Extension and FMD Awareness activities under TSP	Jana C/ Singh NS/ Das T	All scientists
9	Extension and FMD Awareness activities under SCSP	Rout M	All scientists
10	Extension and FMD Awareness activities under NEH	Sahoo NR	All scientists

7.0 Education, capacity building and training programmes

7.1 Serology Proficiency Testing Scheme, 2022 for SPCELISA

Solid Phase Competitive ELISA (SPCELISA), developed at the institute, has been used countrywide since 2017 for FMD post-vaccination seromonitoring under NADCP and LHDCP. All the diagnostic reagents for the test are produced in-house at ICAR-NIFMD and supplied to the various state FMD centres. Necessary HRD support in terms of wet lab hands-on training is imparted by ICAR-NIFMD. However, inter-laboratory comparison of results and proficiency testing for SPCE become more important when the test is used by all the laboratories to generate data on FMD post-vaccination seromonitoring. ICAR-NIFMD, Bhubaneswar, organised the first ever SPCELISA Proficiency Testing, in which a total of 11 operators from NIFMD laboratories and State FMD Regional and Collaborating Centres participated. All the operators performed SPCELISA on the provided PT panel, consisting of six coded samples (trivalent vaccinated serum) of varied titre ranges. Six coded samples, randomly selected from a panel of a total of 15 samples, were received by each operator. Therefore, the same panel was not necessarily received by all the operators. Each operator had to run the experiment twice on different days, where a >35% PI and >Log10 1.65 titre (1:45) cut-off was adopted for the protective antibody status interpretation. The feedback and results were received at ICAR-NIFMD, decoded, and analysed. The summed-up results of the serology proficiency testing scheme for 2022 for serotypes O, A, and Asia1 are presented in the (Fig 30).

Except for a few of the samples with borderline titre values, the overall interpretation of all operators with respect to protective status showed concordance with the ICFMD result. Such an observation is encouraging and builds confidence considering the fact that various state laboratories are participating in FMD post-vaccination seromonitoring under NADCP and LHDCP. Also, this adds credence to the data generated under seromonitoring activity countrywide. The performance of the operators was also evaluated, taking into account reproducibility, consistency, and accuracy in the final interpretation of the result.

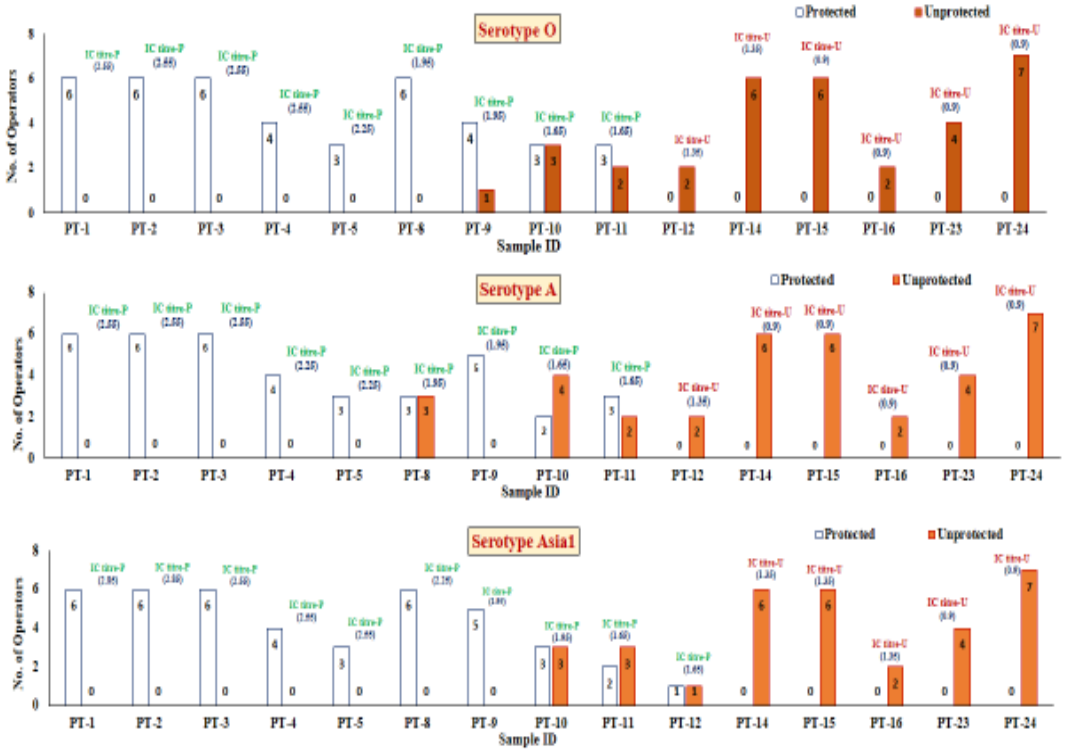

Fig 30. Interpretation of Protective Status (Protected and Unprotected) of Each Coded Sample by Various Operators

7.2 Serology Proficiency Testing Scheme, 2022 for 3AB3 NSP ELISA

3AB3 NSP ELISA (DIVA) developed at the Institute is used countrywide since 2009 for FMD serosurveillance under FMDCP/NADCP/LHDCP. All the diagnostics reagents for the test are produced in house at ICAR-NIFMD and supplied to the various state FMD centres. Necessary training is imparted by ICAR-NIFMD to conduct the test. Therefore it becomes increasingly important to determine proficiency of the state laboratories involved in generating critical serosurveillance data from time to time. ICAR-NIFMD, Bhubaneswar organized the first ever 3AB3 NSP ELISA (DIVA) Proficiency Testing in which a total of 21 operators from NIFMD laboratories and state FMD Regional and Collaborating Centres participated. All the operators performed ELISA on the provided PT panel consisting of 3 lyophilized coded samples of varied NSP antibody titre range. Each operator had to run the experiment twice on different days, where 3AB3% cut-off was adopted for NSP-antibody seropositive interpretation. The feedback and results were received at ICAR-NIFMD, decoded, and analysed. The overall results of the Serology Proficiency Testing Scheme, 2022, for 3AB3 NSP ELISA (DIVA) are presented in the (Fig 31).

It was observed that all operators judged the positive sample as positive except for a few operators who misinterpreted the weak positive sample as negative. Also, three of the 21 operators interpreted the negative sample as a positive one. Except for a few operators, the overall interpretation with respect to sero-positive status showed concordance with the NIFMD result. Such an observation is encouraging considering the fact that various state laboratories are participating in FMD surveillance testing under FMDCP, NADCP, and LHDCP. Also, such an exercise adds credibility to the data generated under surveillance activity countrywide and aids in providing critical inputs on virus circulation. The performance of the operators was also evaluated, taking into account reproducibility, consistency, and accuracy in the final interpretation of the result. From PT testing, it was apparent that in three centres where there is a recruitment of fresh manpower, there is a need for intervention and training at NIFMD.

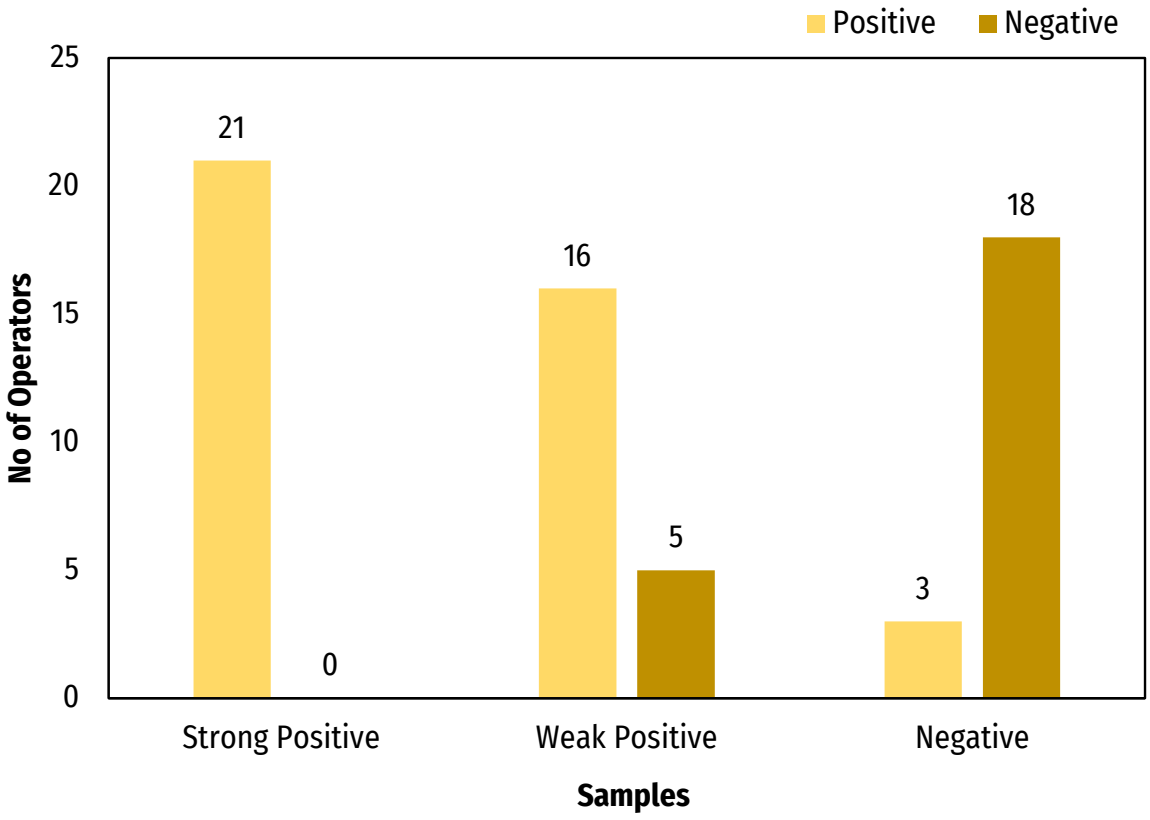

Fig 31. Interpretation of NSP-antibody status (positive and negative) of each coded sample by various operators

7.3 Participation of ICAR-NIFMD in FMD PT Scheme, 2021 organized by the FAO-WRL for FMD

ICAR-NIFMD as 'FAO Reference Centre for FMD' being part of WOAH/FAO FMD reference laboratory network participated in the FMD Proficiency Testing Scheme, 2021 organized by the FAO World Reference Laboratory (WRL) for FMD, UK with support from EuFMD and DEFRA. As per feedback report received, the Institute's performance was defined as **'Category 4'**, the highest, where laboratory's performance and interpretation are considered fit-for-purpose. Based on the range of tests performed Institute's capability was found consistent with a laboratory located in a **'Progressive Control Pathway (PCP) 5'**country (Fig 32). More importantly, all the diagnostics tests applied on PT coded samples are indigenously developed by the scientists of the Institute and are being used countrywide through national FMD network laboratories.

THE Pirbright INSTITUTE

Wednesday 20th July,2022

ICAR - Directorate of Foot and Mouth Disease International Centre for Foot & Mouth Disease (ICFMD),
Arugul, Jatni,
Bhubaneswar,
Khordha, Odisha 752050,
India

Dear Dr Rabindra Prasad Singh

Feedback on the Foot-and-Mouth Disease Proficiency Test Scheme 2021

Thank you for your participation in the 2021 Foot-and-Mouth Disease Proficiency Testing Scheme (Phase XXXIII), organised by the FAO World Reference Laboratory for Foot-and-Mouth Disease (with support from the European Commission for the Control of FMD, EuFMD) and the UK Government's Department of Environment, Food & Rural Affairs (DEFRA).

For the results that you have submitted, we define your performance as category 4 (see Appendix 1). Based on the range of test you have performed this capability is consistent with a laboratory located in a PCP 5 country. See Table 1 for further guidance on what additional test you may want to include in the future.

Performance	Capability
4	5

* As the virology panel 1 was not received by your laboratory, the capability defined here is determined by test results generated for serology panel 2.

Please contact us if you have any queries or corrections to the way in which we have interpreted the data we have received from you. If we do not hear from you within three weeks, we will consider this the final report.

As always please feel free to contact us if you require any further assistance regarding recommended follow-up and corrective actions arising from this proficiency testing scheme.

Yours sincerely,

Dr Donald King
Head of the Vesicular Reference Laboratory
Head of the WRLFMD

Dr Anna Ludi
Head of Serology
Organiser of the PTS

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Preventing and controlling viral diseases
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Biotechnology and Biological Sciences Research Council

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The Pirbright Institute is also a registered charity.
The Institute receives strategic funding from BBSRC UKRI.

Fig 32. Feedback report on the FMD Proficiency Testing Scheme, 2021 from WRL-FMD, UK

7.4 Training/Capacity building organized for staff of FMD Centres

ICAR-NIFMD organized seven training/capacity building programs on FMD diagnosis, serosurveillnace and seromonitoring in which a total of 22 staff were trained (Table 25)

Table 25. Details of training provided during 2022 by ICAR-NIFMD, Bhubaneswar

Participating Institute/ Organization	No. of persons trained	Period of training	Duration (Days)	Type of training
FMD Regional Centre, Cuttack, Odisha	1	01-02-2022 to 03-02-2022	3	FMD serosurveillance and hands on training on DIVA ELISA
FMD Collaborating Centre, Patna, Bihar	1	07-02-2022 to 11-02-2022	5	FMD seromonitoring and hands on training on SPC-ELISA
FMD Collaborating Centre, Ranipet, Tamilandu	1	28-02-2022 to 03-03-2022	4	FMD seromonitoring and hands on training on SPC-ELISA
FMD Regional Centre, Cuttack, Odisha	1	05-03-2022	1	Serotype detection by sandwich ELISA
FMD Collaborating Centre, Shillong, Meghalaya	2	10-05-2022 to 13-05-2022	3	FMD serosurveillance and hands on training on DIVA ELISA and Serotype detection by sandwich ELISA
FMD Collaborating Centre, Ranchi, Jharkhand	2	31-05-2022 to 02-06-2022	3	FMD serosurveillance and hands on training on DIVA ELISA and Serotype detection by sandwich ELISA
FMD Collaborating Centre, Hyderabad, Telangana	1	28-06-2022 to 30-06-2022	3	FMD seromonitoring and hands on training on SPC-ELISA
Veterinary Officers of District, Shahdol and Sidhi, MP	5	22-08-2022 to 25-08-2022		Probang/ oropharyngeal fluid (OPF) sample collection from bovine

8.0 Workshops, seminars, summer / winter schools, short courses, etc. convened

S No	Name of Conference / workshop / seminar	Venue/Date	Number of Participants
1	30th Annual Review Meeting (ARM) of State FMD Regional and Collaborating centres and ICAR-NIFMD	SVPUAT, Meerut November 1-2, 2022	~55
2	Dr C.M. Singh Birth Centenary Year Celebrations cum National Webinar on Advances of Veterinary Sciences during 75 Years of Indian Independence (1947-2022)	Virtual 28-02-2022	~100

3	IP Awareness and Training program under National Intellectual Property Awareness Mission by Intellectual Property Office, India	Virtual 12-01-2022	~100
4	International Collaborative Workshop on FMD Vaccine Quality Testing and Enhancing the India's Animal Vaccine Testing Capabilities	February 6-7, 2023 ICAR-IVRI, Bengaluru	~30

30th ARM of state FMD centres held during November 1-2, 2022

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	Strategic Consultation on Preparedness for Prevention of Trans boundary Infectious Diseases of Livestock and Poultry in South Asian Countries. Organized by ILRI & NAAS, on 15th Feb, 2022.	Dr Singh RP
2	International Veterinary Pathology Congress-2022 on "Global Challenges in Rapid Diagnosis and Management of Animal and Poultry Disease for Improved Health and Productivity" at Department of Veterinary Pathology, College of Veterinary Science, Rajendranagar, P.V. Narsimha Rao Telangana Veterinary University, Hyderabad, 17-19 November 2022.	Dr Jana C Dr Sahoo M Dr Rout M Dr Rajeev R Dr Mallick SM Dr Tareni D
3	International seminar on Interventions for control of AMR: Harnessing one health knowledge. a parallel event of Gander In Aquaculture & Fisheries (GAF8) held during 21-22 November at ICAR- Central Institute of Fisheries, Kochi, Kerala.	Dr Singh RP

4	17th Annual Meeting of the OIE/FAO FMD Reference Laboratory Network OIE/FAO representative, laboratory leaders, SAARC. 29th, 30th November, and 1st December 2022. The Wageningen Bioveterinary Research Institute, Lelystad, the Netherlands and online by video conferencing	Dr Singh RP (Physical) Dr Mohapatra JK (Virtual) Dr Saravanan S (Virtual) Dr Ranjan R (Virtual)

National

S No	Name of Symposium/Seminar	Name of Scientists Attended
1	Annual conference of Vice Chancellor of Agricultural University and Directors of ICAR institute on 13th April 2022 at NASC, New Delhi	Dr Singh RP
2	National Seminar on Emerging and Re-emerging Diseases of Camels organized by ICAR-National Research Centre on Camel, Bikaner on 25th April, 2022	Dr Ranjan R
3	1st India Animal Health Summit 2022, at A.P. Sinde Symposium Hall, NASC Complex, New Delhi. July 6-7, 2022	Dr Singh RP
4	National Webinar on cow based rural development organized by ICAR-CIRC, Meerut, UP, 250001 and Dr. CM Singh Endowment Trust on 30th July, 2022	Dr Das T
5	National Webinar on advances of veterinary sciences during platinum jubilee year of Indian Independence organized by Madras Veterinary College,TNVASU, Chennai, Tamil Nadu and Dr. CM Singh Endowment Trust on 30th September, 2022	Dr Das T
6	National Webinar on “Advances in Veterinary Sciences during 75 Years of Indian Independence (1947- 2022)” organized by ICAR-National Institute of High Security Animal Disease, Bhopal, MP & Dr C M Singh Endowment Trust, Bareilly, UP during Dr C M Singh Birth Centenary Year Celebrations (30.11.2021 to 30.11.2022) on 31st October, 2022	All Scientists of ICAR-NIFMD

17th Annual Meeting of the OIE/FAO FMD Reference Laboratory Network

B. Training/Workshop

International		
S No	**Name of Training/Workshop**	**Name of Scientists Attended**
1	FMD Laboratory Investigation Training Course (Online) from 15th November to 13th December, 2022 organized by EuFMD in collaborating with the The Pribright Institute	Dr Mohapatra JK
2	Electron Microscopy (TEM & SEM) workshop held at Ruska Labs, PVNRTVU, Hyderabad on 20th November 2022 in International Veterinary Pathology Congress-2022.	Dr Ranjan R Dr Mallick SR
National		
S No	**Name of Training/Workshop**	**Name of Scientists Attended**
1	"Science Administration and Research Management" (sponsored by Department of Science & Technology, Government of India, New Delhi) held at ASCI, Hyderabad from September 05-16, 2022.	Dr Saravanan S
2	National Workshop and Brain-storming session on "Strategy on Control and Eradication of Formidable Transboundary Viral Diseases of Livestock-FMD, LSD and ASF" jointly organised by NAVS and GADVASU at GADVASU during November 14-15, 2022.	Dr Singh RP Dr Biswal JK
3	Webinar on 34th Batch Training in Generic Online Training in Cyber Security on 30th March, 2022 by Ministry of Electronics and Information Technology (MeitY), Government of India.	Dr Sahoo AP Dr Das S
4	National Workshop cum Awareness Programme on CeRA, through Zoom platform scheduled on November 21, 2022 organized by Education Division, ICAR, New Delhi	Dr Das S

10.0 Distinguished Visitors

Dr Praveen Malik, AHC, DAHD & Dr Aruna Sharma, DC (LH), DAHD visited ICAR-NIFMD ICFMD Campus, Bhubaneswar on 05th April 2022

Prof Satya Parida, FAO, Italy visited the ICAR-NIFMD (ICFMD), Bhubaneswar on 30th May 2022

Chairman and members of 10th RAC visited ICAR-NIFMD (ICFMD), Bhubaneswar on 15th June 2022

Dr B N Tripathi, DDG (AS), ICAR visited the ICAR-NIFMD (ICFMD), Bhubaneswar (13th Foundation Day) on 05th July 2022

Sh Upamanya Basu, Joint Secretary (LH), DAHD visited the ICAR-NIFMD (ICFMD), Bhubaneswar on 21st Nov 2022

Dr Devendra Tarachand Mourya, ICMR-Chair for Virology & Zoonoses visited the ICAR-NIFMD (ICFMD), Bhubaneswar on 22nd Dec 2022

11.0 Empowerment of Women and mainstreaming gender issues

A total of 19 women farmers from SC community of Benapanjari GP participated on the observance of Kisan Diwas/Farmers Day on 23/12/2022 organized by ICAR-NIFMD. FMD awareness, Swachh Bharat Abhiyan activities and scientific dairy farming practices were discussed in the presence of Sarpanch, Benapanjari GP. The women farmers were distributed with a set of essential input items such as masks, hand-wash, broom, mug, soap and towel for the betterment of their livelihood practices.

12.0 Miscellaneous activities

12.1 हिन्दी अनुभाग:

हिन्दी अनुभाग द्वारा सरकारी कामकाज में हिंदी के प्रयोग को बढ़ावा देने के लिए कई उपाय किए गए हैं। उनका सारांश नीचे दिया गया है:

12.1.1. हिन्दी राजभाषा कार्यान्वयन समिति: आईसीएआर-डीएफएमडी में संस्थान के निदेशक की अध्यक्षता में एक राजभाषा कार्यान्वयन समिति (ओएलआईसी) का गठन किया गया है और इसकी बैठक प्रत्येक तिमाही में नियमित रूप से आयोजित की जाती है। यह समिति राजभाषा विभाग, गृह मंत्रालय द्वारा जारी वार्षिक कार्यक्रम में निर्धारित लक्ष्यों को प्राप्त करने की दृष्टि से राजभाषा नीति के संवैधानिक प्रावधानों को लागू करने की रणनीति तैयार करती है। समिति समय-समय पर राजभाषा (हिंदी) के प्रयोग में हुई प्रगति की समीक्षा करती है और राजभाषा नीति के प्रभावी कार्यान्वयन के लिए सुझाव और उपाय सुझाती है।

12.1.2. राजभाषा नीति का कार्यान्वयन: भारत सरकार की राजभाषा नीति के अनुसरण में, राजभाषा अधिनियम, 1963 की धारा 3)3) के तहत आने वाले सभी दस्तावेज अंग्रेजी और हिंदी में जारी किए जा रहे हैं।

12.1.3. हिन्दी पखवाड़ा2022-: भा.कृ.अनु.प.-खुरपका मुँहपका रोग निदेशालय, अंतर्राष्ट्रीय केंद्र खुरपका मुँहपका रोग, अरुगुल , भुवनेश्वर- 752050, ओड़ीशा में "हिन्दी पखवाड़ा-2022" १५-२९ सितम्बर २०२२ तक मनाया गया। इस हिन्दी पखवाड़ा में विविन्न प्रतियोगिताएँ जैसे कि हिन्दी निबंध प्रतियोगिता: "पशुपालन से आत्मनिर्भरता", कम्प्युटर पर यूनिकोड में हिन्दी अनुवाद टाइपिंग, हिन्दी वाद-विवाद प्रतियोगिता-विषय: संयुक्त परिवार, हिन्दी काव्य-पाठ (स्वरचित/ सस्वर/ बालकविता) प्रतियोगिता (युवा वर्ग) एवं हिन्दी काव्य-पाठ (स्वरचित/ सस्वर/ बालकविता) प्रतियोगिता (बाल-सदस्य) का आयोजन हिन्दी अधिकारी, डा. राजीव रंजन एवं संस्थान के निदेशक महोदय की देख रेख में आभासी एवं प्रत्यक्ष माध्यम द्वारा किया गया। हिन्दी पखवाड़ा-2022 का शुभारंभ १५.०९.२०२२ को कि गयी एवं इस पखवाड़े में संस्थान के वैज्ञानिक, कर्मचारी, अधिकारी एवं उनके परिवार के सदस्यों (पत्नी एवं बच्चें) ने भाग लिया। इस प्रतियोगिता में प्रतिभागियों का चयन निर्णायक मंडल के सदस्यों द्वारा किया गया। प्रतियोगिता में उपस्थित प्रतिभागियों को विभिन्न पुरस्कारों (प्रथम, द्वितीय, तृतीय एवं सांत्वना पुरस्कार) से पुरस्कृत किया गया। हिन्दी पखवाड़ा-2022 के शुभारंभ एवं समापन समारोह में मुख्य अतिथि को आमंत्रित किया गया। हिन्दी पखवाड़ा-2022 का समापन एवं पुरस्कार वितरण ३०.०९.२०२२ को निदेशक महोदय की उपस्थिती में हुआ।

4. Hindi website: वेबसाइट को नियमित रूप से अपडेट भी किया जा रहा है।

5. Aaj ka Shabd: हिंद शब्द को बेहतर बनाने के लिए संस्थान में 'आज का शब्द' लिखा जा रहा है, जिसे हिंदी अधिकारी इस साल भी जारी रखेंगे। इस योजना के तहत अंग्रेजी का एक शब्द और उसका हिंदी पर्याय बोर्ड पर प्रदर्शित किया जा रहा था। ये शब्द प्राय: प्रशासनिक और तकनीकी प्रकृति के होते हैं, जिनका उपयोग दिन-प्रतिदिन के आधिकारिक कार्यों में किया जाता है।

अंग्रेजी में शब्द	हिन्दी में अर्थ
Sealed	मोहरबंद
Response	अनुक्रिया
Administrator	प्रशासक
Council	परिषद
Corrigendum	शुद्धि पत्र
Despatch	रवानगी, प्रेषण
Accure	जमा होना
Scientist	वैज्ञानिक

6. Inspection regarding progressive use of Hindi: राजभाषा विभाग द्वारा जारी वार्षिक कार्यक्रम में निर्धारित लक्ष्यों की प्राप्ति के लिए परिषद् के अधिकारियों ने संस्थान में भ्रमण कर हिन्दी में किये जाने वाले कार्यों का निरीक्षण किया।

Swachha Bharat Activity

ICAR-NIFMD organized Swachha Bharat Activity under Special Campaign 2.0 from 2nd October to 31st October, 2022 and during 16-31 December 2022. Several indoor and outdoor swachhata awareness programs were conducted during this period. On 19.10.2022, an input distribution programme was organized under DAPSC at Kansapada village of Haripur Gram Panchayat, Jatni block. A cleanliness drive was held during the programme followed by an awareness programme on Swachhata and scientific goat and poultry farming practices. Dr R P Singh, Director, ICAR-DFMD, Dr JK Mohapatra, Dr NR Sahoo and Dr S Mallick attended the programme. Dr Singh shared his views about the importance of cleanliness and hygiene to lead a healthy life. After the awareness programme a total of 25 farmers were distributed with a set of essential items such as masks, handwash, broom and phenyl for the betterment of their livelihood practices. On 21.10.2022 Swachha Bharat activity was organized at Arugul village of Haripur Gram Panchayat, Jatni block. The programme was organized by Dr S Mallick, Scientist, ICAR-NIFMD. A cleanliness drive was held and awareness was created on Swachhata and scientific dairy farming practices. A total of 15 farmers from SC community were distributed with a set of essential input items such as facemasks, hand-wash, broom and phenyl bottle.

12.2 Celebration of Important Day/ Events

Important Day	Name of Events	Date of Celebration and Venue	Participants
National Girl Child Day	Webinar on 'Role of Agriculture and Allied sectors in empowering girl child' Selfie with daughters of Employees	24.01.2022; Virtual mode	20
World Water Day 2022	Awareness cum interaction at Mukteswar Drain line cleaning and sanitation at Mukteswar campus Awareness cum sensitization programme at ICFMD, Bhubaneswar (virtual mode)	22.03.2022; Mukteswar, Nainital and virtual mode	27
World Veterinary Day 2022	Two awareness cum animal health camps. Distribution of Calcium supplements for lactating cattle among farmers.	30.04.2022; Sunhkiya and Diyari Villages, Nainital Uttarakhand	71
13th Foundation Day of ICAR-NIFMD		05-07-2022 ICFMD, Bhubaneswar	500

13th Foundation Day Celebration

ICAR-NIFMD celebrated its 13th Foundation day on July 5. Dr. B.N. Tripathi, DDG (AS), ICAR, New Delhi, visited as chief guest to mark the event. Dr. R.P. Singh, Director of ICAR-NIFMD, gave a brief overview of the institute's and FMD's accomplishments. Dr S K Bandyopadhyay, Former Animal Husbandry Commissioner & Member ASRB, Ex. FAO Expert, presented a Foundation Day Lecture on "Prevention and management of transboundary animal diseases (TAD) with specific reference to FMD". More than 150 people participated in this foundation day ceremony, both online and in person. Persons associated with AICRP on FMD/ PNIFMD/ NIFMD/ ICFMD also expressed their experiences and emotions during the celebrations.

On this occasion, "Input distribution programme" for the scheduled caste community was organised under the DAPSC programme, Dr. B.N. Tripathi, DDG (AS), ICAR, New Delhi, inaugurated the "Water Harvesting Facility" at ICAR-NIFMD-ICFMD before the start of the programme.

13.0 Various Committees

13.1 Research Advisory Committee

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, CVS, AAU	Member
Dr S.K. Yadav	Former Prof. and Head, DUVASU, Mathur, UP	Member
Dr V A Srinivasan	Former Advisor, NDDB	Member
Dr Bhaskar Sharma	Former National Professor, ICAR-IVRI, Bareilly	Member
Dr R P Singh	Director, ICAR-NIFMD, Bhubaneswar	Member
Dr Ashok Kumar	ADG (AH), ICAR, New Delhi-110 001	Member
Dr Sanjeev Gupta	S/o Sh. Nand Kumar Gupta, Dehradun	Member
Shri Tara Dutt Joshi	S/O Sh. ManoharDutt Joshi, Nainital	Member
Dr Saravanan S	Pr. Scientist, ICAR-NIFMD	Member Secretary

13.2 Institute Technology Management Committee

Name	Designation	Role
Dr Rabindra Prasad Singh	Director, ICAR-NIFMD	Chairman
Dr S K Singh	Joint Director (R), IVRI, Izatnagar	External Member
Dr Jajati K Mohapatra	Pr. Scientist, ICAR-NIFMD	Member
Dr Saravanan S	Pr. Scientist, ICAR-NIFMD	Member
Dr Shyam Singh Dahiya	Scientist, ICAR-NIFMD	Member
Dr J K Biswal	Sr. Scientist, ICAR-NIFMD	Member Secretary

13.3 Institutional Animals Ethics Committee

Name	Designation	Role
Dr Jajati K Mohapatra	Pr. Scientist, ICAR-NIFMD	Biological Scientist (Chairperson)
Dr. Prakash Kumar Sahoo	ICMR-RMRC, Bhubaneswar	CPSEA Nominee
Shri. Narendra Kumar Parida	The College of Pharmaceutical Sciences, Bhubaneswar	Link Nominee
Dr. S. Parthasarathy	Fisheries & Animal Resources Development Dept, Govt of Odisha,	Scientist from outside of the Institute
Shri Amulya Nayak	PFA, Jagatsinghpur	Socially aware Nominee

Dr. A P Sahoo	Sr. Scientist, ICAR-NIFMD	Scientist from different biological discipline
Dr J K Biswal	Sr. Scientist, ICAR-NIFMD	
Dr Smrutirekha Mallick	Scientist, ICAR-NIFMD	Veterinarian
Dr Rajeev Ranjan	Sr. Scientist, ICAR-NIFMD	Scientist In-charge of Animal House Facility (Member Secretary)

13.4 Institutional Biosafety Committee

Name	Designation	Position
Dr Rabindra Prasad Singh	Director, ICAR-NIFMD	Chairman
Dr Biswajit Mishra	Medical consultant, Khurda	Biosafety officer
Dr Sandeep Bhatia	Pr. Scientist, NIHSAD, Bhopal	Outside Expert
Dr Sidhartha Giri	Scientific E, ICMR-RMRC, Bhubaneswar	DBT nominee
Dr Rajeev Ranjan	Sr. Scientist, ICAR-NIFMD	Internal Member
Dr Shyam Singh Dahiya	Scientist, ICAR-NIFMD	Internal Member
Dr J K Biswal	Sr. Scientist, ICAR-NIFMD	Internal Member
Dr Jajati Keshari Mohapatra	Pr. Scientist, ICAR-ICFMD	Internal Member & Member Secretary

13.5 Institute Management Committee

Name	Designation	Position
Dr Rabindra Prasad Singh	Director, ICAR-NIFMD, Bhubaneswar	Chairman
Dr D Hemadri	Principal Scientist, NIVEDI, Bengaluru	Member
Dr C Tosh	Principal Scientist, NIHSAH, Bhopal	Member
Dr B P Srinivas	Principal Scientist, IVRI, Bengaluru	Member
Dr Sanjay Barua	Principal Scientist, VTCC, NRCE, Hisar	Member
Dr. Ashok Kumar	ADG (AH), ICAR, New Delhi-110 001	Member
Dr Shiba Prasad Biswal	S/o Basanta Kumar Biswal, Bhubaneswar.	Member
Dr Jayanta Mondal	S/o Late Janaki Mondal Bankura, West Bengal	Member
Mr Tarakumar	AAO, ICAR-NIFMD, Bhubaneswar	Member Secretary

13.6 हिन्दी राजभाषा कार्यान्वयन समिति

- डा. रवीन्द्र प्रसाद सिंह : निदेशक एवं अध्यक्ष
- डा. जजाति केशरी महापात्र : प्र. वैज्ञानिक एवं सदस्य
- डा. चंद्रकांत जाना : प्र. वैज्ञानिक एवं सदस्य
- डा. सरवनन सुबरमणियम : वरिष्ठ वैज्ञानिक एवं सदस्य
- डा. सागर अशोक खुलापे : वैज्ञानिक एवं सदस्य
- श्री तारा कुमार : स.प्र.अ. एवं सदस्य
- डा. राजीव रंजन : वरिष्ठ वैज्ञानिक, हिन्दी अधिकारी एवं सदस्य सचिव ।

Staff of ICAR-NIFMD

S No	Name	Designation
1	Dr. Rabindra Prasad Singh	Director (RMP)
	Scientific staff	
	Veterinary Microbiology	
1	Dr. Jajati K Mohapatra	Principal Scientist
2	Dr. Saravanan Subramaniam	Principal Scientist
3	Dr. Shyam S Dahiya	Scientist (Sr. Scale)
	Veterinary Pathology	
4	Dr Chandrakanta Jana (up to 08-12-22)	Principal Scientist
5	Dr. Monalisa Sahoo	Senior Scientist
6	Dr. Manoranjan Rout	Senior Scientist
7	Dr. Rajeev Ranjan	Senior Scientist
8	Dr. Tareni Das	Scientist
	Animal Physiology & Biochemistry	
9	Dr. Jitendra K Biswal	Senior Scientist
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)
	Agriculture Statistics	
14	Dr Samarendra Das	Scientist (Sr. Scale)
	Technical staff	
1	Sh. Nayan Sanjeev	T-5 (Lab)
2	Sh. S.L.Tamta	T-1 (Lab)
	Administrative staff	
1	Sh. Tara Kumar	AAO
2	Sh Prabhat Kumar Nayak	F&AO (Additional Charge, Regular service in CIWA))
3	Sh. R.N.Sahoo	Assistant
4	Sh. Ravi Chaudhary	Junior Stenographer

Promotion/Transfer

Dr Biswal JK and Dr Ranjan R promoted as Sr. Scientist (From RGP 7000 to RGP 8000)

Dr Samarendra Das Joined ICAR-NIFMD on 04-04-2022

Dr. Tareni Das Joined ICAR-NIFMD on 27-07-2022

Dr Chandrakanta Jana relieved from ICAR-NIFMD on 08-12-022

Sh. Tara Kumar and Sh. Ravi Chaudhary transferred from regional campus, Mukteswar to Head Office, Bhubaneswar

In Charges of section/unit/cell

Sl No	In Charge/Nodal Officer	Section/unit/cell/others
1	Dr Mohapatra JK	Scientist In-Charge ICFMD, Bhubaneswar Bio Safety Officer Public Relation Officer
2	Dr Saravanan S	PME cell Vigilance Officer NSL, Bengaluru
3	Dr Biswal JK	ITMU
4	Dr Ranjan R	Animal House Facility HRD Hindi Cell Krishi Portal
5	Dr Mallick SM	Women Cell Horticulture and civil management Swachh Bharat Abhiyan General Item Store
6	Dr Rout M	DAPSC
7	Dr Jana C	DAPST
8	Dr Sahoo NR	NEH
9	Dr Dahiya SS	Engineering Section
10	Dr Sahoo AP	Website Management
11	Dr Das S	Library & Journal Club
12	Dr Khulape SA	Public Information Officer, Scientific RTI, CPGRAMS, Mukteswar Centre

NOTE

ICAR- National Institute on Foot and Mouth Disease
Arugul, Bhubaneswar-752050, Odisha