Seroprevalence of infectious bovine rhinotracheitis (IBR) in India: a 5-year study

Sharanagouda S. Patil*, Kuralayanapalya Puttahonnappa Suresh, Akshata Velankar, C. Shivaranjini, Divakar Hemadri, Jagadish Hiremath and Siju Susan Jacob

ICAR-National Institute of Veterinary Epidemiology and Disease Informatics, India.

*Corresponding author at: : ICAR-National Institute of Veterinary Epidemiology and Disease Informatics, India.
E-mail: sharanspin13@gmail.com.*

Veterinaria Italiana 2022, **58** (3), 339-345. doi: 10.12834/VetIt.2433.16160.1
Accepted: 15.11.2021 | Available on line: 31.12.2022

Keywords
BoHV-1,
Buffaloes,
Cattle,
ELISA,
IBR,
India,
Prevalence.

Summary
Infectious bovine rhinotracheitis (IBR) is a highly contagious disease of bovines causing respiratory symptoms, abortions, and reduced milk yield, leading to huge economic losses. Reports on seroprevalence in bovines in India are available and restricted to districts/states. In the present study, a nationwide seroprevalence of IBR in bovines was conducted to provide a national IBR seroprevalence to the Chief Veterinarian who in turn can design the control strategies. A total of 15,592 cattle and buffalo serum samples from 25 states and 3 Union Territories viz., Jammu and Kashmir, Puducherry, and Andaman and Nicobar Islands were tested for IBR antibodies using Avidin-Biotin (AB) ELISA. Cumulative seropositivity was found to be 31.37%. Maharashtra and Rajasthan states , part of the west zone of the country, showed the highest and lowest seroprevalence, respectively. A total of 11,423 cattle and 4,169 buffalo serum samples were tested, which showed 33.91% and 24.39% seropositivity, respectively. India has the highest buffalo population. Presently, no IBR vaccination programs are implemented in India. Considering the high seroprevalence, the authorities should plan control strategies for vaccinating dairy cows and buffaloes in India.

Infectious bovine rhinotracheitis (IBR) is a highly contagious disease of cattle caused by the bovine alphaherpesvirus 1 (BoHV-1) which belongs to the genus *Varicellovirus*, subfamily *Alphaherpesvirinae*, family *Herpesviridae* (Mc Lachlan 2011). Four subtypes of the virus are known: 1.1 and 1.2a (associated with infectious bovine rhinotracheitis), 1.2b (associated with infectious pustular vulvovaginitis and infectious balanoposthitis (IBP), and, 1.3 (encephalitis) (Biswas *et al.* 2013). These serotypes cannot be differentiated by common serological tests, so most of the studies describe them as IBR viruses. Latent and subclinical infections are common in IBR (Ranganatha *et al.* 2013) which can be identified through the detection of antibodies against BoHV-1 in serum (Lemaire *et al.* 2000). BoHV-1 infection was first reported in India in 1976 (Mehrotra *et al.* 1976). It causes huge economic losses due to a drop in milk production, repeat breeding, and abortions. Screening, surveillance, and monitoring are important to maintain the herd's health status and to decrease the economic losses caused by this disease (Raizman *et al.* 2011).

IBR is endemic in India and there is no systematic study on the seroprevalence of IBR though many have reported IBR antibody prevalence either restricted to districts/states/zones (Choudhury *et al.* 2016, Farooq *et al.* 2019, Goswami *et al.* 2017, Kathiriya *et al.* 2018, Katoch *et al.* 2017, Kollannur *et al.* 2014, Krishnamoorthy *et al.* 2015, Saravanajayam *et al.* 2015, Patil *et al.* 2012, Patil *et al.* 2017, Trangadia *et al.* 2012, Tresamol *et al.* 2019, Verma *et al.* 2014). There are no reports on the seroprevalence of IBR in the bovine population covering the vast majority of states of the country which is reared under a smallholder production system.

In India, dairy farming is not organized and farmers do hold a small number of cattle and buffaloes. Similar husbandry practices are followed at the village level. The animals are grazed in pastures in the daytime and kept in their barnes during the night. Therefore, there is a strong possibility that each animal has an equal opportunity of getting infected.

An epidemiological study was conducted to estimate the frequency of zone-, and species-specific IBR. Information, based on IBR serosurveillance about the disease burden within the defined populations is very useful to researchers and policymakers, thereby

supporting the process of identification of priorities in Veterinary healthcare, prevention, and policy. The study aimed to screen the bovine serum samples for antibodies against BoHV-1 selected randomly to understand the prevalence.

A total of 25 states (out of 28 states) and three Union Territories (out of 8 Union Territories) of the country with cattle and buffalo populations were included in the study.

Backyard dairy farming is most common in India and husbandry practices remain the same in most of the households having bovines. A two-stage random sampling methodology was followed wherein the number of random and representative villages and the number of animals in each village were selected using a survey toolbox (Seargent *et al.* 2018). Villages having a minimum of 100 bovines were selected. A total of 15,592 bovine serum samples from 1,828 villages in 369 districts from 25 states and 3 Union Territories viz., Jammu and Kashmir, Puducherry, and Andaman and Nicobar Islands were collected (Table I).

Bovine serum samples were obtained from the National Livestock Serum Repository (NLSR) maintained at ICAR-NIVEDI, Bengaluru, which were stored at - 20 °C.

Enzyme immunoassay for detection of IBR antibodies

Serum samples were subjected to an enzyme immunoassay for the detection of antibodies against IBR using developed home made Avidin-Biotin ELISA (AB ELISA). Positive and negative serum controls were selected from the repository and were subjected to a serum neutralization test using known BoHV-1. Each serum sample showing a > 1.5 neutralization index (as per WOAH) was selected as a positive control and the serum showing the lowest neutralization index (< 1.5) was selected as a negative control. All the controls (positive, negative, and conjugate controls), test samples, and other reagents were used and dissolved in a blocking buffer (1% bovine gelatin and 0.05% Tween 20) and dispensed in 100 µl of volume. The 1:100 diluted controls and test samples were dispensed to BoHV-1 antigen-coated plates. Later on, plates were incubated on a shaker at 37 °C for 1 hr. Afterward, the plates were washed three times with washing buffer (1X PBS with 0.05% Tween 20). Then, biotinylated anti-bovine IgG (1:10,000 diluted in blocking buffer) raised in goats was added to all wells and incubated on a shaker at 37 °C for 1 hr. Again, plates were washed as described earlier. Then, horseradish peroxidase (HRPO) conjugated Avidin (1:10,000) was added to all wells, incubated at 37 °C for 20 min and followed by the washing of the plate as described above. Later on, 100 µl of TMB (3,3', 5,5;-tetramethylbenzidine) was added to all wells, incubated at 37 °C for 6-8 min, and kept observed for color development. In the final step, 50 µl of 1M stop solution (H_2SO_4) were added to all wells and measured OD at 450 nm (reference at 620 nm) (Annual Report 2018). The sensitivity and specificity of the assay were found to be 92% and 95%, respectively. There was no cross-reactivity between the samples as the antigen was precipitated and purified with polyethylene glycol (PEG). Results were interpreted as below:

'X'= Average OD of Strong Positive X 0.64;

A Test sample is positive if its OD values are greater than 'X';

A Test sample is negative if its OD values are less than 'X'.

MS Excel v2016 has been used for the entry, storing, and management of surveillance data and SPSS v22 has been used for statistical analysis. The chi-square test has been used to determine the significant difference in the distribution of positive results with the total sample size in a different zone. The significance was assessed at a 5% level. True prevalence (TP) has been computed to adjust for the imperfectness of the test used for screening the samples.

TP was calculated with Blaker's confidence limit using values obtained from apparent prevalence (AP) with Wilson's confidence limit at 95% confidence interval (CI) in the Epitool: https://epitools.ausvet.com.au/trueprevalence (Seargent *et al.* 2018) in which sample size, sensitivity (0.92), and specificity (0.95) of the diagnostic test were considered. The significance of the difference was calculated by

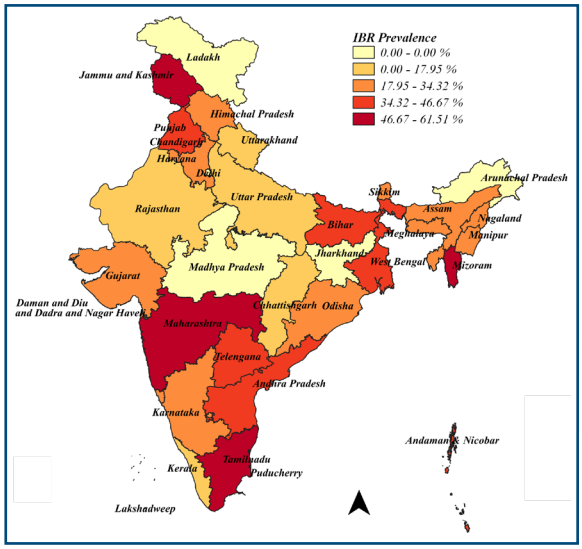

Figure 1. *Percent positivity of Infectious bovine rhinotracheitis (IBR) in India.*

the chi-square test and $p < 0.001$ was considered statistically significant.

A total of 15,592 bovine serum samples were collected during 2015-2019 and tested for IBR antibodies which showed a percent positivity of 31.37 [30.31 (95% CI: 29.48-31.15)] (Figure 1). Maharashtra showed the highest percent positivity. Maharastra is a geographically large state and is also known for dairy farming, whereas Rajasthan showed the lowest percent positivity (Table I). European countries like Ireland and Italy have reported seroprevalence of 20-80% in all age groups of dairy animals and 55.49% of national herd prevalence, respectively (Brock *et al.* 2020, Maresca *et al.* 2018). Kipyego and colleagues (Kipyego *et al.* 2020) reported 17.4% animal-level seroprevalence in dairy cattle of Meru County, Kenya. Noaman and colleagues (Noaman *et al.* 2020) have reported a seroprevalence of 72.20% in crossbred dairy cattle in the Isfahan province of Iran. The overall seroprevalence study conducted on 176 serum samples obtained from cattle imported from Sudan to Egypt showed 99.75% BoHV-1 antibodies

Table I. *Infectious bovine rhinotracheitis seroprevalence in Indian cattle according to states of origin between 2015-2019.*

Sl No	Zone	State /Union Territory	No Districts	No Villages	No tested	No Positive	% Positivity	True Prevalence at 95% CI*
1	North	Himachal Pradesh	11	116	935	204	21.82	19.33 (16.42-22.50)
		Haryana	23	74	715	176	24.62	22.55 (19.08-26.33)
		Jammu and Kashmir	23	78	519	289	55.68	58.26 (53.31-63.10)
		Punjab	18	60	974	372	38.19	38.15 (34.71-41.71)
		Uttar Pradesh	16	22	204	23	11.27	7.21 (3.02-13.05)
			13	50	290	50	17.24	14.07 (9.57-19.55)
		Total	**104**	**400**	**3637**	**1114**	**30.63**	**29.46 (27.76-31.20)**
2	East	Andaman & Nicobar	2	59	570	266	46.67	47.89 (43.23-52.61)
		Bihar	14	26	217	95	43.8	44.57 (37.18-52.22)
		Odisha	33	80	898	242	26.95	25.23 (22.01-28.67)
			3	11	217	88	40.55	40.87 (33.61-48.50)
		Total	**52**	**176**	**1902**	**691**	**36.33**	**36.01 (33.56-38.53)**
3	North East	Assam	27	77	657	158	24.05	21.90 (18.32-25.82)
		Manipur	8	55	874	300	34.32	33.71 (30.17-37.40)
		Meghalaya	7	52	346	94	27.17	25.48 (20.40-31.13)
		Mizoram	7	45	111	59	53.15	55.35 (44.74-65.72)
		Nagaland	11	122	530	171	32.26	31.34 (26.92-36.05)
		Sikkim	4	101	683	221	32.36	31.45 (27.54-35.58)
			4	110	604	202	33.44	32.69 (28.50-37.13)
		Total	**68**	**562**	**3805**	**1205**	**31.67**	**30.65 (28.98-32.37)**
4	Central	Madhya Pradesh	29	89	798	143	17.92	14.85 (11.97-18.08)
		Total	**29**	**89**	**798**	**143**	**17.92**	**14.85 (11.97-18.08)**
5	South	Andhra Pradesh	13	59	301	135	44.85	45.81 (39.46-52.30)
		Karnataka	20	63	519	135	26.01	24.15 (20.03-28.68)
		Kerala	14	92	925	166	17.95	14.88 (12.19-17.87)
		Puducherry	2	64	387	166	42.89	43.56 (38.00-49.28)
		Tamil Nadu	2	58	279	159	56.99	59.76 (53.02-66.28)
			8	70	333	155	46.55	47.75 (41.68-53.92)
		Total	**59**	**406**	**2744**	**916**	**33.38**	**32.62 (30.62-34.68)**
6	West	Goa	2	14	251	56	22.31	19.90 (14.48-26.27)
		Gujarat	26	104	1650	410	24.85	22.81 (20.49-25.28)
		Maharashtra	25	55	530	326	61.51	64.95 (60.11-69.60)
			4	22	275	30	10.91	6.79 (3.16-11.66)
		Total	**57**	**195**	**2706**	**822**	**30.38**	**29.17 (27.21-31.19)**
Grand Total			**369**	**1828**	**15592**	**4891**	**31.37**	**30.31 (29.48-31.15)**

Zone wise = χ^2=96.3, $p < 0.001$, significant; *Diagnostic sensitivity = 92% and Diagnostic specificity = 95%.

(Hekal *et al.* 2019).

The following six zones of India had a varied seroprevalence of the IBR (Table I).

North zone. Six states viz., Himachal Pradesh, Haryana, Punjab, Uttar Pradesh, Uttarakhand, and Jammu and Kashmir Union Territory formed this zone. Cumulative percent positivity was found to be 30.63 [29.46% (95% CI: 27.76-31.20%)]. The samples collected from 78 villages of 23 districts of Jammu and Kashmir, which shares an international border with Pakistan, showed the highest percent positivity of 55.68 [58.26 (95% CI: 53.31-63.10%)]. Pakistan has shown an IBR seropositivity of 69% in dairy cattle of Lahore (Rehman *et al.* 2020). There are illegal movements of men and materials alongside the border though it is under strict vigilance. Uttar Pradesh (UP) showed the lowest seropositivity of 11.27% [7.21 (95% CI: 3.02-13.05)] and it shares a border with Nepal. The overall seroprevalence of IBR was 18.47% in Nepal (Tiwari *et al.* 2020). UP is a very large state and is required to test more samples for the IBR antibodies. Haryana and Punjab are prosperous states having more high-yielding cattle and buffalo and have recorded 24.62% and 38.19% positivity, respectively. Earlier reports have recorded the seroprevalence of IBR in Haryana as 48.78% (Farooq *et al.* 2020) and in Punjab as 29.78% (Gill *et al.* 1984), 42.85% (Aradhana *et al.* 2004), 34.16% (Dhand *et al.* 2002), 36.51% (Kollannur *et al.* 2014), 38.50 (Goswami *et al.* 2017), and 84.50% (Farooq *et al.* 2019).

East zone. This is comprised of West Bengal, Odisha, Bihar, and the Union Territory of Andaman and Nicobar Islands. A total of 1902 samples from 117 villages of 52 districts were tested for IBR antibodies. This zone showed 36.33% positivity [36.01 (95% CI: 33.56-38.53)]. Andaman and Nicobar Islands located 1,350 km from the Indian mainland showed the highest seropositivity of 46.67% [47.89 (95% CI: 43.23-52.61)]. These islands are located at the remotest which procure dairy animals from Tamil Nadu and West Bengal whose IBR seropositivity is also high. The overall seroprevalence of the IBR in the Andaman and Nicobar Islands was recorded as 17.68% in 2005 and 20.58% in 2014 (Sunder *et al.* 2005, Sunder, 2014). Odisha showed the lowest of 26.95% seropositivity against 12.22% seropositivity reported earlier (Das *et al.* 2014).

North East zone. Samples collected were from 7 states of this region viz., Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, and Sikkim. A total of 3805 samples were tested and 31.67% positivity was recorded. Mizoram showed the highest seropositivity of 53.15%. Meghalaya showed the lowest positivity of 27.17%. Rajkhowa and colleagues (Rajkhowa *et al.* 2004) found a seroprevalence of 52% and 8% in Mizoram and Meghalaya, respectively. Sikkim showed a percent positivity of 32.35, which shares a border with China and there is a restricted movement of men and materials along the border. Overall, nationwide seroprevalence was found to be 35.8% (481/1,344) in dairy cattle in China (Yan *et al.* 2008).

Central zone. A total of 798 samples from 89 villages of 29 districts of Madhya Pradesh were tested, of which 143 were found positive (17.92%) [14.85 (95% CI: 11.97-18.08)]. A seroprevalence of 68.9% was recorded in Madhya Pradesh in 2011 (Nandi *et al.* 2011).

South zone. Samples analyzed from this zone were from 5 states (Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Telangana) and one Union Territory of Puducherry. A total of 2,744 bovine serum samples were tested and this zone showed a seropositivity of 33.38%. Patil and colleagues (Patil *et al.* 2017) showed a seroprevalence of 56.20% in bovines from the southern region of India comprising Tamil Nadu, Andhra Pradesh, and Karnataka. In the present study, Tamil Nadu showed the highest seropositivity of 56.99% [56.99 (95% CI: 53.02-66.28)], while the lowest positivity of 17.95% [14.88 (95% CI: 12.19-17.87)] was recorded in Kerala. During 2016-2017, Kerala showed a seroprevalence of 12% (Tresamol *et al.* 2019). Earlier, seropositivity of 65.88% was recorded in Tamil Nadu (Saravanajayam *et al.* 2015). Puducherry showed 42.89% positivity.

West zone. Goa, Maharashtra, Rajasthan, and Gujarat were a part of this zone. A total of 2,706 bovine serum samples were tested and showed positivity of 30.38% [29.17 (95% CI: 27.21-31.19)]. Maharashtra showed the highest seropositivity of 61.51% [64.95 (95% CI: 60.11-69.60)] and Rajasthan showed the lowest seropositivity of 10.91% [6.79 (95% CI: 3.16-11.66)]. Geographically, Maharashtra is a very large state that has a greater number of dairy animals, including organized dairy farms. Patil and colleagues (Patil *et al.* 2017) showed a seroprevalence of 76.5% in Maharashtra, whereas a seropositivity of 0% was recorded in Rajasthan earlier (Tanwar *et al.* 2009).

The chi-square test ($\chi^2 = 96.3$; $p < 0.001$) analysis of zone-wise seroprevalence of IBR antibodies was found significant (Table I).

Seroprevalence of IBR, species-wise

A total of 11,423 cattle and 4,169 buffalo serum samples from 25 states and 3 Union Territories were tested for IBR antibodies. 33.91% [33.23 (95% CI: 32.24-34.24)] positivity was recorded in cattle samples, whereas buffalo samples showed 24.39% [22.29 (95% CI: 20.82-23.82)] seropositivity. India is the highest buffalo-populated country and more

Table II. *Seroprevalence of IBR in India, species wise.*

Species	Total Tested	No positive	% Positivity	True Prevalence at 95% CI
Cattle	11423	3874	33.91	33.23 (32.24-34.24)
Buffalo	4169	1017	24.39	22.29 (20.82-23.82)
Total	15592	4891	31.37	30.31 (29.48-31.15)

$\chi^2 = 129$, $p < 0.001$, significant.

samples need to be tested against IBR antibodies to obtain a more detailed picture of IBR prevalence.

Seroprevalence of IBR antibodies between cattle and buffalo was significant, as evidenced by the chi-square test ($\chi^2 = 129$, $p < 0.001$) (Table II).

Year-wise seropositivity of IBR

Bovine serum samples were collected from 2015-2019 (five years) and tested for IBR antibodies. The highest seropositivity of 42.88% [43.55 (95% CI: 41.63-45.49)] during 2019 was recorded. The lowest seropositivity was 18.04% [15 (95% CI: 13.46-16.63)] (Table III). The positivity varied between years though the total samples tested were almost the same and was not able to attribute the reason since the samples did not have sufficient data available.

Presently, the bovine population in the country is not vaccinated against IBR. The seroprevalence of IBR in the bovine population appears to be very high as the bovines must have experienced the infection and are latently infected, such animals are a continuous source of infection whenever there is a reactivation of the virus. Therefore, the authorities should plan control strategies for vaccinating dairy cows and buffalo, if not bulls. Bulls should be tested for IBR antibodies periodically and each semen ejaculate must be tested for virus by polymerase chain reaction.

Table III. *Details of year wise collection of bovine serum samples.*

Sl No	Year	No tested	No positive	% Positivity	True Prevalence at 95% CI
1	2015	3003	542	18.04	15 (13.46-16.63)
2	2016	3130	1002	32.01	31.03 (29.20-32.95)
3	2017	3117	861	27.62	26 (24.23-27.84)
4	2018	3003	1054	35.09	34.60 (32.66-36.58)
5	2019	3339	1432	42.88	43.55 (41.63-45.49)
	Total	15592	4891	31.37	30.31 (29.48-31.15)

Acknowledgments

The authors are grateful to DG and DDG, ICAR, New Delhi, and the Director, ICAR-NIVEDI, Bengaluru for their financial support and guidance throughout the study. Acknowledgments are due to the serum repository of the institute. The authors are highly thankful to all the Principal/Co-Principal investigators of the All India Coordinated Research Project on Animal Disease Monitoring and Surveillance (AICRP on ADMAS).

Grant support

This study No IXX10709 was funded by ICAR-NIVEDI under Project No. 201/2012-19.

References

Biswas S., Bandyopadyay S., Dimri U. & Patra P.H. 2013. Bovine herpesvirus-1 (BoHV-1) – a re-emerging concern in livestock: a revisit to its biology, epidemiology, diagnosis, and prophylaxis. *Vet Quart*, **33**, 68-81.

Brock J., Lange M., Guelbenzu-Gonzalo M., Meunier N., Margarida Vaz A., Tratalos J.A., Dittrich P., Gunn M., More S.J., Graham D. & Thulke H. 2020. Epidemiology of age-dependent prevalence of Bovine Herpes Virus type 1 (BoHV-1) in dairy herds with and without vaccination. *Vet Res*, **51**, 124.

Chowdhury S., Mitra J., Sarkar S.N., Panda S., Bakshi S. & Mukherjea R. 2016. Prevalence of Bovine Herpes Virus-1 in organized farms of West Bengal, India. *Explor Anim Med Res,* **6**, 113-118.

Das P., Mohanty N.N., Ranganatha S., Ranabijuli S., Sarangi L.N. & Panda H.K. 2014. A comparative evaluation of avidin-biotin ELISA and micro SNT for detection of antibodies to infectious bovine rhinotracheitis in cattle population of Odisha, India. *Vet World*, **7**, 548-552.

Dhand N.K., Singh G., Sharma D.R. & Sandhu K.S. 2002. Seroprevalence of IBR in Punjab. *Ind J Anim Sci*, **72**, 850-852.

Farooq S., Kumar A., Chaudhary S. & Maan S. 2019. Bovine Herpesvirus 1 (BoHV-1) in cattle and buffalo: a review with emphasis on seroprevalence in India. *Int J Curr Microbiol App Sci*, **8**, 28-35.

Gill J.S., Kwatra M.S., Singh N., Singh G. & Singh S.P. 1984. A note on epizootiology and pathology of foot and mouth diseases in exotic pigs. *Ind J Vet Med*, **8**, 175-178.

Goswami P., Banga H.S., Mahajan V., Singh N.D., Deshmukh S. & Brar R.S. 2017. Detection of multiple antibodies and risk factor association of common respiratory viruses in the State of Punjab, India. *Int J Curr Microbiol App Sci*, **6**, 567-577.

Hekal S.H.A., Al-Gaabary M.H., El-Sayed M.M., Sobhy H.M. & Fayed A.A.A. 2019. Seroprevalence of some infectious transboundry diseases in cattle imported from Sudan to Egypt. *J Adv Vet Animal Res*, **6**, 92-99.

Kathiriya J., Sindhi S., Mathapati B. & Bhedi K. 2018. Seroprevalence of infectious bovine rhinotracheitis (BHV-1) in dairy animals with reproductive disorders in Saurashtra of Gujarat, India. *Int J Curr Microbiol App Sci*, **7**, 1371-1376.

Katoch S., Dohru S., Sharma M., Vashist V., Chahota R., Dhar P., Thakur A. & Verma S. 2017. Seroprevalence of viral and bacterial diseases among the bovines in Himachal Pradesh, India. *Vet World*, **10**, 1421-1426.

Kipyego E.S., Gitau G., Vanleeuwen J., Kimeli P., Abuom T.O., Gakuya D., Muraya J. & Makau D. 2020. Sero-prevalence and risk factors of infectious bovine rhinotracheitis virus (type 1) in Meru County, Kenya. *Prev Vet Med*, **175**, 104863.

Kollannur J.D., Syam R. & Chauhan R.S. 2014. Epidemiological studies on infectious bovine rhinotracheitis (IBR) in different parts of India. *Int J Livestock Res*, **4**, 21-27.

Krishnamoorthy P., Patil S.S., Shome R. & Rahman H. 2015. Sero-epidemiology of infectious bovine rhinotracheitis and brucellosis in organised dairy farms in southern India. *Ind J Ani Sci*, **85**, 695-700.

Lemaire M., Weynants V., Godfroid J., Schynts F., Meyer G., Letesson J.J & Thiry E. 2000. Effects of Bovine Herpesvirus type 1 infection in calves with maternal antibodies on immune response and virus latency. *J Clin Microbiol*, **38**, 1885-1894.

Mac Lachlan N.J. & Dubovi E.J. 2011. *In* Fenner's Veterinary Virology. 4th ed. Academic Press, London.

Maresca C., Scoccia E., Dettori A., Felici A., Guarcini R., Petrini S., Quaglia A. & Filippini G. 2018. National surveillance plan for infectious bovine rhinotracheitis (IBR) in autochthonous Italian cattle breeds: results of first year of activity. *Vet Microbiol*, **219**, 150-153.

Noaman V. & Nabinejad A.R. 2020. Seroprevalence and risk factors assessment of the three main infectious agents associated with abortion in dairy cattle in Isfahan province, Iran. *Trop Anim Health Prod*, **52** (4), 2001-2009.

Mehrotra M.L., Rajya B.S. & Kumar S. 1976. Infectious bovine rhinotracheitis (IBR) – keratoconjunctivitis in calves. *Ind J Vet Pathol*, **1**, 70-73.

Patil S.S., Ravindran R., Sowjanyakumari R., Suresh K.P., Hiremath J., Hemadri D., Shivamallu C. & Rahman H. 2021. Seroprevalence of infectious bovine rhinotracheitis (IBR) in North Eastern (NE) States of India. *J Exp Biol Agricultural Sci*, **9**, 305-310.

Patil S.S., Hemadri D., Veeresh H., Chandranaik B.M. & Prabhudas K. 2012. Genetic characterization of BoHV-1 isolates in India. *Ind J Anim Sci*, **82**, 848-850.

Patil S.S., Prajapati A., Krishnamoorthy P., Desai G.S., Manjunathareddy G.B., Suresh K.P. & Rahman H. 2017. Seroprevalence of infectious bovine rhinotracheitis in organized dairy farms of India. *Ind J Anim Research*, **51**, 151-154.

Raizman E.A., Pogranichniy R., Negron M., Schnur M. & Tobar-Lopez D.E. 2011. Seroprevalence of infectious bovine rhinotracheitis and bovine viral diarrhea virus type 1 and type 2 in non-vaccinated cattle herds in the Pacific Region of Central Costa Rica. *Trop Anim Health Prod*, **4**, 773-778.

Ranganatha S., Rathnamma D., Patil S.S., Chandranaik B.M., Isloor S., Veeregowda B.M., Narayanabhat M. & Srikala. 2013. Isolation and molecular characterization of bovine herpes virus-1 by polymerase chain reaction. *Ind J Anim Res*, **47**, 340-343.

Rehman H., Rabbani M., Ghafoor A., Riaz A., Awan F.N. & Raza S. 2020. First isolation and genetic characterization of Bovine herpesvirus 1 from cattle in Pakistan. *Pak Vet J*, **41**, 163-165.

Saravanajayam M., Kumanan K. & Balasubramaniam A. 2015. Seroepidemiology of infectious bovine rhinotracheitis infection in unvaccinated cattle. *Vet World*, **8**, 1416-1419.

Sergeant E.S.G. 2018. Epitools Epidemiological Calculators. Ausvet. http://epitools.ausvet.com.au.

Sunder J. 2014. Status of livestock and poultry diseases in A & N Islands: strategies to make island disease free. *Adv Anim Vet Sci*, **2**, 42-47.

Sunder J., Rai R.B., Kundu A., Chatterjee R.N., Senanis S. & Jeyakumar S. 2005. Incidence and prevalence of livestock diseases of Andaman and Nicobsr Islands. *Ind J Anim Sci*, **75**, 1041-1043.

Trangadia B.J., Rana S.K., Nagmani K. & Srinivasan V.A. 2012. Serological investigation of bovine brucellosis, Johne's Disease and infectious bovine rhinotracheitis in two States of India. *J Adv Vet Res*, **2**, 38-41.

Tiwari M.R., Ghimire R.P. & Shrestha S.P. 2019. Proceedings 11th National Workshop on Livestock and Fisheries Research in Nepal, 16-17 June 2019.

Tresamol P.V., Rincy K.M. & Dev P.A. 2019. Seroprevalence of Bovine Herpes Virus-1 among cattle and buffaloes in Central Kerala, India. *Int J Livestock Res*, **1**, 68-73.

Verma A.K., Amit Kumar S., Prakash Reddy N.C. & Shende A.N. 2014. Seroprevalence of infectious bovine rhinotracheitis in dairy animals with reproductive disorders in Uttar Pradesh, India. *Pakistan J Biol Sci*, **17**, 720-724.

Yan B.F., Chao Y.J., Chen Z., Tian K.G., Wang C.B., Lin X.M., Chen H.C. & Guo A.Z. 2008. Serological survey of bovine herpesvirus type 1 infection in China. *Vet Microbiol*, **127**, 136-141.