



## OPEN ACCESS

## EDITED BY

Krishna Thakur,  
University of Prince Edward Island, Canada

## REVIEWED BY

Begna Bulcha,  
Wollega University, Ethiopia  
B. Vimala Devi,  
Vijayawada, Andhra Pradesh, India

## \*CORRESPONDENCE

T. A. N. Mahakapuge  
✉ thiliniupama@vet.pdn.ac.lk  
R. T. Kangethe  
✉ r.t.kangethe@iaea.org

RECEIVED 24 October 2025

REVISED 27 November 2025

ACCEPTED 30 November 2025

PUBLISHED 16 December 2025

## CITATION

Weerasekara WMGK, Dhananjaya WMC,  
Ashinika WMD, Wijewardana V, Kangethe RT,  
Kalupahana AW and Mahakapuge TAN (2025)  
Seroprevalence of bovine viral diarrhea virus  
(BVDV) in cattle in the northern, Northern,  
Northcentral, Central, and Southern  
provinces of Sri Lanka.  
*Front. Vet. Sci.* 12:1730906.  
doi: 10.3389/fvets.2025.1730906

## COPYRIGHT

© 2025 Weerasekara, Dhananjaya, Ashinika,  
Wijewardana, Kangethe, Kalupahana and  
Mahakapuge. This is an open-access article  
distributed under the terms of the [Creative  
Commons Attribution License \(CC BY\)](#). The  
use, distribution or reproduction in other  
forums is permitted, provided the original  
author(s) and the copyright owner(s) are  
credited and that the original publication in  
this journal is cited, in accordance with  
accepted academic practice. No use,  
distribution or reproduction is permitted  
which does not comply with these terms.

# Seroprevalence of bovine viral diarrhea virus (BVDV) in cattle in the Northern, Northcentral, Central, and Southern provinces of Sri Lanka

W. M. G. K. Weerasekara<sup>1</sup>, W. M. C. Dhananjaya<sup>1</sup>,  
W. M. D. Ashinika<sup>1</sup>, V. Wijewardana<sup>2</sup>, R. T. Kangethe<sup>2\*</sup>,  
A. W. Kalupahana<sup>1</sup> and T. A. N. Mahakapuge<sup>1\*</sup>

<sup>1</sup>Department of Veterinary Pathobiology, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, Sri Lanka, <sup>2</sup>Animal production and Health Laboratory, Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture, Department of Nuclear Sciences and Applications, International Atomic Energy Agency, IAEA Laboratories, Seibersdorf, Austria

Bovine Viral Diarrhea Virus (BVDV) is a highly significant cattle pathogen with economic impacts that lead to reproductive failures, immunosuppression, and low productivity. This research paper examined the seroprevalence of BVDV in four Provinces in Sri Lanka, namely Northern, North Central, Central and Southern, which represents both wet and dry agro-climatic zones. In total, 178 archived bovine serum samples collected during 2022 and 2023 were tested to evaluate BVDV-specific antibodies with an indirect ELISA. Numerically, the wet zone had 14.7% seropositive (10/68), and none of the cattle in the dry zone were found to be positive (0/110). The prevalence may be higher in the wet zone due to grazing practices and shared water sources, which facilitate viral transmission. This paper highlights the need of constant surveillance to monitor the seroprevalence while establishing methods to detect BVDV antigens among the local cattle populations. The importance of maintaining vaccine records are needed to prevent the interference with surveillance studies. Further research with larger and more geographically diverse sampling, including buffaloes, are recommended to clarify the national status and economic impact of BVDV infection in Sri Lanka.

## KEYWORDS

bovine viral diarrhea, agro-climatic zones, indirect ELISA, antibodies, seroprevalence

## 1 Introduction

Bovine Viral Diarrhea (BVD) affects cattle globally and causes significant economic losses in both the dairy and beef industries (1). Belonging to the *Pestivirus* genus within the *Flaviviridae* family, BVDV is a highly versatile and an adaptive virus. Bovine Viral Diarrhea Virus (BVDV) is classified into two main genotypes, BVDV-1 and BVDV-2. Each genotype can exist in one of two biotypes: cytopathic (CP), which causes visible damage to cells, and non-cytopathic (NCP), which does not. The NCP biotype is of particular importance, as it is more frequently linked to the development of persistent infections in cattle (2).

The infection of BVDV can manifest various clinical symptoms, which depend on the age of the infected animal, immune status of the host, and the virulence of the viral strain involved. Fever, diarrhea and immunosuppression may occur in acute infections, along with respiratory signs. This results in affected animals to be more susceptible to secondary infections (3). More

severe manifestations include hemorrhagic syndrome, reproductive failures such as abortions and stillbirths, and mucosal disease, a fatal outcome in persistently infected (PI) animals (4).

Persistently infected (PI) cattle pose specific concerns as they continually serve as a reservoir of the virus and shed it frequently, which exposes other animals to infections (5). *In-utero* infections are associated with exposure to the virus in early gestation. The developing immune system then does not recognize the virus as foreign and thus, stops the PI animals from mounting an immune response against the BVDV (6). These animals are underweight and do not acquire appropriate weight for the age and later perpetuating transmission cycles within herds (7). BVDV infection in cattle can range from inapparent subclinical infection to severe clinical disease, with most herds remaining at a subclinical level that often goes unrecognized (8); however, once infection surpasses a critical threshold, the disease manifests clinically, making later detection less effective, which highlights the importance of early detection for prevention (3, 9).

Globally, BVDV have been associated with considerable economic losses brought about by decreased milk production and growth rates, increased costs for veterinary medicine, and reproductive inefficiencies in animals (10). Diseases cause losses in the infected herds through sickness and death as well as through the costs of culling PI animals. Many countries have adopted vaccination and biosecurity measures to minimize the adverse economic impact incurred by this disease to some extent (11).

The livelihoods in the rural economy of Sri Lanka are largely sustained through livestock. While BVDV is quite detrimental to the productivity and profitability of cattle farming, it brings about enormous problems in livestock production. Although BVDV is considered as a significant pathogen worldwide, with respect to Sri Lanka, the data available on this virus infection is scarce. The Epidemiology of this disease in the country is not well-understood due to a total absence of systematic surveillance and diagnosis efforts (5, 7). Furthermore, the cattle population in Sri Lanka shows clear variation across agro-climatic zones. In the wet zone (mid-country, up-country, and wet-lowland areas), exotic European breeds such as Friesian, Jersey, and Ayrshire, as well as their crosses, are widely used due to their higher milk-yield potential under semi-intensive and intensive management systems (12, 13). In contrast, in the dry lowland agro-ecological zones, cattle populations are predominantly composed of indigenous Zebu-type animals and Zebu exotic crosses, which are better adapted to heat stress, poor-quality roughage, and extensive grazing systems. Indigenous Zebu cattle in Sri Lanka have been well characterized for their genetic background and adaptive traits, including disease resistance and drought tolerance, although they typically exhibit lower milk yields compared to exotic dairy breeds (14, 15).

## 2 Materials and methods

### 2.1 Ethical approval

The research study was approved by the Ethics Committee, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya (Ethical clearance ID: VERC\_24\_02). Consent was attained from the owners of the cattle before using the previously collected blood samples during 2022–2023.

### 2.2 Sample size determination

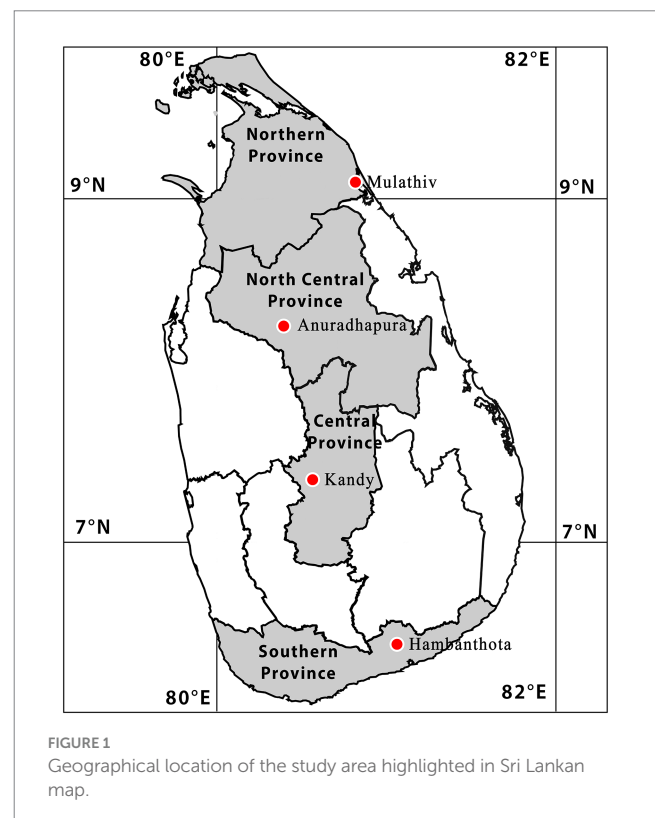
According to the data provided by Department of Census and Statistics-2024 (16), National Livestock Statistics, there are around 834,170 local cattle and 291,280 improved cattle. According to Orban (17) when the population size is more than 250,000 at 95% confidence level, 5% error, and the sample size will be 384. However, due to the logistical constraints, the sample size for this study was reduced to 178 cattle.

### 2.3 Sample collection

The blood samples archived from bovines were used. Those were collected from the Central Province (Kandy), Northern Province (Mullaitivu), Southern Province (Hambanthota) and North Central Province (Anuradhapura) from January 2022 to December 2023. Blood was collected from cattle of all ages, sexes, breeds and body condition score. The collected blood samples were immediately centrifuged at 3,000 rpm for 10 min to separate the serum (Figure 1). The sera were then aliquoted into sterile cryovials to prevent repeated freeze thaw cycles and stored at  $-20^{\circ}\text{C}$  until laboratory analysis. (18).

### 2.4 Detection of antibody using ELISA

The ELISA procedure to detect antibodies against BVDV was carried out using the Abnova BVDV IgG ELISA Kit (Catalog No. KA4890, Version 02), following the manufacturer's instructions. This assay is based on a sandwich enzyme immunoassay (EIA) principle, in



which wells were coated with purified and inactivated BVDV antigen to capture BVDV specific antibodies present in the test samples. After sample incubation, a horseradish peroxidase (HRP)-conjugated anti-bovine immunoglobulin was added, which binds to the captured antibodies. The presence of HRP activity is detected by a substrate solution containing 3,3',5,5'-tetramethylbenzidine (TMB), resulting in a blue color development. Upon addition of the stop solution, the color changes to yellow, and the absorbance is measured at 450 nm.

A volume of 10 µL of each serum sample was diluted 1:20 with the sample diluent and added to the wells of the microtiter plate pre-coated with purified and inactivated BVDV antigen following manufacturer's instructions. After mixing thoroughly, the plate was incubated at 37 °C for 60 min. Following incubation, the wells were aspirated and washed four times using a wash buffer to remove unbound components. Then, 100 µL of horseradish peroxidase (HRP)-conjugated rabbit antibodies against bovine immunoglobulin was added to each well, followed by a 30-min incubation at 37 °C. After the second washing step, 100 µL of the TMB chromogenic substrate was added to each well and incubated at room temperature for 15 min. The enzymatic reaction was then stopped by adding 100 µL of acidic stop solution, resulting in a color change from blue to yellow. The absorbance of each well was read at 450 nm using a microplate reader (TECAN, Switzerland), and the optical density (OD) values were recorded. The results were interpreted by calculating the S/P (sample to positive) ratio using the formula provided by the manufacturer:

$$S/P \text{ Ratio} = \frac{\text{Absorbance of the sample}}{\text{Mean absorbance of Positive Control Serum} - \text{limit}} \times 100\%$$

Samples with S/p values below 30% were considered negative for BVDV-specific antibodies, those between 30 and 40% were borderline, and those equal to or above 40% were considered positive, indicating current or past exposure to BVDV. The diagnostic sensitivity and specificity of the test kit were 99.20 and 99.25%, respectively.

## 2.5 Data analysis

All obtained laboratory results were stored and cleaned in Excel Spreadsheet (Microsoft Office, 2016). Data were analyzed to determine the seroprevalence of BVDV infection in the total sampled population and at the individual herd level, following the method described by Phillips and Acheson (19):

$$\text{Seroprevalence (\%)} = \frac{\text{Number of animals tested seropositive}}{\text{Total number of animals tested}} \times 100\%$$

## 3 Results

The overall and individual zone seroprevalence of BVDV in cattle in Sri Lanka is summarized in Table 1. Accordingly, samples obtained from the Central Province (Kandy) represent the wet zone, whereas those collected from the Northern Province (Mullaitivu), Southern

TABLE 1 Overall and individual zone seroprevalence of BVDV exposure in cattle in Sri Lanka.

Zone	Total no. of animals tested	No. of animals tested seropositive	Prevalence of BVDV exposure
Wet zone	68	10	14.7%
Dry zone	110	0	0%
Total	178	10	5.6%

Province (Hambantota), and North Central Province (Anuradhapura) represent the dry zone. The overall seroprevalence of BVDV IgG antibodies was 5.6%. Among the two agro-climatic zones, the wet zone showed the highest seroprevalence, with 14.7% (10 out of 68 animals) testing seropositive. Notably, all the seropositive samples originated from the wet zone. In contrast, no detectable antibodies against BVDV were found among the 110 animals tested in the dry zone (0% seroprevalence). Figure 2 shows the number of seropositive and seronegative cattle in the wet and dry agro-climatic zones.

## 4 Discussion

The present study provides valuable insight into the seroprevalence of BVDV in cattle across the Northern, North Central, Central, and Southern Provinces of Sri Lanka. Among the 178 animals tested, an overall seroprevalence of 5.6% was detected. BVDV antibodies were found exclusively in cattle from the wet zone (14.7%), while no seropositive cases were detected in the dry zone. It should also be acknowledged that the observed seroprevalence could vary under different herd conditions, management systems, and animal movement patterns, which were not controlled in this study. Our observed seroprevalence is high relative to the past local reports, 2.6% reported by Dasinaa (20) in the Eastern Province in which an OIE reference laboratory verified the diagnosis in the calves. Such a difference might be due to regional variation in the circulation of the virus, different diagnostic procedures (antigen or antibody detection), or temporal changes in the prevalence of the disease.

When placed in the broader South Asian context, the seroprevalence in Sri Lanka appears relatively low. For instance, Uddin et al. (18) reported a 51.1% seroprevalence in crossbred dairy cattle in Bangladesh. Raheem et al. (21) identified an overall BVDV seropositivity of 18.77% of all processed samples in Pakistan with 19.81% (129/651) of cattle and 8.82% (6/68) of buffaloes showing seroconversion. This shows a significant prevalence difference between species, which is also reflected in the trend in other countries. In India, Narayan Sarangi et al. (22) found a true prevalence of 56.67% in organised herds, where cattle had a much higher prevalence (65.42%) than buffaloes (32.49%). Tandan and Paudel (23) recorded a prevalence of 10.86% in Nepal, which is similar to our results in the wet zone, but still higher than the overall prevalence observed in Sri Lanka. Remarkably, buffalo seroprevalence in Pakistan (8.82%) is consistent with the cattle trends, in which buffaloes always have lower prevalence as compared to cattle (21, 22).

The relatively low prevalence of BVDV in Sri Lanka can be related to the differences in cattle management, biosecurity, herd composition and ecology (24, 25). Cattle farming in Sri Lanka predominantly consists of small-scale operations where farmers typically rear a few

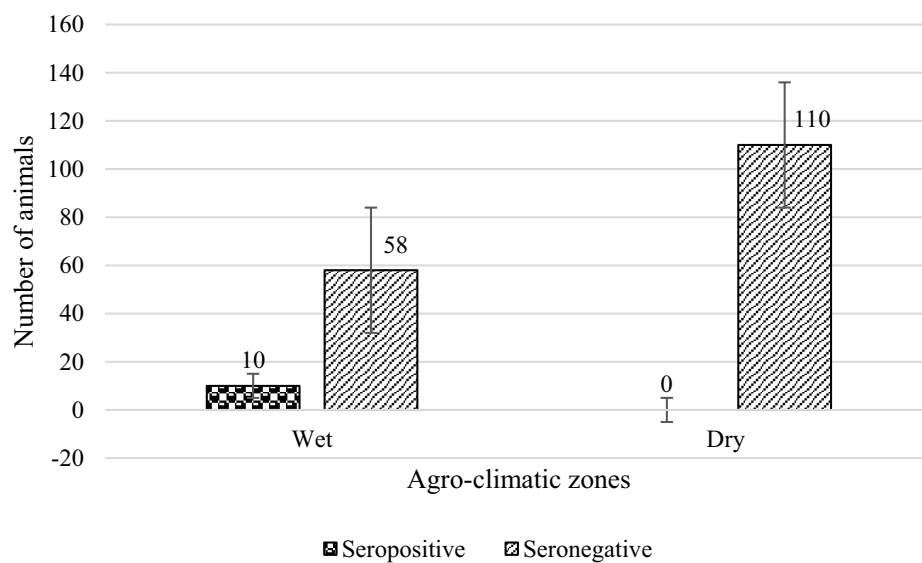


FIGURE 2

Seropositive vs. Seronegative Cattle by Agro-Climatic Zone. From the 68 cattle serum samples tested from the wet zone, 10 were seropositive for BVDV while from 110 cattle serum samples tested from dry zone were seronegative for BVDV.

animals, and the overall animal density is relatively low compared to the larger commercial farms found in neighboring countries (26). The greater seropositivity in the wet zone might be attributed to communal grazing practices, extensive farming practices including shared feeders and waterers, abortions occurring while cattle graze, and the use of a common bulls can facilitate transmission of virus (24, 27). In the dry zone of Sri Lanka, the absence of detectable antibodies against BVDV in cattle populations may be attributed to several interactive factors. Extensive free grazing and low stocking density are prominent features of cattle management in this area, which limit close contact between animals and consequently reduce opportunities for viral transmission (25). Currently, there are no commercially available BVD vaccines widely used in Sri Lanka. Vaccination is uncommon and is limited to a small number of private farms that use imported inactivated vaccines. Among these, aluminium-salt-adjuvanted inactivated BVDV vaccines have been used on a limited basis. Since the ELISA detects both antibodies generated from the infection and vaccine, the disease prevalence rates may largely vary.

Our results support the significance of the specific surveillance and more effective biosecurity in light of the high economic cost of BVDV to cattle productivity in the form of reproductive losses, immunosuppression, and susceptibility to secondary infections. Scheduled screening of the herd, improved farm management techniques, and educational programs for the farmers are suggested to assist with the decrease of BVDV spread, especially in the regions with higher risks (18, 21, 22).

The limited sample size and geographical coverage are limitations of this study. This narrow range might not give a complete picture in terms of herd management and the agro-ecological situation in Sri Lanka. Additionally, while this study relied on antibody-based diagnostics, the inclusion of antigen detection in seropositive animals could offer a more comprehensive understanding of disease epidemiology, particularly by identifying persistently infected (PI) animals. However, clinical disease was not observed in any of the seropositive animals. Future studies should therefore include larger and more diverse cattle populations, with

expanded sampling across additional provinces (23). Incorporating buffalo populations into future research would also be valuable for understanding the valid data on prevalence, transmission dynamics, and overall economic impact of BVDV in Sri Lanka (21, 22).

## 5 Conclusion

This study represents the seroprevalence of Bovine Viral Diarrhea Virus (BVDV) in cattle in Sri Lanka in the Northern, North Central, Central and Southern Provinces. An overall prevalence of 5.6% was detected, with significantly higher exposure in the wet zone (14.7%) compared to no seropositivity in the dry zone. It was not as high as in the neighboring countries, however, the extreme disparity between agro-climatic zones indicates that environmental influence and managerial practices may play a role in the dynamics of the virus dissemination. Enhancing biosecurity at the farm level, regular screening of herds, and increasing awareness among farmers are needed to reduce the spread of the BVDV and to minimize the losses linked to BVDV. The future research must involve the use of large, geographically mixed populations of cattle and buffalo herds, detection of BVDV antigen in infected herds, obtaining a complete epidemiological profile, and to direct the development of sustainable national control measures.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The animal studies were approved by Ethics Committee, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya (Ethical clearance ID: VERC\_24\_02). The studies were



conducted in accordance with the local legislation and institutional requirements. Written informed consent was obtained from the owners for the participation of their animals in this study.

## Author contributions

WW: Writing – original draft, Data curation. WD: Investigation, Writing – review & editing, Resources. WA: Supervision, Data curation, Writing – review & editing. VW: Funding acquisition, Writing – review & editing. RK: Writing – review & editing. AK: Conceptualization, Writing – review & editing. TM: Project administration, Writing – review & editing, Supervision, Conceptualization.

## Funding

The author(s) declared that financial support was received for this work and/or its publication. This research was supported by the International Atomic Energy Agency under CRP D32037 (Novel Test Approaches to Determine Efficacy and Potency of Irradiated and Other Vaccines) through the contract 26188, and by the Earned Funds, Department of Veterinary Pathobiology, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya.

## Acknowledgments

The authors would like to acknowledge the support provided by International Atomic Energy Agency under CRP D32037 (Novel

Test Approaches to Determine Efficacy and Potency of Irradiated and Other Vaccines) through the contract 26188.

## Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declared that Generative AI was not used in the creation of this manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References

- Zemke, J, König, P, Mischkale, K, Reimann, I, and Beer, M. Novel BVDV-2 mutants as new candidates for modified-live vaccines. *Vet Microbiol.* (2010) 142:69–80. doi: 10.1016/j.vetmic.2009.09.045
- Houe, H, Baker, J, Maes, R, Wuryastuti, H, Wasito, R, Ruegg, P et al. Prevalence of cattle persistently infected with bovine viral diarrhoea virus in 20 dairy herds in two counties in Central Michigan and comparison of prevalence of antibody-positive cattle among herds with different infection and vaccination status. *J Vet Diagn Invest.* (1995) 7:321–6. doi: 10.1177/104063879500700304
- Baker, JC. The clinical manifestations of bovine viral diarrhoea infection. *Vet Clin North Am Food Anim Pract.* (1995) 11:425–45. doi: 10.1016/S0749-0720(15)30460-6
- Pizarro-Lucero, J, Celedón, MO, Aguilera, M, and de Calisto, A. Molecular characterization of pestiviruses isolated from bovines in Chile. *Vet Microbiol.* (2006) 115:208–17. doi: 10.1016/j.vetmic.2006.02.009
- Lindberg, A, and Houe, H. Characteristics in the epidemiology of bovine viral diarrhoea virus (BVDV) of relevance to control. *Prev Vet Med.* (2005) 72:55–73. doi: 10.1016/j.prevetmed.2005.07.018
- Lanyon, SR, Hill, FI, Reichel, MP, and Brownlie, J. Bovine viral diarrhoea: pathogenesis and diagnosis. *Vet J.* (2014) 199:201–9. doi: 10.1016/j.tvjl.2013.07.024
- Moennig, V, and Becher, P. Control of bovine viral diarrhoea. *Pathogens.* (2018) 7:29. doi: 10.3390/pathogens7010029
- Grünberg, W. Bovine viral diarrhoea and mucosal disease complex. *Merck Vet Man.* (2021)
- Walz, PH, Chamorro, MF, Falkenberg, M, Passler, T, van Der Meer, F, and Woolums, AR. Bovine viral diarrhoea virus: an updated American College of Veterinary Internal Medicine consensus statement with focus on virus biology, hosts, immunosuppression, and vaccination. *J Vet Intern Med.* (2020) 34:1690–706. doi: 10.1111/jvim.15816
- Stahl, K, and Alenius, S. BVDV control and eradication in Europe—an update. *Jpn J Vet Res.* (2012) 60:S31–9.
- Clegg, TA, Graham, DA, O'Sullivan, P, McGrath, G, and More, SJ. Temporal trends in the retention of BVD+ calves and associated animal and herd-level risk factors during the compulsory eradication programme in Ireland. *Prev Vet Med.* (2016) 134:128–38. doi: 10.1016/j.prevetmed.2016.10.010
- Buvanendran, V, and Mahadevan, P. Crossbreeding for milk production in Sri Lanka. 1975
- Spoelstra, M, Sölkner, J, Bovenhuis, H, Babigumira, B, Periasamy, K, and Dematawewa, C. Estimation of breed admixture levels in Sri Lanka cattle and its relation to performance traits. Wageningen: Wageningen Academic Publishers; 2022. p. 1745–1748.
- Wickramasinghe, S, Abbas, K, Hussain, T, Ramasamy, S, Manomohan, V, et al. Indigenous cattle of Sri Lanka: genetic and phylogeographic relationship with zebu of Indus Valley and south Indian origin. *PLoS One.* (2023) 18:e0282761. doi: 10.1371/journal.pone.0282761
- Abeygunawardena, H, and Abayawansa, W. Studies on indigenous zebu cattle 1: reproductive pattern under traditional management. *J Natl Sci Found.* (1995) 23:131. doi: 10.4038/jnsfsv.23i4.5850
- Department of Census and Statistics [Internet]. 2025. Available online at: <https://www.statistics.gov.lk/Agriculture/StaticInformation/NationalLivestockStatistics#gsc.tab=0> (Accessed October 13, 2025).
- Orban, HR. A novel risk-based sampling calculator. *Int J Agric Ext Rural Dev Stud.* (2021) 8:1–11. doi: 10.2139/ssrn.3829029
- Uddin, MA, Ahasan, ASML, Islam, K, Islam, MZ, Mahmood, A, Islam, A, et al. Seroprevalence of bovine viral diarrhoea virus in crossbred dairy cattle in Bangladesh. *Vet World.* (2017) 10:906–13. doi: 10.14202/vetworld.2017.906-913
- Phillips, A, and Acheson, N. Basic epidemiology. Gynaecological oncology for the MRCOG and beyond, 2nd. 2014. 1–14.
- International K, Lanka S. Prevalence of cattle diseases and its impacts in dry zone, Sri Lanka S. Dasinaa Department of Biosystems Technology, Faculty of Technology, Eastern University Sri Lanka. 2022;15:126–136.

21. Raheem, A, Ahmad, A, Rabbani, M, Ghafoor, A, Ajnum, A, Avais, M, et al. Determination of sero-prevalence and associated risk factors of bovine viral diarrhoea virus (BVDV) in bovine population from southern Punjab, Pakistan. *J Anim Plant Sci.* (2020) 30, 545–551. doi: 10.36899/JAPS.2020.3.0064
22. Sarangi, LN, Prasad, A, Thodangala, N, and Muthappa, P. Seroprevalence of bovine viral diarrhoea in organized herds in India. *Vet Arch.* (2023) 1: 389–98. doi: 10.24099/vet.arhiv.1560
23. Tandan, P, and Paudel, M. Seroprevalence and associated risk factors of bovine viral diarrhoea in the dairy cattle of Rupandehi District of Nepal. *Int J Appl Sci Biotechnol.* (2023) 11:128–34. doi: 10.3126/ijasbt.v11i3.55779
24. Lindberg, AL, and Alenius, S. Principles for eradication of bovine viral diarrhoea virus (BVDV) infections in cattle populations. *Vet Microbiol.* (1999) 64:197–222. doi: 10.1016/S0378-1135(98)00270-3
25. Houe, H. Epidemiological features and economical importance of bovine virus diarrhoea virus (BVDV) infections. *Vet Microbiol.* (1999) 64:89–107. doi: 10.1016/S0378-1135(98)00262-4
26. Hitihamu, S, Jayasinghe, U, and Aiome, GN. Factors affecting technical efficiency of dairy production in the dry zone of Sri Lanka. (2025).
27. Grooms, DL. Reproductive consequences of infection with bovine viral diarrhoea virus. *Vet Clin Food Anim Pract.* (2004) 20:5–19. doi: 10.1016/j.cvfa.2003.11.006