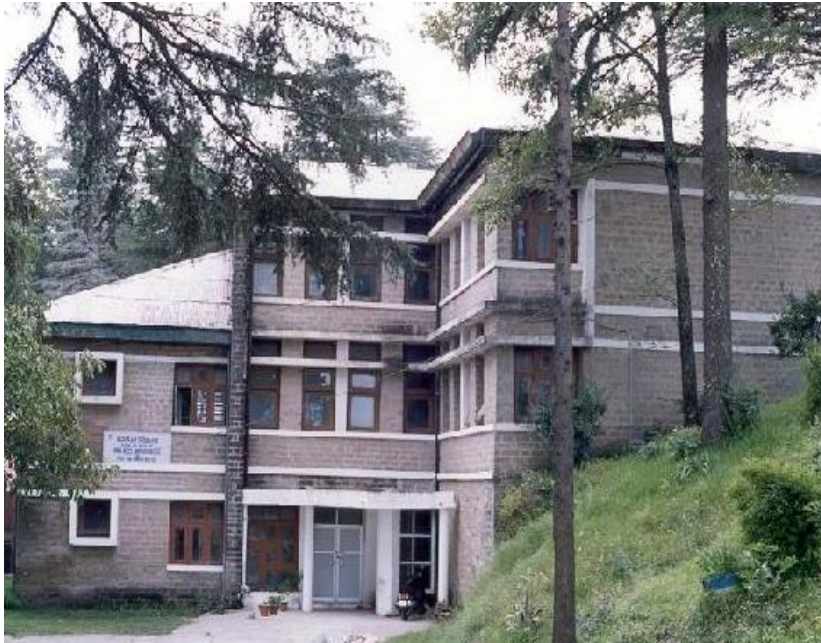


South Asia: Action Plans, future directions and needs

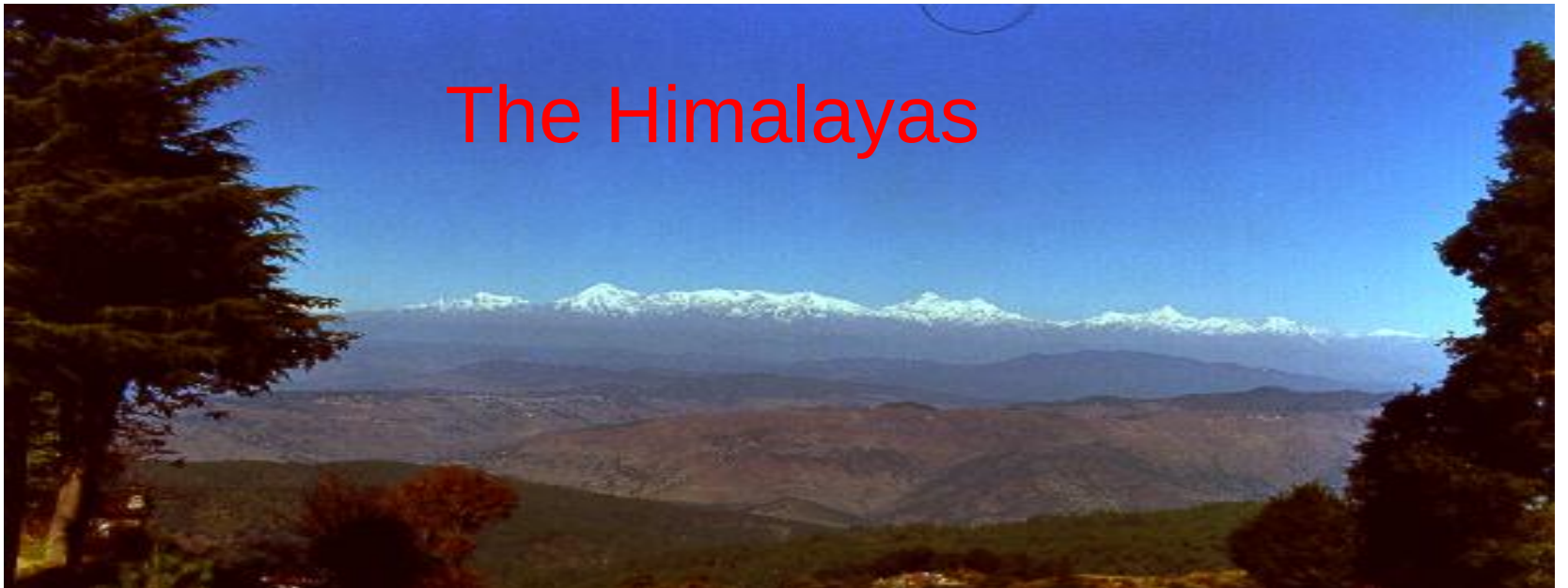


Bramhadev Pattnaik
Project Director

Project Directorate on Foot and Mouth Disease
Indian Council of Agricultural Research
Mukteswar-263 138



The Himalayas



Susceptible Livestock Population in SAARC countries

Country	Species (in millions)			
	Cattle	Buffalo	Goats	sheep
Bangladesh	23	1.3	21.6	2.8
Nepal	9.71		4.3	
Pakistan	26	28	62	26
Sri Lanka	1.1	0.4	0.38	0.08
Afghanistan	1	--	1.1	7.7
Bhutan	9.9	2.1		
India	199	105.3	71.5	140.5

Total cattle and buffalo population is ~ 400 millions

Agro-climatic zones in SAARC countries

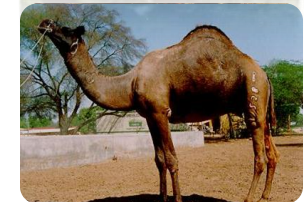
S No	Country	Agro-Climatic zones
1	Nepal	5
2	Bhutan	6
3	Sri Lanka	3
4	India	20
5	Pakistan	30

Scenario in India

Susceptible Livestock



The country has 528 million FMD susceptible livestock population & several species of wild animals





Scenario in India

- FMD virus serotypes O, A, and Asia-1
- Serotype O predominates in India followed by serotypes A and Asia-1, in terms of number of outbreaks caused
- Emergence and re-emergence of strains
- Control is mainly sought by vaccination programme and constant surveillance and monitoring



Scenario in South Asia

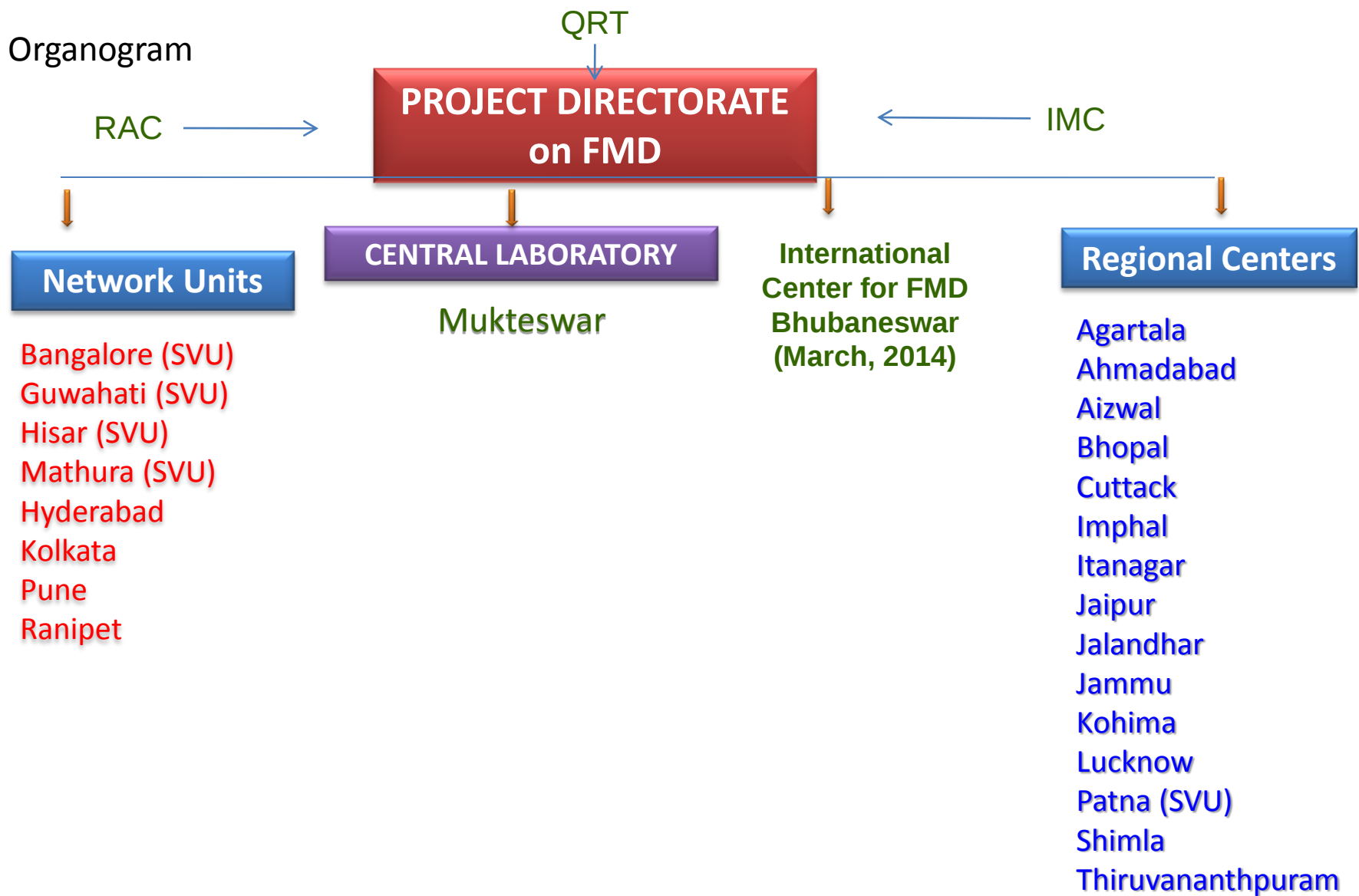
- Most important disease currently causing severe economic difficulties to the sub-regions
- Endemic in all countries in the region and occurs throughout the year
- Serotypes prevalent are O, A, and Asia-1
- Serotype O predominates followed by A and Asia-1
- Sri Lanka has recorded only serotype O for more than 10 years now



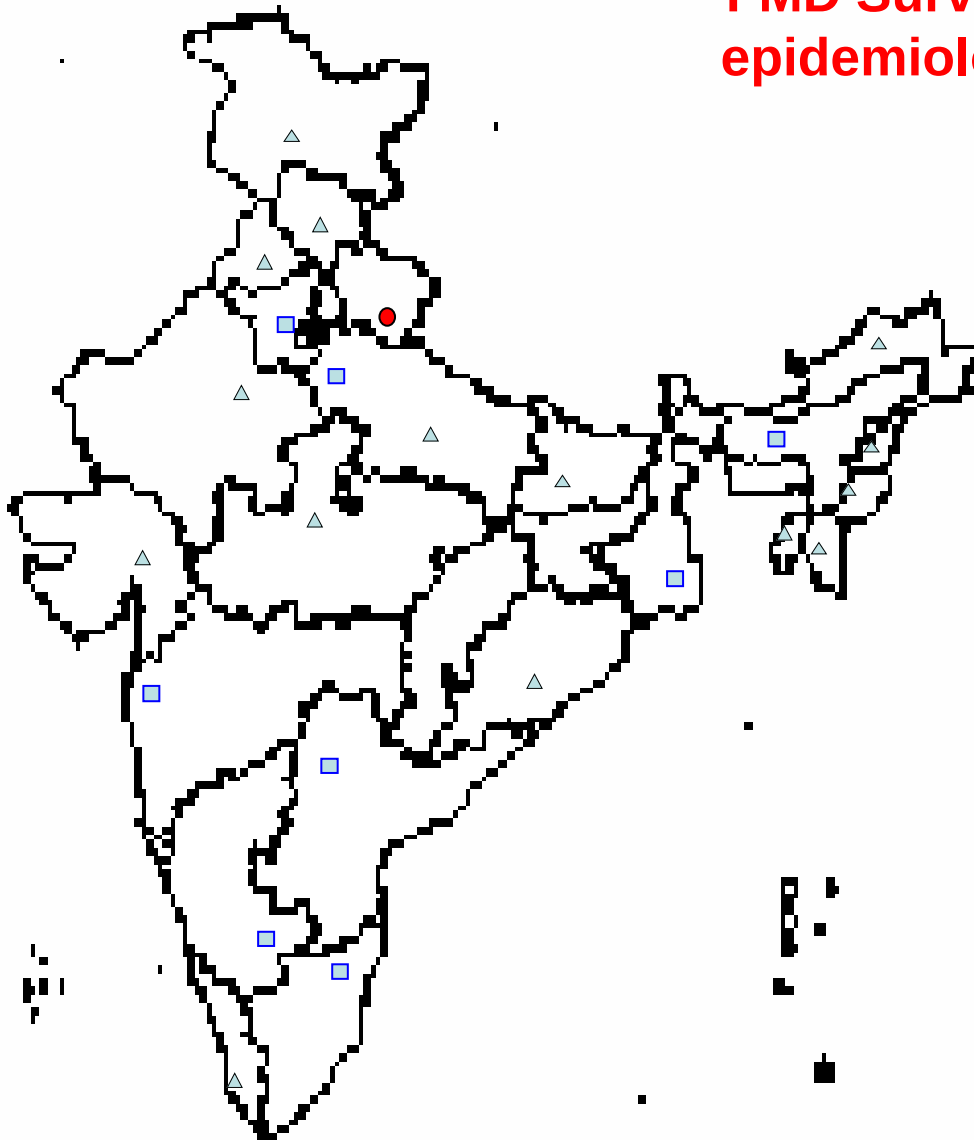
FMD Research In India/ ICAR

- 1943- “Vaccination of Indian cattle against FMD”
- 1968- "All India Co-ordinated Research Project for FMD virus typing"
- 1971- “All India Co-ordinated Research Project for Epidemiological studies on Foot-and-Mouth Disease”
- 2001- Upgraded to an Institute (Project Directorate on FMD)

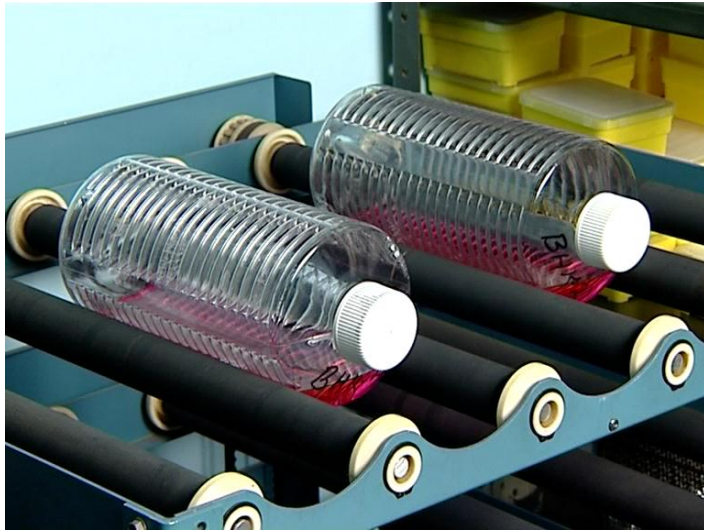
Organogram



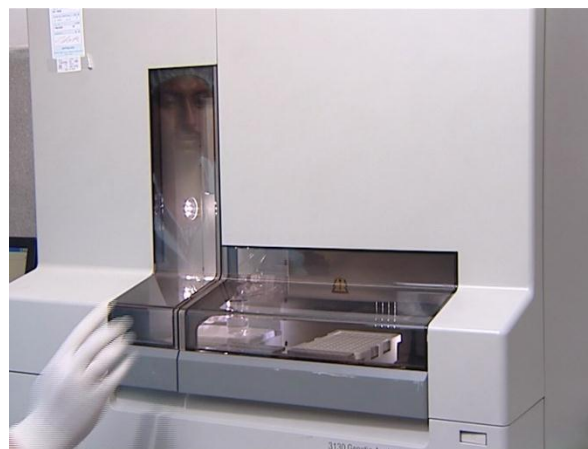
FMD Surveillance and epidemiology network











International Center for FMD



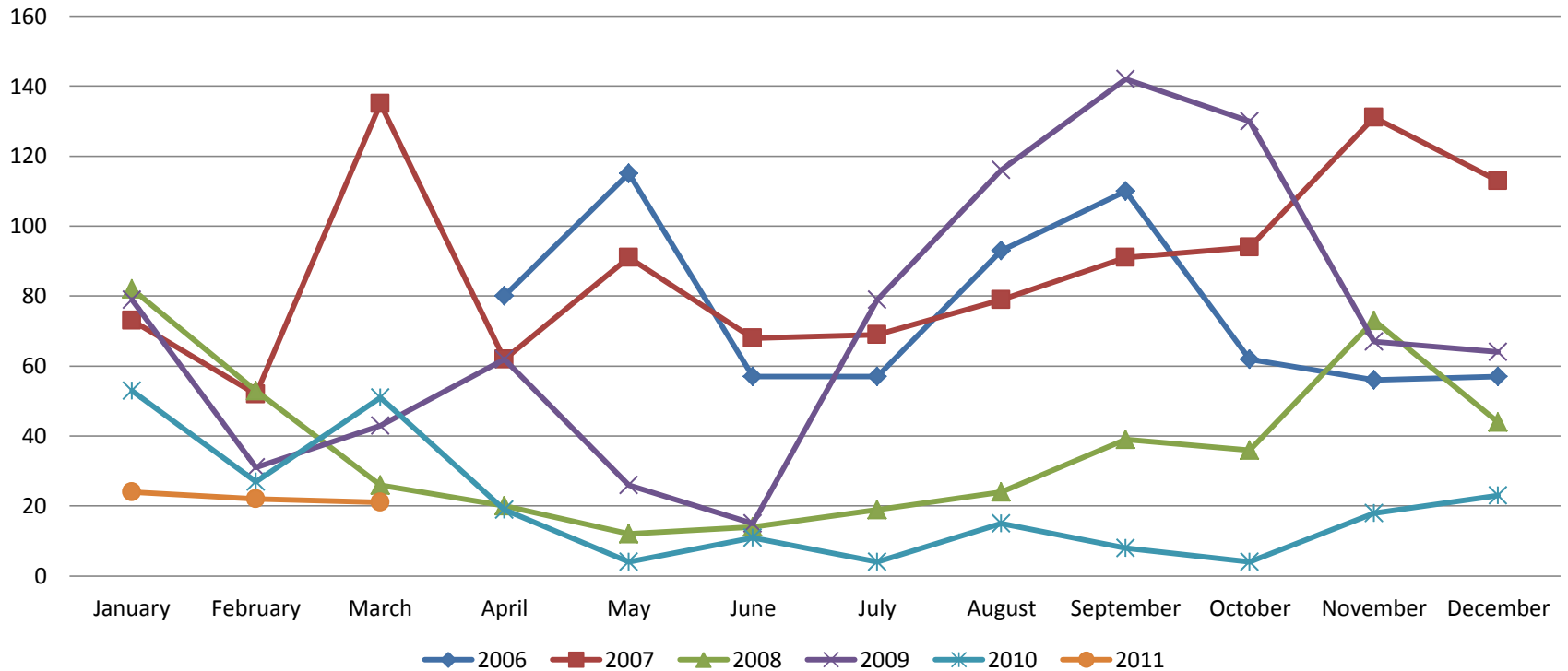
LABORATORY COMPETENCY & STRENGTH

- **Network of Laboratories and trained man power**
- **Diagnostic competency and Indigenous kits**
- **Sandwich ELISA for FMDV serotype identification**
- **LPB ELISA for seromonitoring**
- **DIVA Panel test**
- **Virus diagnosis in bovine semen**
- **Two-dimensional Micro-neutralization and LPB-ELISA for vaccine matching**
- **Multiplex PCR for serotyping of FMDV on difficult samples**
- **Molecular typing for identification of lineage and sub-lineages**
- **Molecular epidemiology and virus evolution**
- **Complete genome sequence analysis to monitor recombination(s).**
- **Recombinant antigen and recombinant antibody**
- **Cytokine response analysis**
- **Bioinformatics**
- **National FMD virus repository**
- **National FMD sero-surveillance**

FMD outbreaks 2006-11

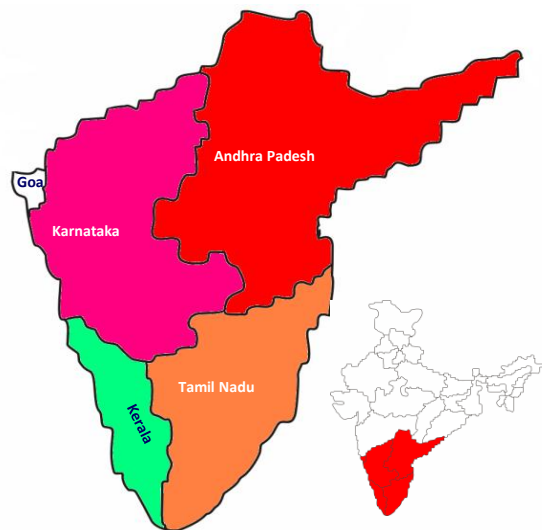
Year	No. of Outbreaks reported	No. of outbreaks investigated	Serotype O	Serotype A	Serotype Asia-1
2006-07	1467	1210	748	141	321
2007-08	1211	842	721	65	56
2008-09	511	241	198	19	24
2009-10	799	610	568	33	09
2010-11	253	180	154	10	16
TOTAL	4241	3083	2389	268	426

Occurrence of FMD outbreaks in different seasons

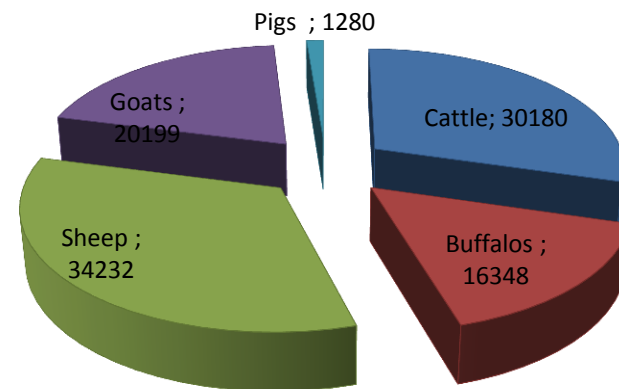


Outbreak occur through out the year
Maximum in end of the monsoon and post monsoon season

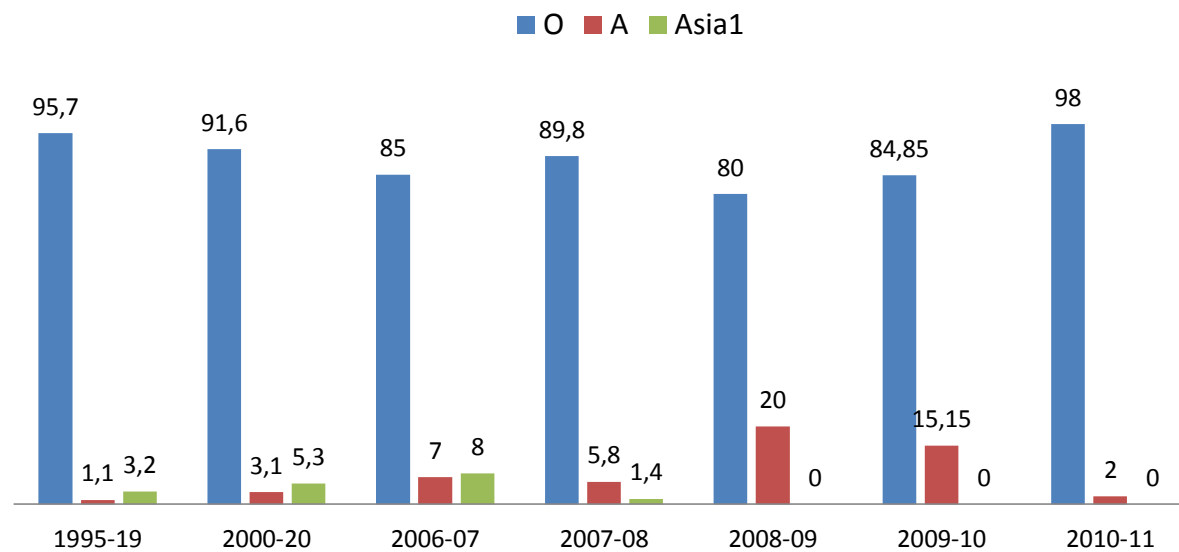
Scenario of FMD in Southern Region



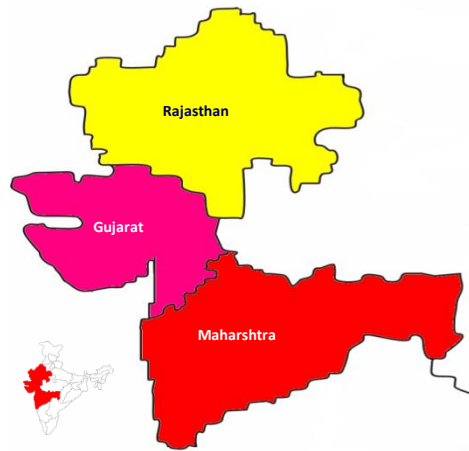
Susceptible animal population (in thousands)



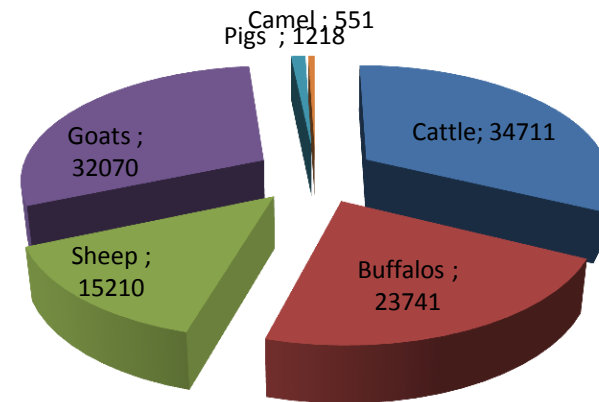
Serotype-wise prevalence



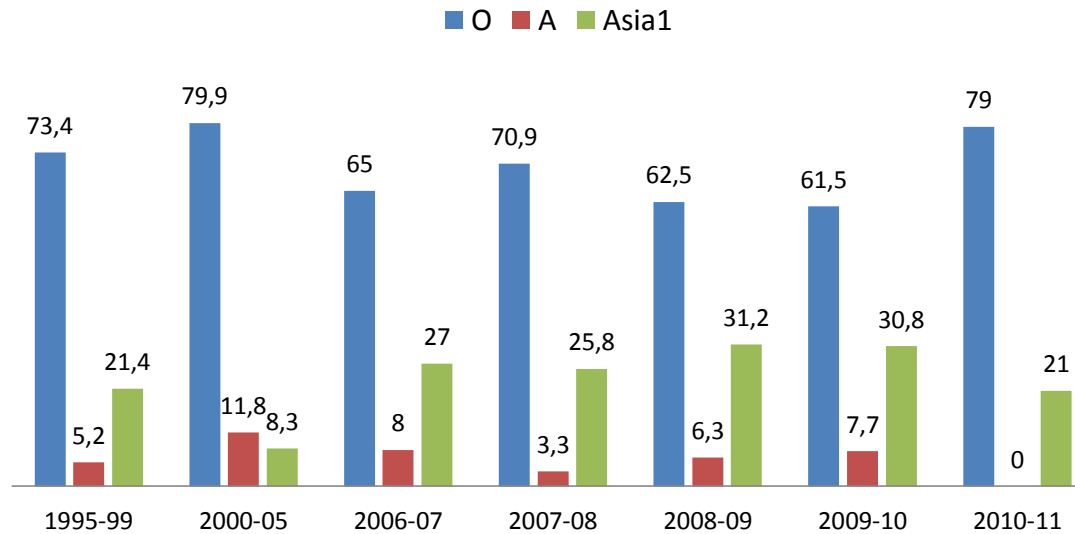
Scenario of FMD in Western Region



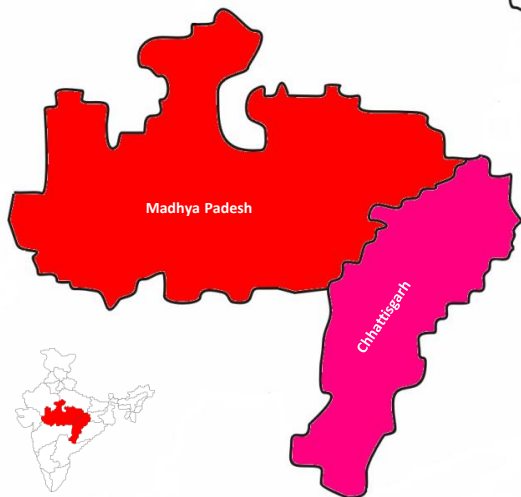
Susceptible animal population
(in thousands)



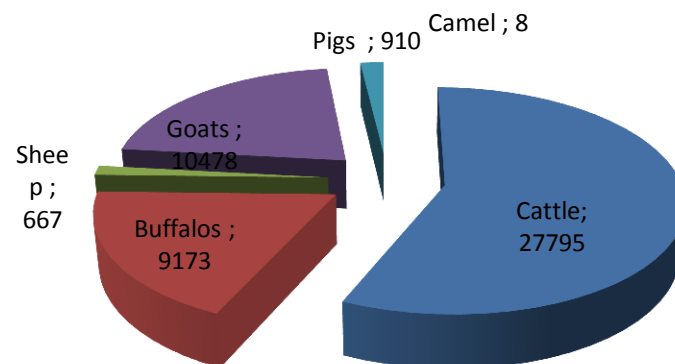
Serotype-wise prevalence



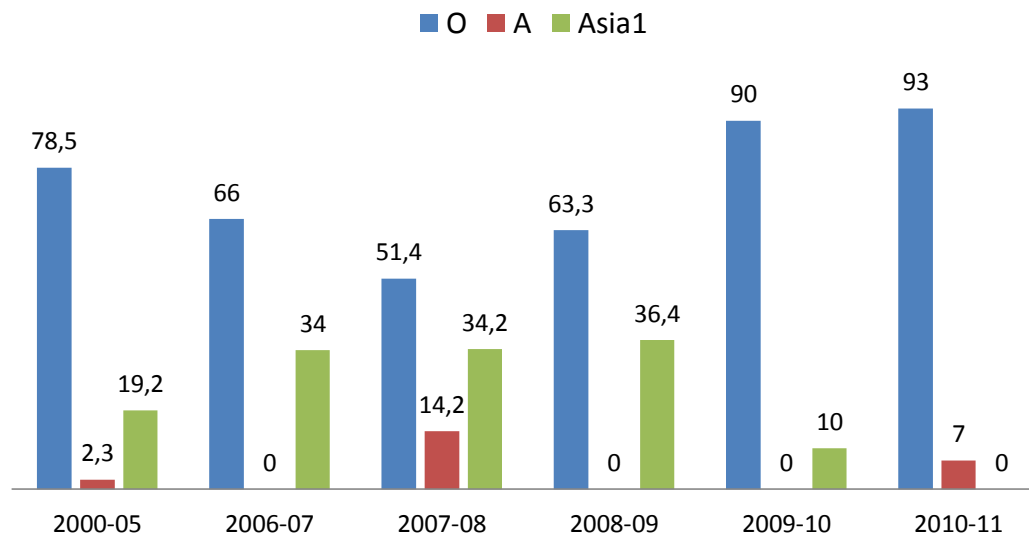
Scenario of FMD in Central Region



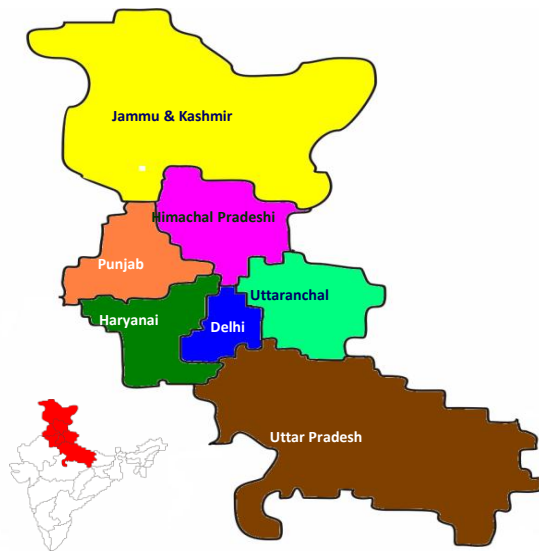
Susceptible animal population
(in thousands)



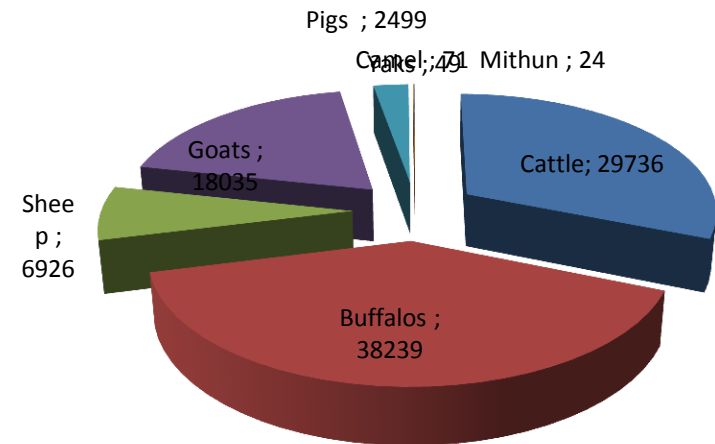
Serotype-wise prevalence



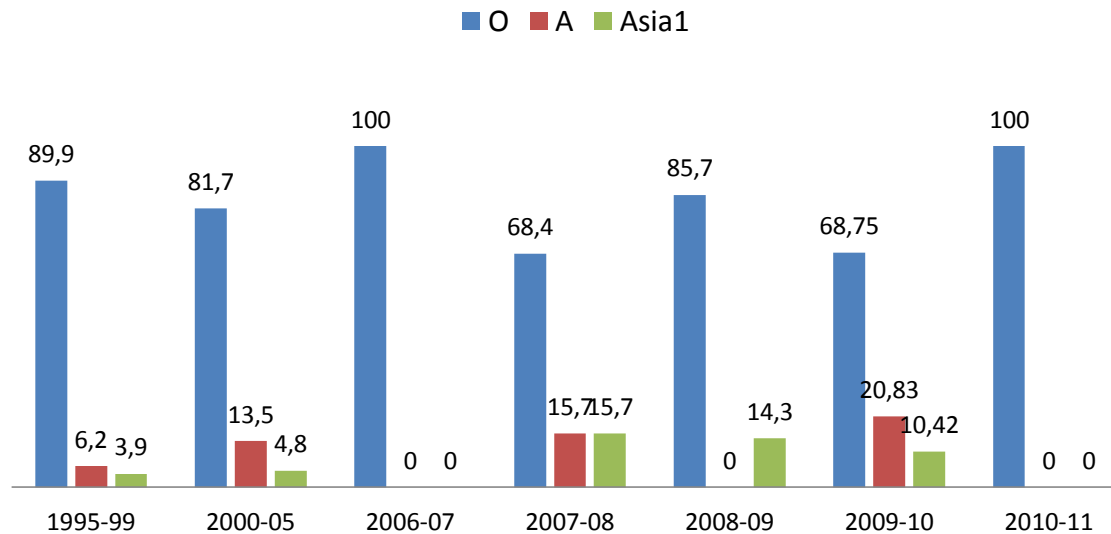
Scenario of FMD in Northern Region



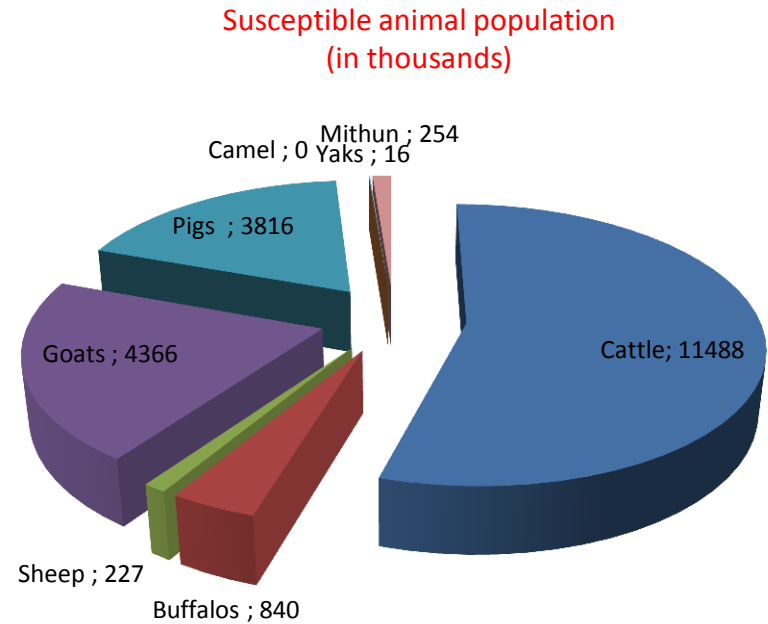
Susceptible animal population
(in thousands)



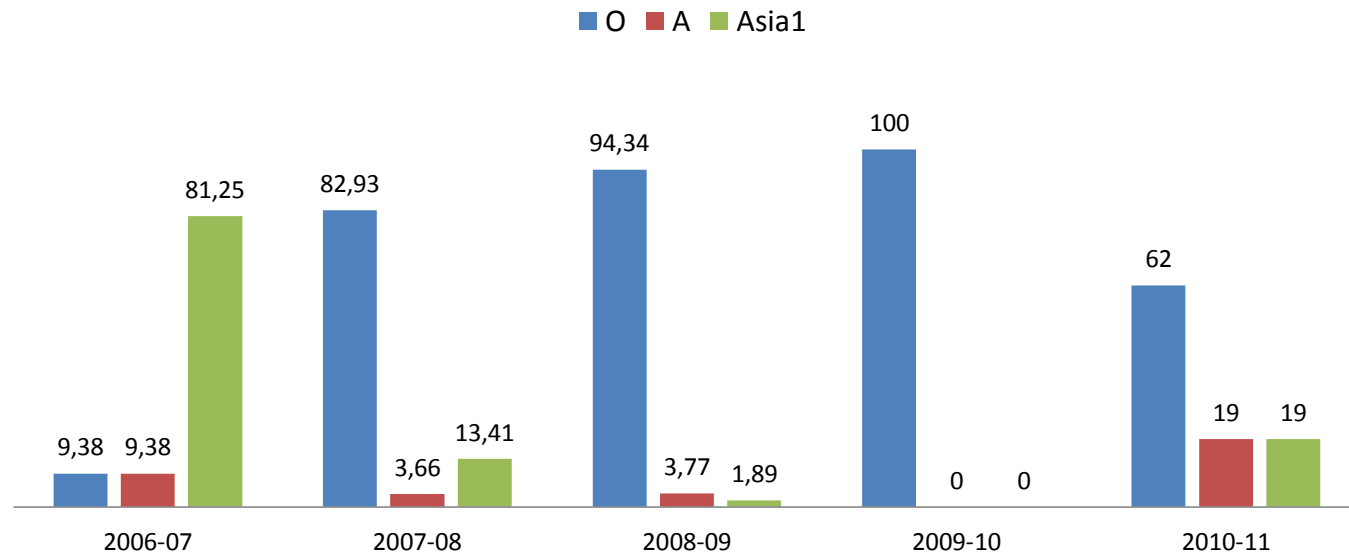
Serotype-wise prevalence



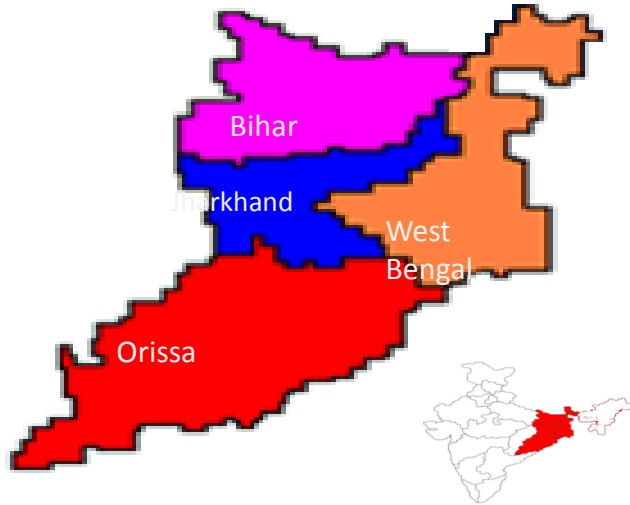
Scenario of FMD in North Eastern State



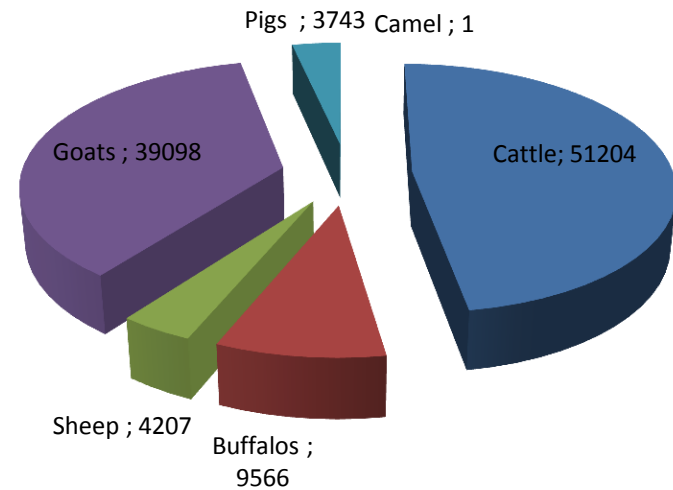
Serotype-wise prevalence



Scenario of FMD in Eastern State

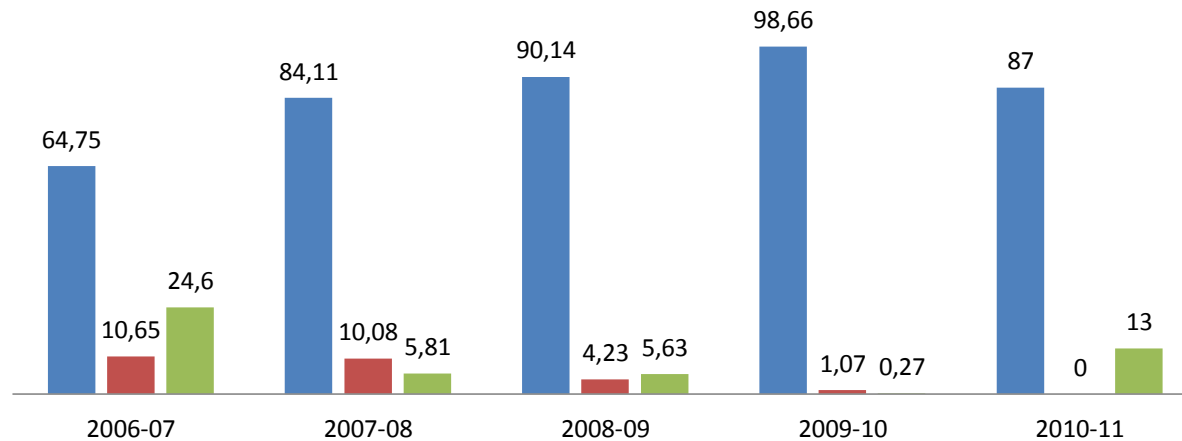


Susceptible animal population
(in thousands)



Serotype-wise prevalence

■ O ■ A ■ Asia1



Vaccine Matching Exercise

Year	Type O	Type A	Type Asia1
2006-2007	12	11	7
2007-2008	36	13	14
2008-2009	35	8	16
2009-2010	20	6	9
2010-2011	16	10	1
TOTAL	119	48	47

Vaccine Matching exercise 2010-11

- 1. Antigenically divergent strains within the VP3⁵⁹-deletion group in serotype A was observed that supports within the group antigenic diversity.**
- 2. All vaccine strains maintained their appropriateness in the scenario of emergence and re-emergence.**

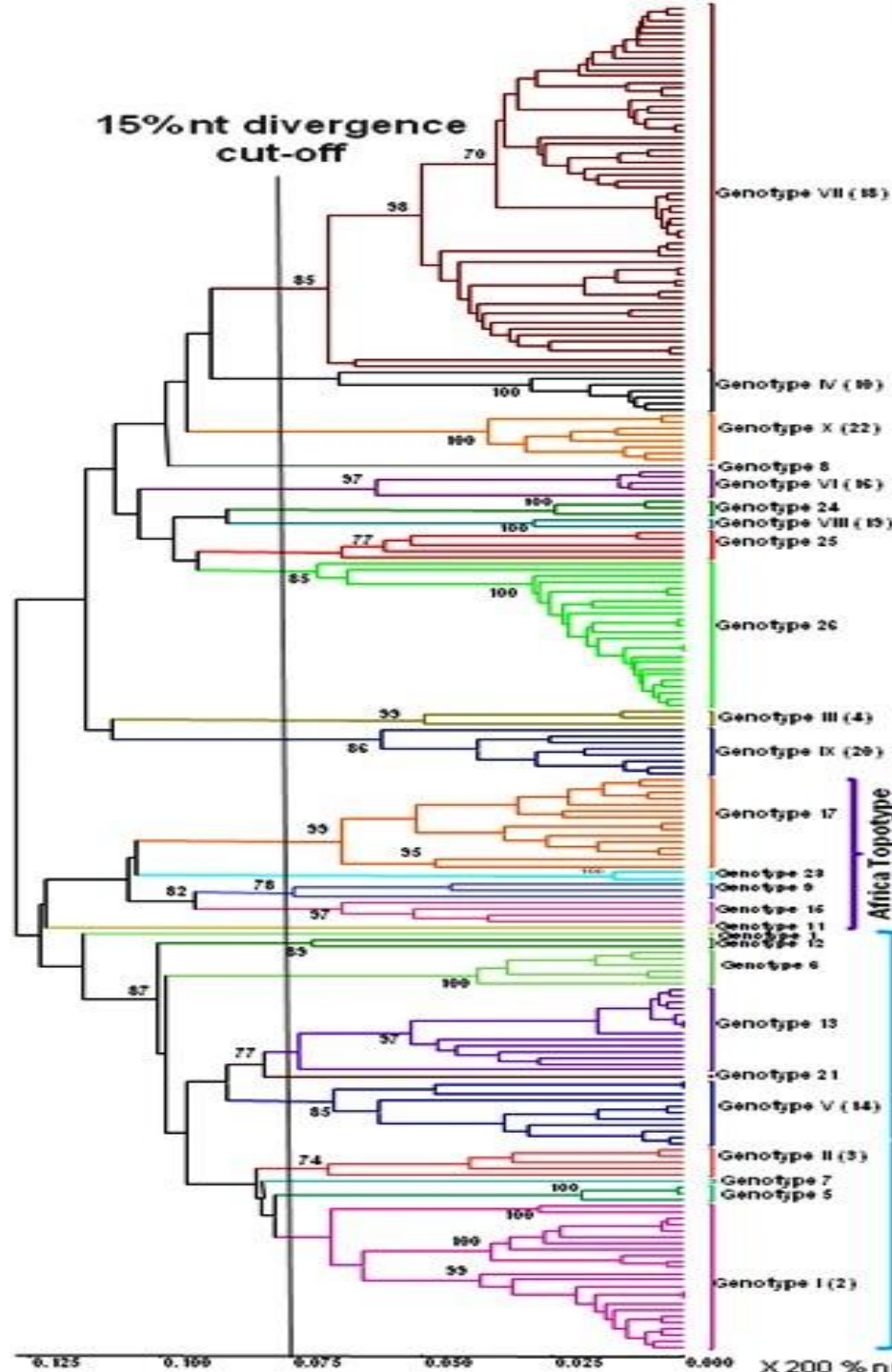
Molecular Epidemiology

➤ Phylogenetic analysis based on 1D region to assess genetic variations, inter-strain relationships and track movement of the virus.

Year	Type O	Type A	Type Asia1
2006-2007	25	11	5
2007-2008	49	17	19
2008-2009	40	7	6
2009-2010	116	7	11
2010-2011	46	11	7
TOTAL	276	53	48

Phylogenetic structure of serotype A foot-and-mouth disease virus

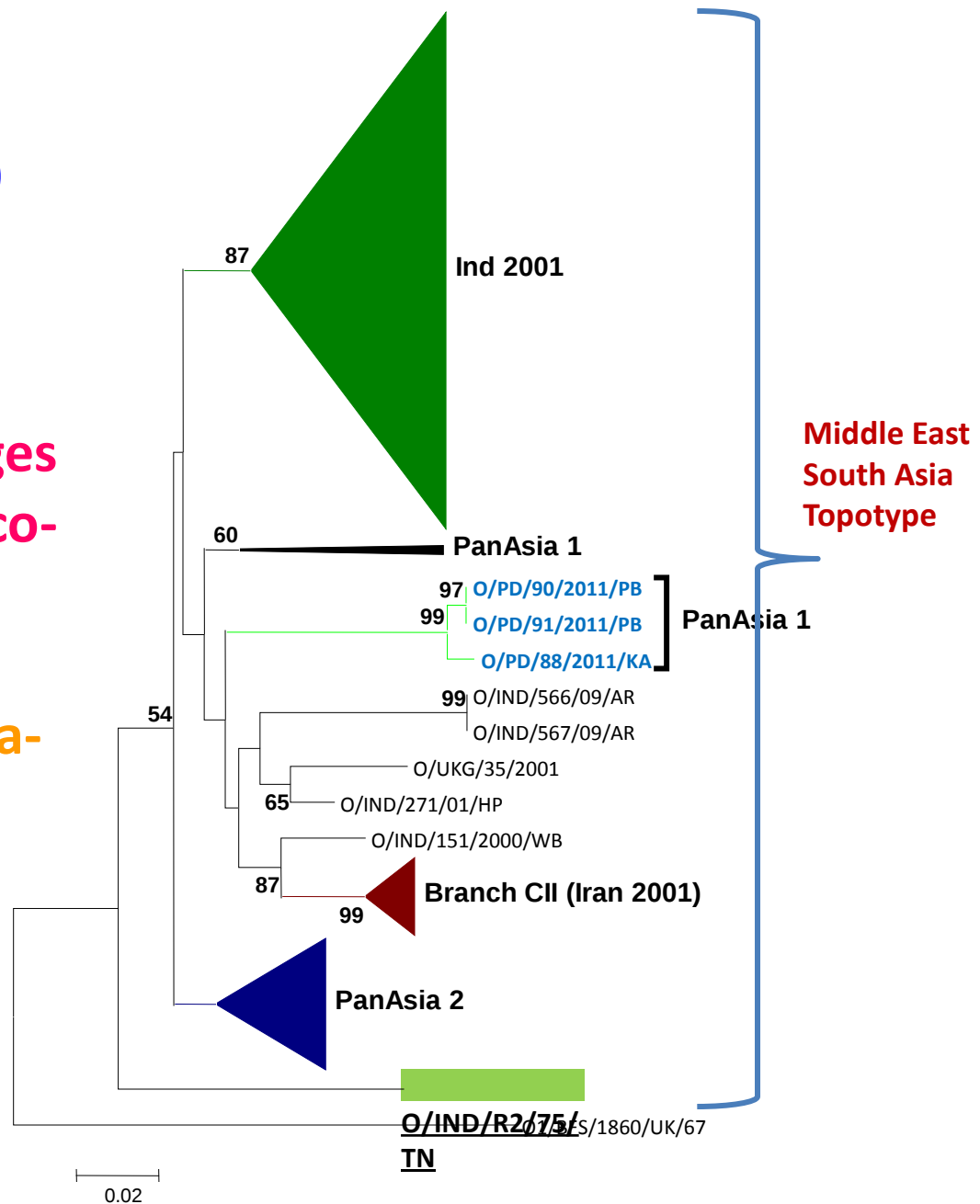
A total of **26 regional genotypes** within **3 continental topotypes**, based on 15% nucleotide divergence cut-off criterion. These are distinct evolutionary lineages.



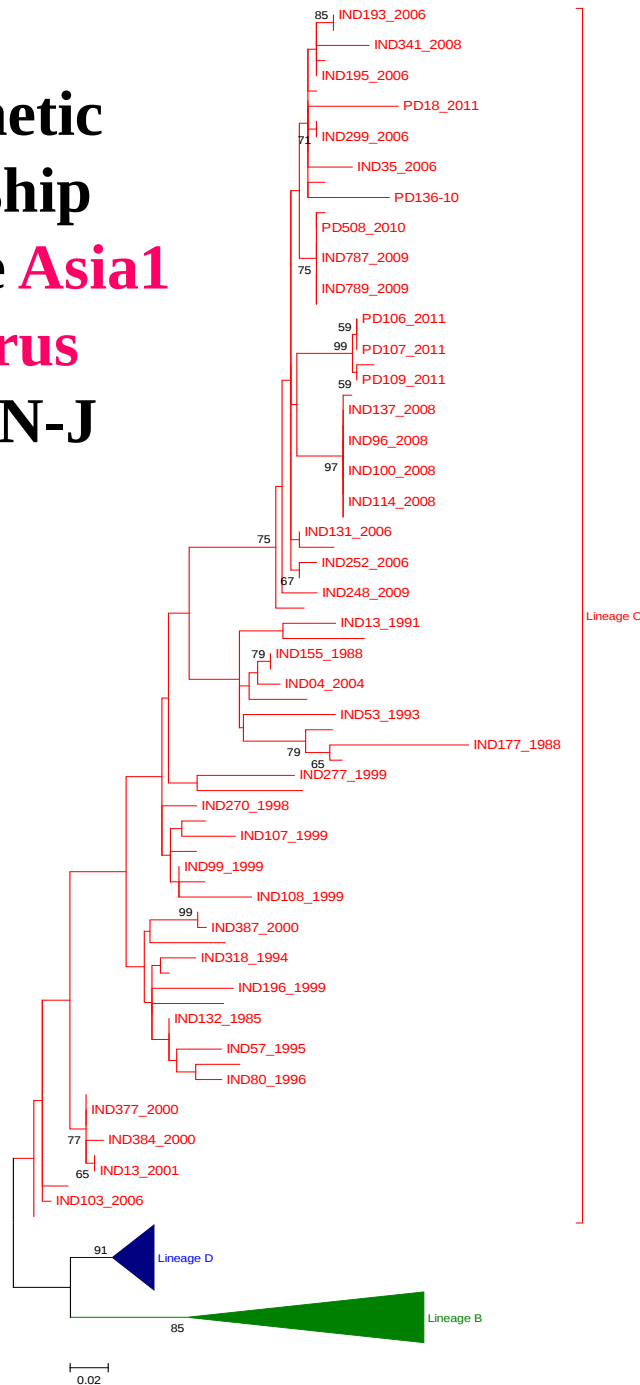
In India, four genotypes [genotypes I (2), IV (10), VI (16) and VII (18)] have been documented. **Genotypes 2 (Euro-SA topotype) and 10 (Asia topotype) were recorded before 1990 and no longer seem to exist in India.**

Indian serotype O FMD virus. (N-J tree)

There are 3 sub lineages
of FMD virus type O co-
circulating in India,
namely “Ind2001”,
PanAsia-1 and PanAsia-
2 .



**Phylogenetic
relationship
among type **Asia1**
FMD virus
isolates (N-J
tree).**



Of the three lineages (B, C and D) present in the country, **Lineage C has been responsible for all Asia1 outbreaks in the country since 2005.**

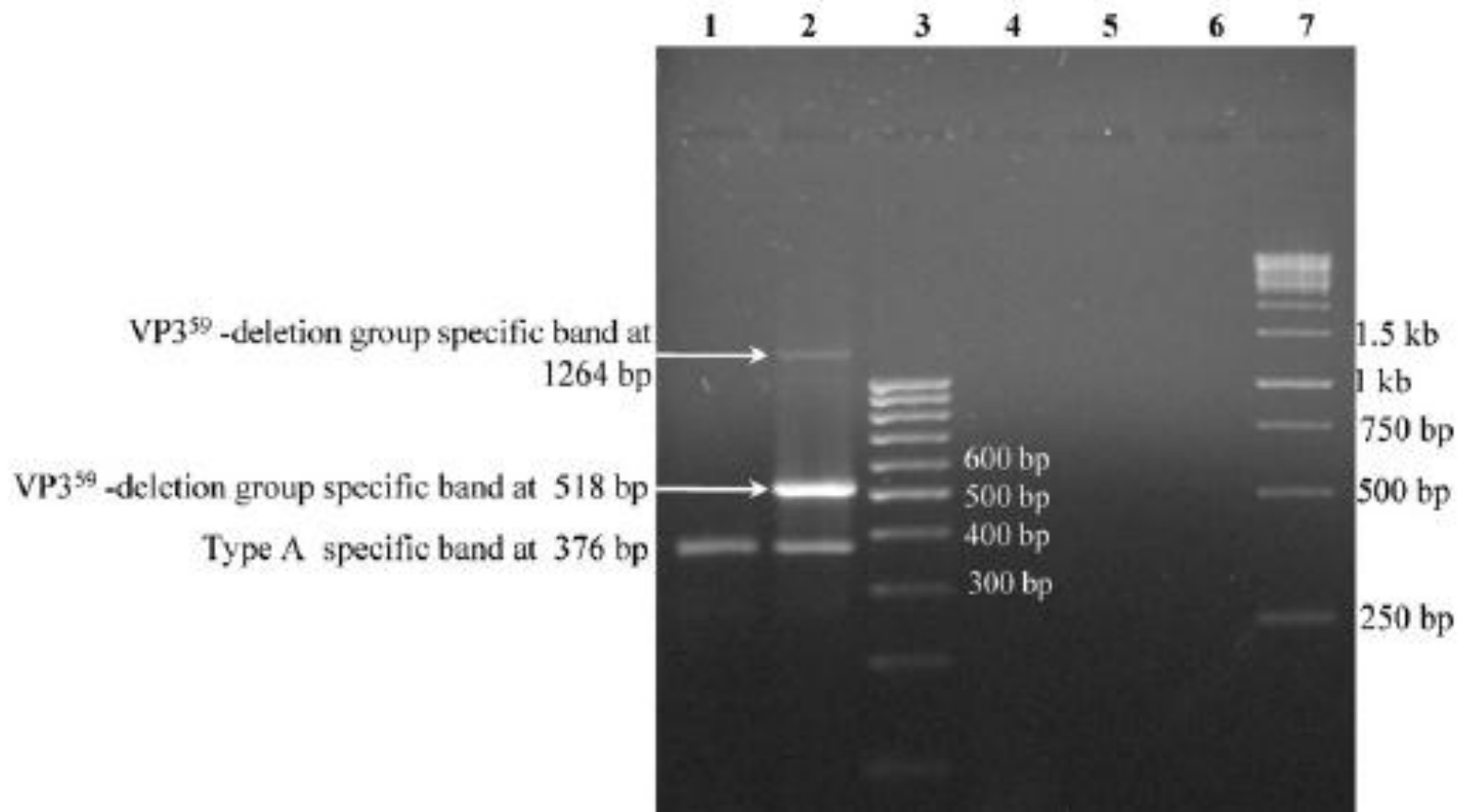
Molecular Epidemiology during 2010-11

1. 'Ind2001' strains of serotype O, which reemerged in late part of the year 2008, spread to majority of states in **Northern, Eastern, North-Eastern and Southern India**.
2. In 10 out of 12 states where disease due to type O was experienced were traced back to this lineage. Next to 'Ind2001' lineage, **Pan Asia II** was responsible for sporadic outbreaks/cases in West Bengal, **Arunachal Pradesh** and Maharashtra.
3. There were cases of FMD in cattle in **Punjab** caused by PanAsia I lineage.
4. In case of serotype A, there was exclusive dominance of genotype 18 (VII), but grouped both in the non-deletion and the VP3⁵⁹-deletion sub-lineages.
5. The Asia1 field isolates were grouped with lineage C reiterating the supremacy of this lineage since 2005.

Newer diagnostic techniques applied/ kits developed

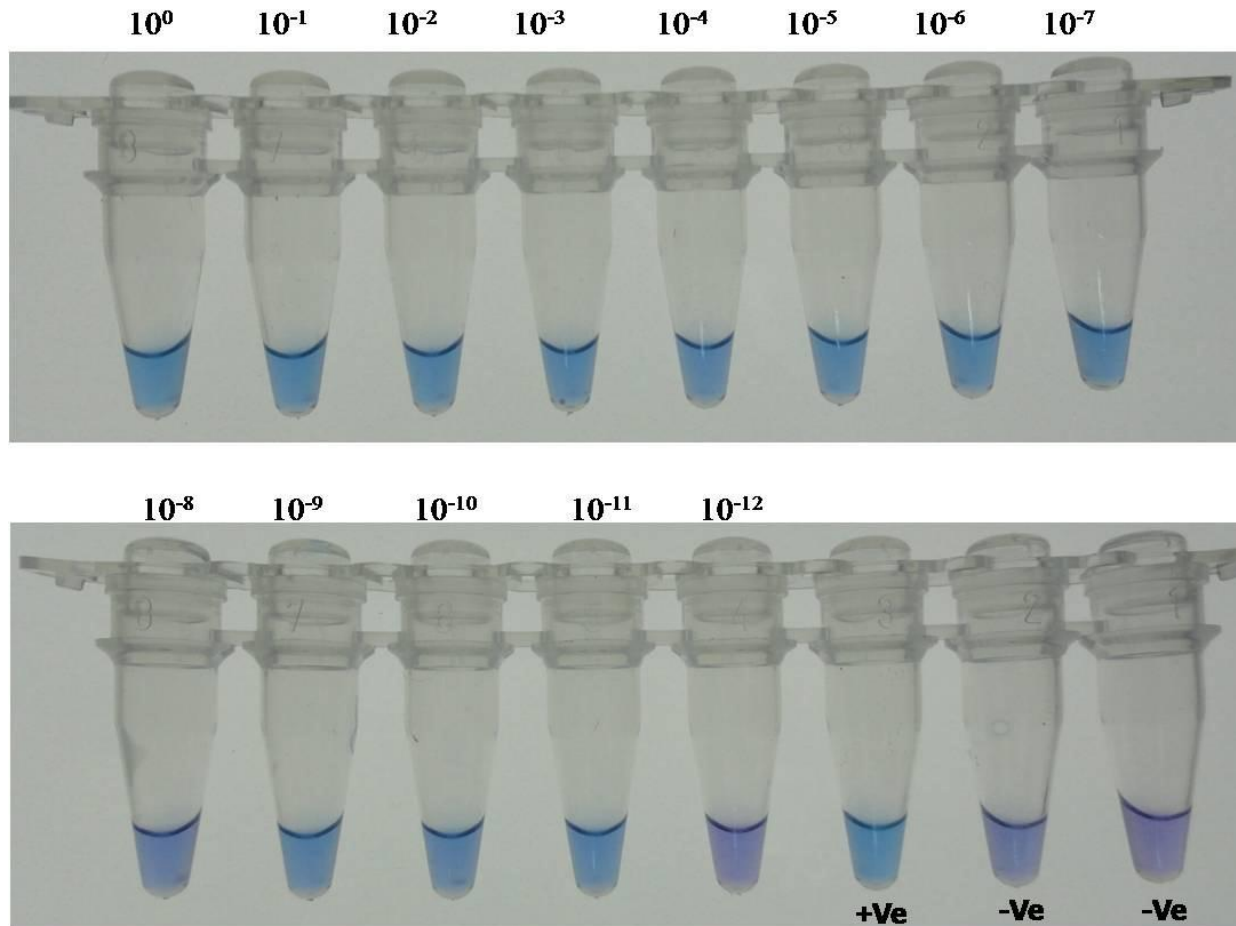
- Real time PCR/ mPCR for serotyping of FMD virus in difficult clinical materials
- LAMP (loop mediated isothermal amplification of DNA) for FMD virus detection with high sensitivity by the side of the animal. We have formulated a kit that is under evaluation.
- RNA transfection to increase diagnosis and isolation.
- DIVA panel test and 3ABC competition ELISA to cover all species
- Bovine semen PCR: to identify FMD virus negative semen (a biosecurity measure)

Multiplex PCR for rapid detection of serotype A foot-and-mouth disease virus variants with amino acid deletion at position 59 of the capsid protein VP3

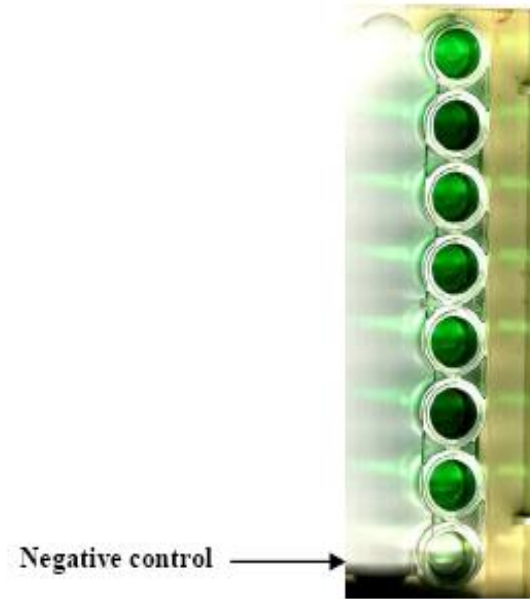


LAMP Test for FMDV-RNA detection

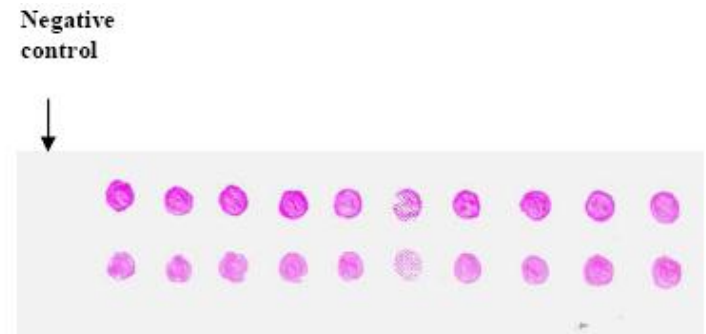
Sensitivity: 10^{-2} fg; 10^{-14} microgram of RNA



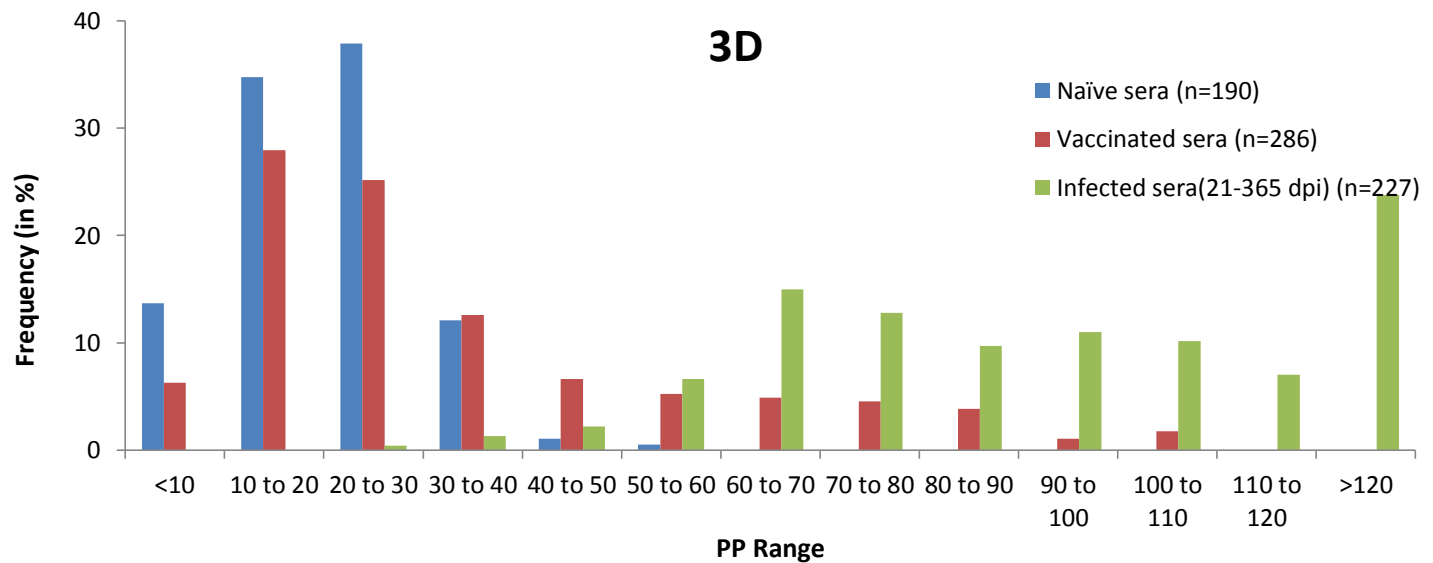
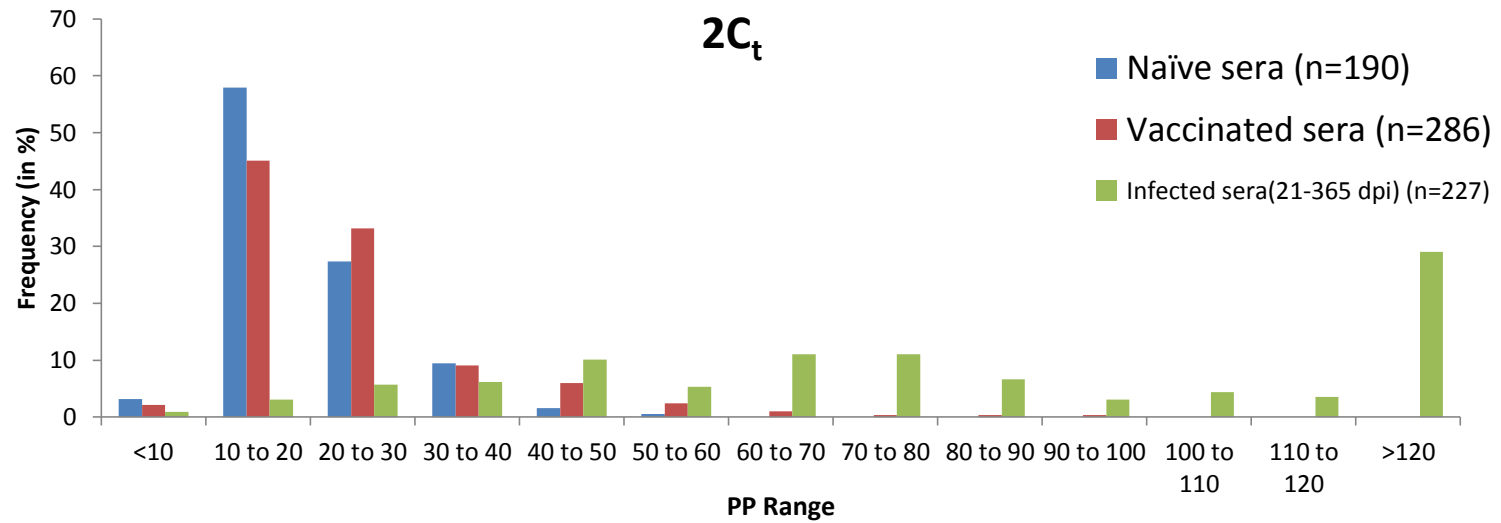
A RT-PCR (oligoprobing) ELISA in both solid and aqueous phase hybridization formats targeting an across serotype conserved site at the IRES and 3C-3D region

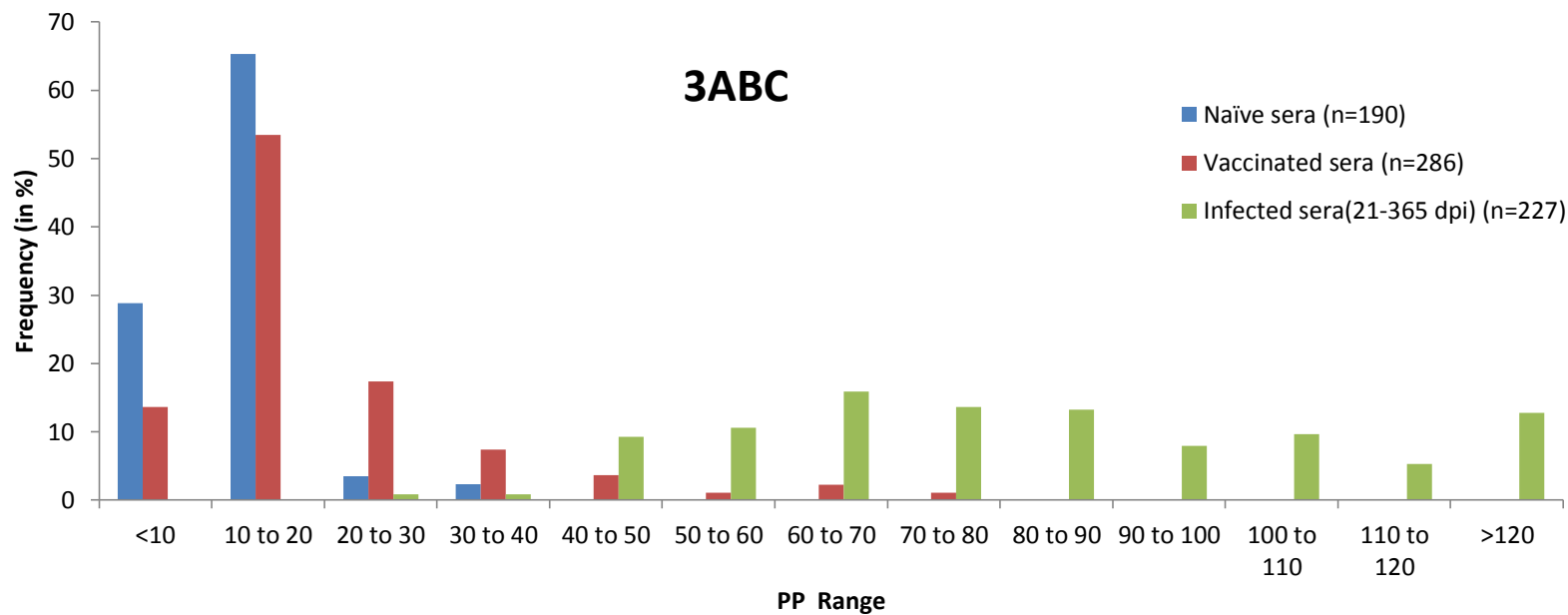
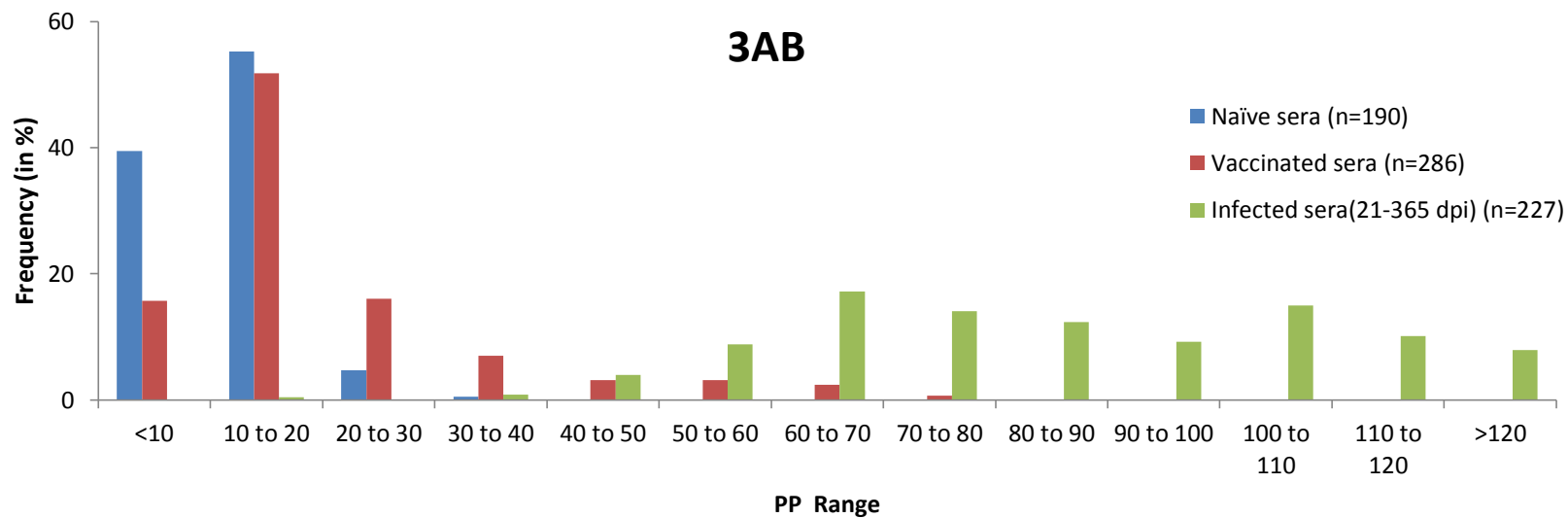


A non-isotopic RNA dot hybridization test with colorimetric detection targeting both the IRES and the 3D region an across serotype



- Recombinant Multiple NSP antigen (2C-3D-3AB-3ABC) **DIVA** for disease controlled zones.



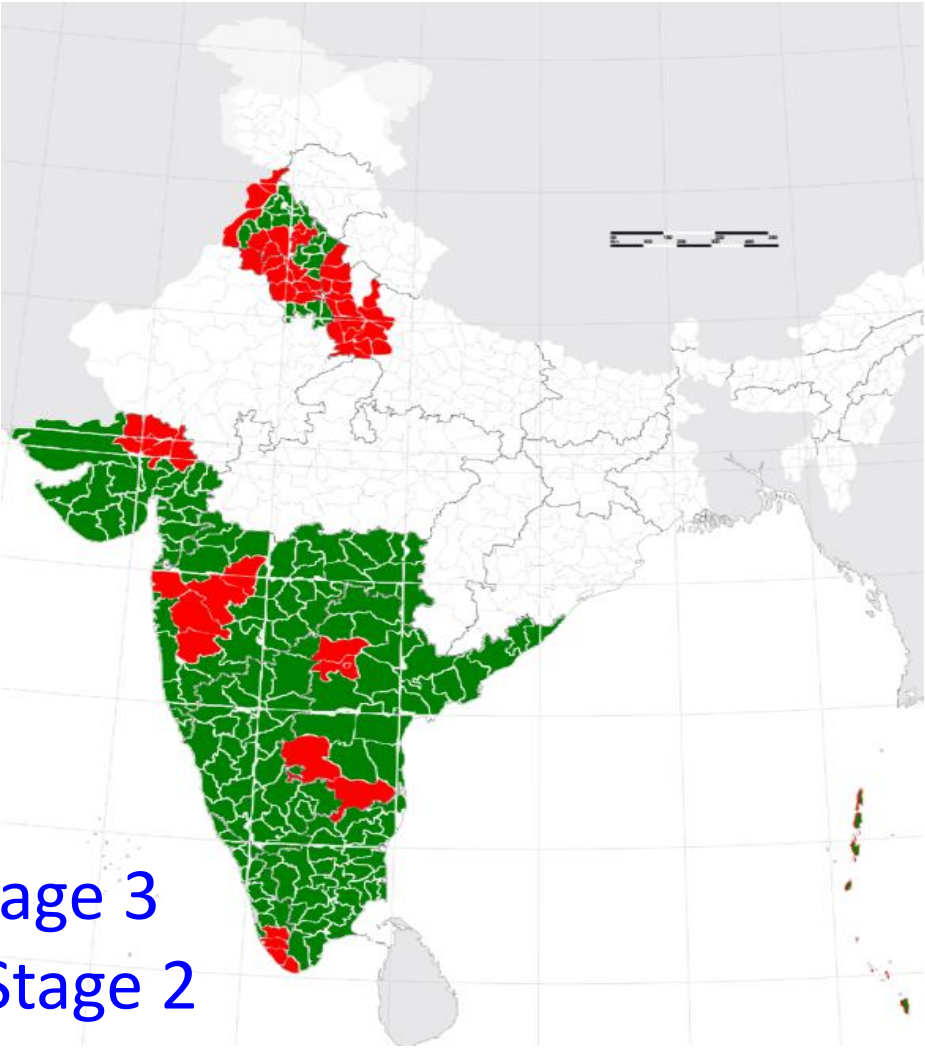


➤ It was observed that the **2C_t and 3D** are required to be included in combination **with 3AB and 3ABC DIVAs** as an integrated confirmatory serological assay system in detecting evidence of FMDV activity at the herd level **with high level of confidence.**

➤ **To maintain and monitor disease free zones (DFZs).**
DIVA Converters & **DIVA** Reactors to be differentiated by regular/ repeated testing



FMD Control Program in India



2003-04

2010-11

54 Districts: Stage 3
167 Districts: Stage 2

FMDCP

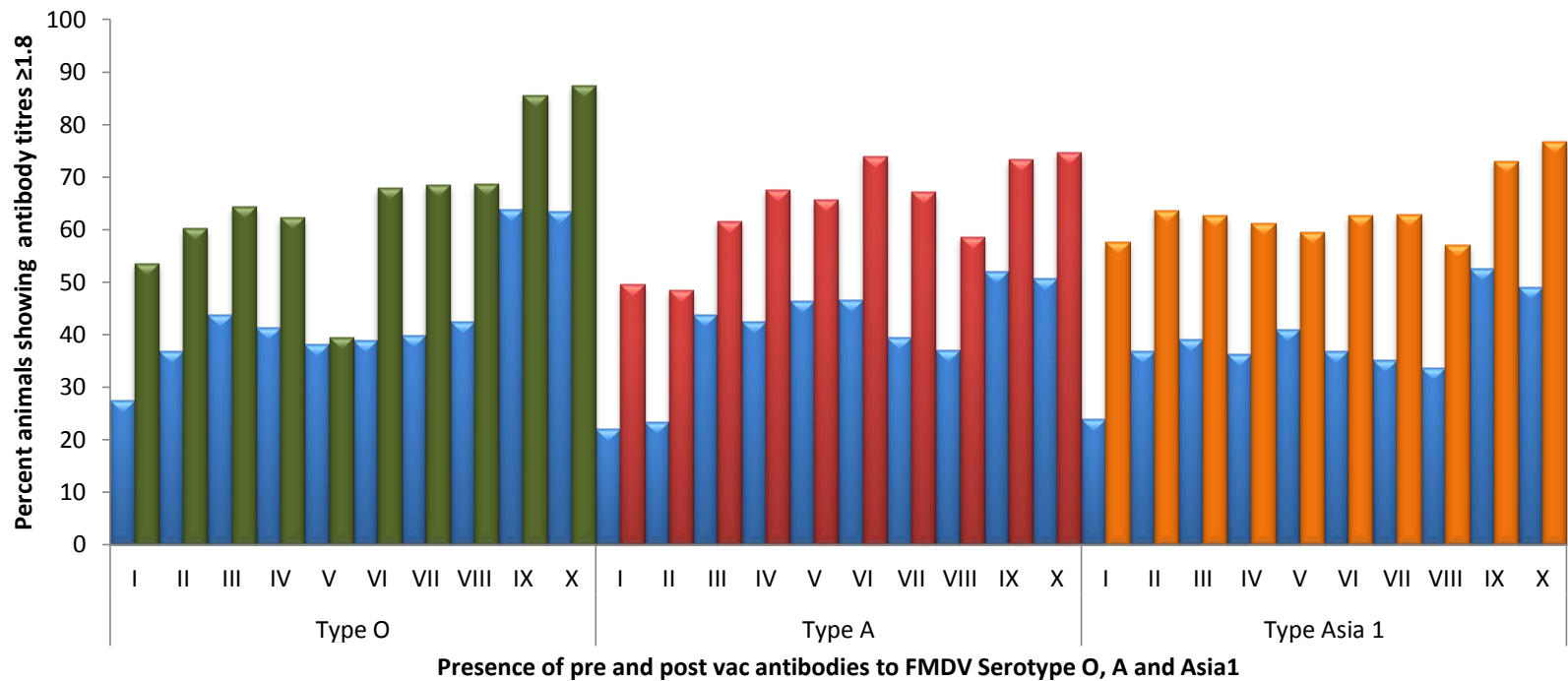
- **Sero monitoring of FMD Control Program** in the country has been completed up to phase 10 vaccination (**>1.2 Lakh serum samples tested**).
- It has revealed **gradual decline in the disease situation** in regularly vaccinated areas with progressive **build up of herd immunity**.
- This has given **valuable input to the policy makers in expanding the FMD control program from 54 to 221 districts**.

Percent animals showing post vaccinal antibody titers of ≥ 1.8 $\log_{10}$ against FMD virus

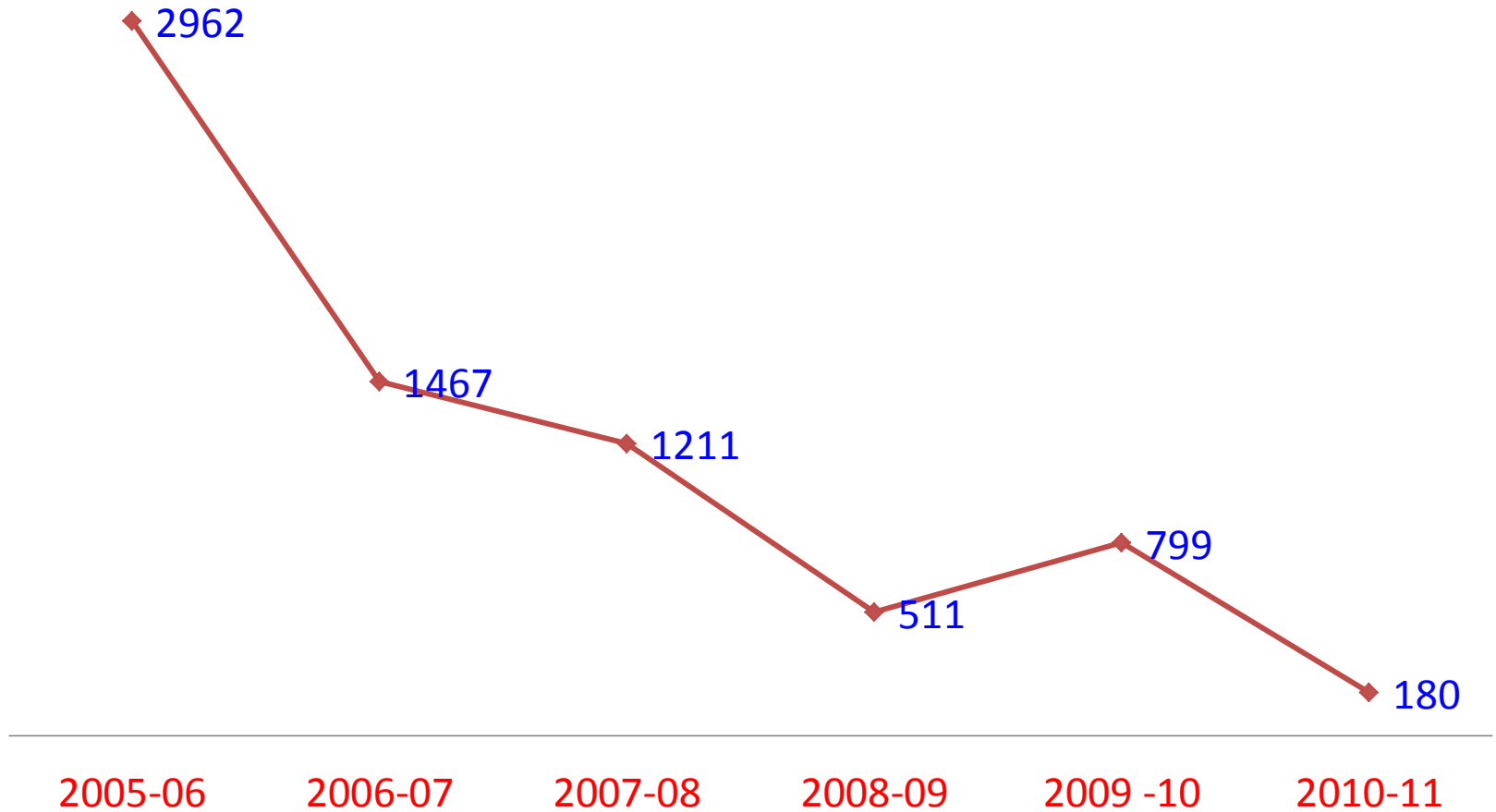
Phase	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	27.3	53.5	22.0	49.5	23.8	57.6
II	36.7	60.2	23.3	48.4	36.8	63.5
III	43.7	64.3	43.7	61.5	39.1	62.6
IV	41.2	62.3	42.4	67.5	36.2	61.1
V	38.0	39.3	46.3	65.6	40.8	59.4
VI	38.9	67.9	46.6	73.9	36.8	62.6
VII	39.7	68.5	39.4	67.1	35.1	62.8
VIII	42.3	68.7	37	58.6	33.5	57
IX	63.7	85.6	52	73.3	52.6	73
X	63.4	87.4	50.6	74.7	48.9	76.7

FMD CP

Overall Seroconversion



Decline trend of Occurrence of FMD Outbreaks in the country



Effect of regular vaccination on incidence of FMD

No of Outbreaks/cases in FMDCP districts											
STATES	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Uttar Pradesh	8	1	39	42	3	2	1	---	---	15	1
Haryana	19	29	27	60	1	---	1	---	---	1	1
Punjab	2	2	4	4	---	---	---	---	---	---	2
Maharashtra	43	77	64	29	1	3	---	1	---	6	4
Gujarat	28	6	7	12	1	1	1	1	2	0	3
Andhra Pradesh	52	28	65	37	---	---	---	---	---	3	--
Tamil Nadu	---	---	4	---	---	---	---	---	---	---	--
Kerala	2	44	135	63	1	---	---	---	---	---	1
Lakshadweep	---	---	---	---	---	---	---	---	---	---	--
Dadra and Nagar Haveli	---	---	---	---	---	---	---	---	---	---	--
Andaman Nicobar	---	---	---	---	---	---	---	---	---	---	--
Total	154	187	345	247	7	7	3	2	2	15	12

National FMD Serosurveillance: LPB- Antibody

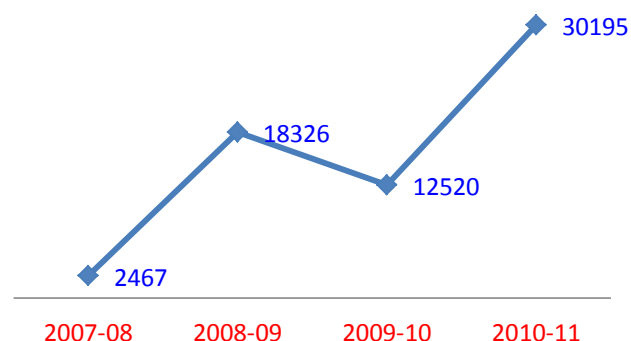
State	2008-09	2009-10	2010-11	Total
Assam	0	519	2264	2783
Jammu & Kashmir	0	1038	0	1038
Madhya Pradesh	0	2487	1784	4271
Manipur	0	538	792	1330
Maharashtra	0	2990	178	3168
Nagaland	0	232	0	232
Orissa	854	1195	0	2049
Uttar Pradesh	0	484	1707	2191
Tamil Nadu	32	168	278	478
Uttaranchal	0	132	0	132
Kerala	3	37	0	40
Karnataka	275	62	3035	3372
Punjab	23	544	739	1306
Himachal Pradesh	0	35	0	35
West Bengal	0	1099	626	1725
Haryana	0	0	1220	1220
AP	0	0	2245	2245
HP	25	0	1238	1263
J & K	160	0	943	1103
Tripura	99	0	194	293
Gujarat	0	0	72	72
Arunachal	0	0	315	315
Rajasthan	417	0	918	1335
TOTAL	1888	11560	18548	31996

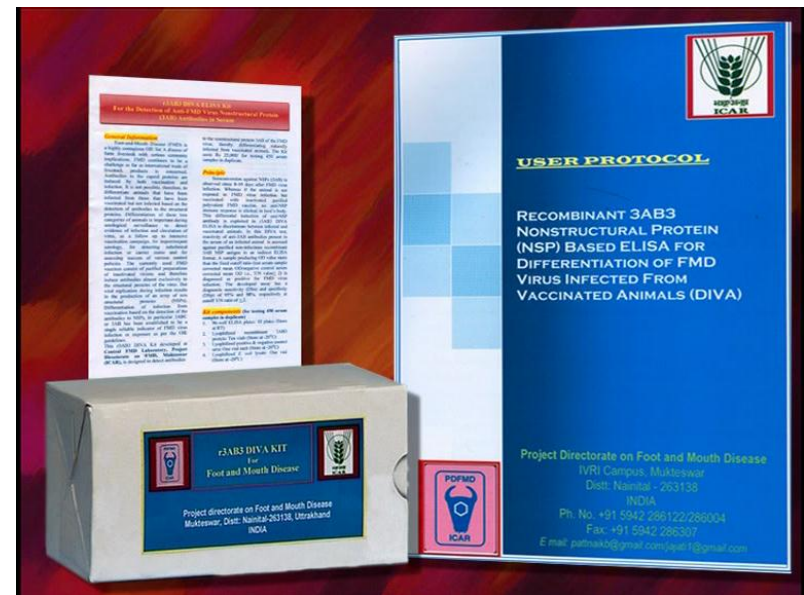
During 2010-11,
protective antibody
titre in 38.5%, 35.4% and
32.3% samples/animals
against serotypes O, A
and Asia1, respectively.

National FMD Serosurveillance: DIVA Reactivity

States	2007-08	2008-09	2009-10	2010-11	Total
Haryana	700	888	676	2054	4318
Karnataka	438	1477	632	2795	5342
Uttar Pradesh	403	0	0	1173	1576
Orissa	205	2780	0	2140	5125
Andhra Pradesh	200	1700	0	2622	4522
Assam	197	0	450	1184	1831
Rajasthan	162	247	215	492	1116
Arunachal Pradesh	108	493	225	315	1141
Manipur	28	501	500	630	1659
Nagaland	26	195	0	0	221
Tripura	0	391	0	642	1033
Gujarat	0	612	1383	2730	4725
Mizoram	0	799	0	800	1599
Himachal Pradesh	0	957	0	790	1747
Bihar	0	558	3262	3915	7735
Madhya Pradesh	0	3330	662	383	4375
West Bengal	0	657	0	1087	1744
Maharashtra	0	1252	1524	1005	3781
Punjab	0	155	1900	2000	4055
Kerala	0	900	509	540	1949
Jammu & Kashmir	0	74	0	1498	1572
Tamil Nadu	0	360	0	1390	1750
Nagaland	0	0	582	10	592
TOTAL	2467	18326	12520	30195	63508

Number of Serum samples tested





Diagnostic Kits

Supply of Reagents/ kits for diagnosis

➤ No Commercial production in the region

➤ Diagnostic Kits and reagents for FMD Virus detection, seromonitoring and serosurveillance were produced, optimized, evaluated and supplied to different units/centres, vaccine industry and other agencies on a routine basis.

Year	LPBE	Serotyping	DIVA
2006-2007	25,000	3000	-
2007-2008	1,00,000	10,000	-
2008-2009	80,000	7,000	30,000
2009-2010	80,000	7,000	54,485
2010-2011	82,800	9,000	58,440

Human Resource Development

1. Training programs on diagnostic techniques and epidemiology
2. M.V.Sc & Ph.D. teaching and research in Veterinary Virology

Year	Trainees	Training days
2007-2008	34	157
2008-2009	28	117
2009-2010	57	362
2010-2011*	18	107

*Training programs also conducted for Trainees from **SAARC Countries**.

LABORATORY TRAINING ON FOOT AND MOUTH DISEASE DIAGNOSIS FOR SAARC MEMBER COUNTRIES (2- 7 May, 2011)





Scientist of PDFMD providing training on FMD diagnosis and epidemiology at the National Center for Animal Health (NCAH), Serbithang, Thimpu, Bhutan from 2-16 November 2011



New Research Initiatives

- Development of lateral flow device for diagnosis at the farm level. (collaboration with vaccine industry)
- Development of infectious clone for modified virus vaccine. (replacement of unstable amino acids)
- Development viral vectored vaccine (hAd5 defective virus) [ICAR-USDA-ARS collaboration]
- Use of Recombinant antibodies in diagnosis
- Landscape Genetics of FMD and the virus (virus ecology and host-parasite genetics etc)

Publications

- ❖ *Journal of General Virology*
- ❖ *Virus Genes*
- ❖ *Virus Research*
- ❖ *Infection, Genetics and Evolution*
- ❖ *Transboundary and Emerging Diseases*
- ❖ *Journal of Virological Methods*
- ❖ *Research in Veterinary Science*
- ❖ *Veterinary Microbiology*
- ❖ *Acta Virologica*



Challenges

Socio political issues

- 1. Political will and grass roots initiatives**
- 2. Limited investment from private sector/
mobilization of resources**
- 3. Collaboration with global disease control partners**
- 4. Weak recognition of the importance of livestock
sector**

Issues

- Establishment of **FMD Control Commission** and **Central Quality Assurance of FMD vaccines and diagnostics** for control & eradication of FMD from the region.
- Making available quality diagnostics to meet the demand in the Region in PPP mode.
- Introduction of animal identification system
- Streamlining disease reporting and sharing system.
- Increasing antigen payload in the vaccine to 6-8 PD₅₀ for fast and longer duration of immunity.

Action Plans for South Asia

- Indian model of surveillance and control is suitable
 1. Integrated active and passive surveillance using uniform diagnostics
 2. Classification of zones as per occurrence of the disease and formulation of control program
 3. Regular Vaccination and seromonitoring
 4. Assessment of disease situation and virus circulation/ clearance following vaccination programme from time to time

Future Directions

- Constitution of SAARC FMD Control Commission to implement, monitor and evaluate the control program

Needs

- Availability of vaccine and diagnostics, human resource and laboratory facility
- 1. Country wise surveillance and epidemiology network with basic laboratory facility**
 - 2. Uniform Diagnostic kits suitable to detect/ diagnose virus strains in circulation**
 - 3. Use of uniform vaccine (other than type A in Pakistan) and seromonitoring assay**
 - 4. Creation of human resource for surveillance and epidemiology**

What RLDEL-FMD can offer

- 1. Training on FMD diagnosis**
- 2. Training on FMD epidemiology**
- 3. Proficiency testing**
- 4. Supply of diagnostic kits**
- 5. Setting of FMD laboratory**
- 6. Referral diagnostic service**

Diagnostic kits for FMD

FMDV Serotyping:

1. Sandwich ELISA
2. Multiplex PCR

Strain
characterization:

1. Genome sequencing
2. 2DMNT
3. LPBELISA

Serosurveillance:

1. LPB-ELISA
2. DIVA

A large, light blue globe with white grid lines is centered in the background.

*THANKS
FOR
KIND ATTENTION*